Urban dynamics modelling, application to economics assessment of climate change

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Abstract

Because they are home to more than half of the world population, and because most of the world economic activity takes place within them, cities are at the forefront of global environmental issues. Land use planning, urban transport and housing policies are now recognized as major tools for the reduction of both greenhouse gases emissions and vulnerability to climate change impacts. So far, however, how to use these tools efficiently remains unclear. At least three main difficulties explain this, and play a key role in urban climate policies analysis. First, urban climate policies are also not developed or implemented in a vacuum; they interact with other policy goals, such as economic competitiveness or social issues, giving rise to both synergies and conflicts. Second, inertia is a key factor when designing optimal climate policies: structural modifications in cities occur slowly over a long time horizon. Some immediate actions are required if cities are to be adapted to a different climate or to help reduce greenhouse gases emissions within a few decades. Third,

the evolution of a city depends on several external factors, on which local policy-makers do not generally have much influence: demographic, socio-economic, cultural, political and technological changes will play a major role. This uncertainty has to be taken into account, and climate policies have to be robust against future possible global evolutions is important. These three difficulties are not, however, impossible to overcome, and we will illustrate how integrated city modelling can help address these issues.

Summary

Because they are home to more than half of the world population, and because most of the world economic activity takes place within them, cities are at the forefront of global environmental issues, among which greenhouse gas emissions reduction, and vulnerability to climate change and natural hazards. Interactions between a city and its environment are complex, and influenced by numerous factors. One of them, however, plays a special role: the urban geographical form, i.e. the spatial repartition of people and assets because it plays a major role in shaping the fluxes[1] that characterize the life of a city, and in constraining the infrastructure[2] locations, types and shapes.

Land use planning, urban transport and housing policies are now recognized as major tools for the reduction of both greenhouse gases emissions (climate change "mitigation") and vulnerability to climate change impacts ("adaptation" to climate change). It is therefore not surprising that reflexions on city spatial structure are at the heart of many prospective studies on climate change adaptation and mitigation, for instance in IPCC, OCDE, UN-Habitat or the World Bank[3]. So far, however, how to use efficiently most of these tools remains rather unclear. In this work, our thesis is that at least three main difficulties explain this, and play a key role in urban climate policies analysis.

First, inertia is a key factor when designing optimal climate policies: structural modifications in cities occur slowly over a long time horizon. Some immediate actions are required if cities are to be adapted to a different climate or to help reduce greenhouse gases emissions within a few decades. We claim that it is especially urgent to start changing building design and urban planning habits.

Second, the evolution of a city depends on several external factors, on which local policy-makers do not generally have much influence: demographic, socio-

[1] of people, goods, energy, water, information etc.

[2] transport infrastructure, buildings, plants etc.

[3] cf. Van Ypersele (2007), Kamal-Chaoui and Robert (2009), UN-Habitat (2011) and Hoornweg et al. (2011).

economic, cultural, political and technological changes will play a major role. For instance, success of strategies aiming at reducing transport related energy consumption is dependent on future transport prices. This uncertainty has to be taken into account, and climate policies have to be robust against future possible global evolutions. We affirm that urban planning needs to be done in a "prospective" mindset, considering the uncertainty on many drivers of urban dynamics, and we propose a scenario-based approach to do so.

Third, urban climate policies are not developed or implemented in a vacuum; they interact with other policy goals, such as economic competitiveness or social issues. Urban policies have multiple goals, such as enhancing the quality of life and the city's economic competitiveness by means of affordable housing and office space, amenities, and efficient public services (from good schools to rapid transportation). Urban policies also have social objectives aimed at poverty and social segregation issues, safety and security, and public health. They have local environmental goals as well, such as reducing air and water pollution and preserving natural areas. In addition to this long list of goals, urban policies now face new challenges from climate change. Environmental policies can result in positive feedback with respect to economic and social issues. Conflicts among different policy goals can also take place leading to trade-offs and implementation obstacles. Social and political acceptability issues are important and the political economy of climate policies needs to be investigated. We show that integrating various goals in a consistent decision-making framework (what is sometimes referred to as "mainstreaming") allows for more efficient and acceptable policies.

We will present some tools which can help solve these problems. Prospective studies that explore various possible evolutions of global variables and their local consequences on cities are for instance especially useful to design the best policies. Quantitative models, although they are highly simplified descriptions of reality, with hypotheses restricting the possibilities they can explore, are an efficient tool to create such prospective scenarios and analyze complex feedbacks. By enabling decision makers and stakeholders to understand the main mechanisms and interactions between variables, they can create a basis for policy discussion. We will present here such a model, NEDUM-2D, and use it to illustrate to what extent it can help address previous issues.

Developing models which can help policy making raises technical difficulties: models have to include the main processes and mechanisms, to be able to properly analyze the reality. At the same time, however, they have to be simple enough so that their conclusions and their validity remain clear to its users, to avoid the "black-box"effect: models have to be designed based on the question they are trying to answer. For climate questions, existing integrated urban models are not sufficient:

they are often too complex, and at the same time often do not take into account mechanisms relevant for environmental issues. We therefore decided to develop our own model, NEDUM-2D.

Such a model is a never-ending work: it should be always completed, refined, or sometimes simplified to meet needs, questions, and beliefs of its users. What we propose here is not a definitive tool to solve all urban climate problems, but it is a first step towards the development of a framework which may enable to address some issues.

Part I is an introduction that develops the ideas presented here. It presents to what extent climate issues are of relevance for urban decision-makers. The first chapter deals with mitigation issues : it highlights why urban greenhouse gases emissions matter in the broader global warming debate, and how urban policies act on them. The second chapter looks into detail at cities vulnerability to climate change impacts, and at policy options to reduce this vulnerability. Based on these reviews, Chapter 3 will explain the thesis of the present document, and will sum up the main findings we will present in Parts II and III.

Part II explains the modeling approach we have followed. Integrated city modeling (ICM) aims at giving a quantitative description of the interaction between different urban processes, and can describe the influence of the evolution of global parameters on these local processes. It is therefore an efficient tool to address issues described in Chapter 3. Using ICM poses however specific problems, to which each chapter of this Part aims to answer. Chapter 4 does, first, a brief review of existing approaches and theories for city modeling. It defines more precisely what exactly means "City Modeling", and its challenges, advantages and limitations. Next chapters present and explain the models we have designed. Our approach is iterative. Starting from the classical urban economy model, we introduce progressively additional mechanisms to answer increasingly complex problems.

Part III explores to what extent the models we have designed can answer the questions we have raised in Part I, and to what extent it can give some useful information for the design and assessment of mitigation and adaptation policies at local scale. This part is based on the text of three research articles (Viguié and Hallegatte (2011); Viguié et al. (2011); Viguié and Hallegatte (2012)). Before each of them, a short introduction explains the context and highlights main conclusions.

References

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