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Counter urban sprawl in the metropolitan area of Luxembourg: a spatial modeling application to reduce car dependence

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Abstract:

Managing urban sprawl is a major concern for urban planning. Its negative effects on the environment are indeed of great significance: air pollution, noise, destruction of natural resources... The central aim of the project is to give new insights on the relationship between patterns of residential development and daily mobility. Is the fractal city model an interesting alternative either to the classical compact or wisely compact city or to the New Urbanism? Is one of those models better adapted to the spatial organization and spatial functioning that characterize the urban area of Luxembourg? The project aims at answering those questions by following a two-steps methodology: 1) simulation of scenarios of residential development, and 2) assessment of the simulated scenarios in terms of daily mobility and accessibility to urban and rural amenities.

Keywords: Urban sprawl, urban and regional planning, daily mobility, urban forms, spatial simulation

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Description of PhD project:

On a socio-economic point of view, the negative effects of urban sprawl are worrying: increase of travel costs, and their consequences: social segregation and social inequity. Yet, in many countries, the need for new urban developments is real due to an increase of the number of households and inhabitants. Consequently, the recurring question is: where to locate new urban developments that do not increase the negative effects of urban sprawl? In this perspective, the case of Luxembourg is particularly interesting. Indeed, cross border and residents commuting involves a massive use and increasing dependence to cars [Gerber et al. 2008, Petit 2009], which favours urban sprawl as shown by the increasing number of people who decide to leave their homes in Luxembourg for new accommodations in the surrounding countries (7,715 workers in the period 2001-2007, [Carpentier 2010]).

Increasing density in existing urban patterns and urban renewal are solutions usually adopted to counter urban sprawl. However, the limits of the compact city model have been demonstrated, in particular road congestion, reduced living space, poor access to open spaces, and increasing housing prices [Breheny1997][Burton2000]. One answer proposed is to combine wisely compact and polycentric urban forms [Camagni2002][Davoudi2003]. The New urbanism also spreads out mainly in the United States [Ghorra-Gobin2006]. It promotes traditional neighbourhood developments, which include high building densities, mixed uses, grid street patterns, narrow streets, and short setbacks [Calthorpe1993]. Last but not least, urban fractal models have begun to be applied. Some applications have put forward aesthetic qualities of urban fractal forms [Cooper2008][Stamps2002]. [Thomas2008] have shown a positive statistical relationship between residential satisfaction and fractal dimension of the built environment. Yet others have shown that, in the case of theoretical cities, a fractal city is more interesting than a compact city for people who visit frequently small and medium size centres, but not so often the main centre, and who want to be close to open spaces [Cavailhès2004].

However, despite the best efforts of scientists and developers, the quest to find the optimal urban form (in terms of sustainability) is far from over. Concerning more specifically the field of mobility, the relationship between urban form and travel behaviour is still not clearly established. For one thing, academic research into the connections between compact urbanization and travel behaviour is not conclusive, with results differing depending on the methodology used, data limitations and spatio-temporal settings [Cervero2010]. For another, studies of the impact of ‘new urbanism’ developments on travel behaviour have also had mixed fortunes: some report lower car ownership and usage in ‘new urbanism’ communities, others not [Conway2009]. And finally, attempts to tie in the more or less prominent polycentric character of some urban areas with the organization of flows and movement within those areas have failed to come up with any general rules for the development of urban areas [Aguilera2005][Schwanen2003]. To escape the constraints of case studies, some workers have developed simulation models for forecasting the impact of travel behaviour on future urbanization concepts. These studies have failed to prove any one urbanization model is superior to any other. However, they have confirmed the influence of the land use pattern on travel behaviour [Geurs2006].

A scenario is defined as both a planning concept and additional planning requirements (e.g. number and types of new dwellings, maximal distance between new residential locations and retail centres, creation of new railway stations...). Three planning concepts will be tested: 1) the IVL (Integratives Verkhers und Landesentwicklungskonzept) developed by the Luxembourg's planning authorities; 2) continuation of urban sprawl in the future (laissez-faire or business as usual); and 3) fractal urban planning (Frankhauser et al, 2010). Scenarios considering the two first planning concepts are being developed in the frame of the MOEBIUS project. The PhD project will re-use them. By contrast, fractal scenarios will be developed specifically in the frame of the PhD project. Each scenario will be used as a basis for the simulation of new residential developments. The simulation results will be maps locating new residential developments at a very fine scale (spatial resolution of about 20 m for the Grand Duchy of Luxembourg). Considering all possible variations of the scenarios and their spatial simulations, more than hundred maps of simulated residential developments will be created.

It is important not to consider the Grand Duchy of Luxembourg isolated from its surrounding cross-border commuting areas (border regions of France, Belgium, and Germany). However, data available for the Grand Duchy are more detailed and fine scale than data available for the surrounding commuting areas. Hence those two zones, corresponding to two spatial scales, will be distinguished. Simulations and accessibility measures will be performed with a high degree of precision on the Grand Duchy whereas only main tendencies will be identified for the surrounding commuting areas. Coarse-grained simulations of residential developments will be performed for the surrounding commuting areas using GIS computing. Only two land use change scenarios will be modelled. Conversely, simulations of residential development will be more numerous and more detailed for the Grand Duchy. The simulations will be done using the software application MUP-city developed by the ThéMA research team [Tannier2010]. MUP-City is dedicated to the simulation of fractal and non fractal residential developments on the basis of a multiscale cellular space; four additional rules introduce accessibility constraints to facilities and open spaces, and a proximity constraint to the existing roads. The actual version of MUP-city only considers accessibility to local amenities (e.g. shopping centers daily or weekly visited, neighboring open spaces). One objective of the PHD project is to enlarge the actual MUP-city modelling to take into account accessibility to central amenities (e.g. cultural amenities of Luxembourg-city).

The PhD project also provides ex-post assessment of the simulations by measuring accessibility to various (urban and rural) amenities. The actual version of MUP-City allows the calculation of 8 spatial accessibility indexes (e.g. average distance between residential places and the urban border, number of residential places located at less than 400 m. from a daily frequented retail centre...). Spatial accessibility only considers distances between places but, from the planning point of view, the behaviour of individuals is also important to take into account: individual time constraints, activity chains... In the PhD project, the development of indexes of behavioural accessibility (utility-based or activity-based [Neutens2010]) is planned. A sustainable urban form must be able to adapt to behaviours that may change over time. So, to simulate different possible changes of the social, economic and

technological context (e.g. higher fuel prices, more ecology-mindedness, etc.) a variety of behaviours in terms of frequentation of amenities will be modelled.

The second aspect of the ex-post assessment of residential development simulations consists in the analysis of daily mobility patterns that result from each simulated residential configuration. Daily mobility will be simulated using a LUTI (Land Use Transport Interaction) model named MobiSim, and developed by the ThéMA research team [Antoni 2010]. The simulation of daily mobility within MobiSim is based on a four-step model. At the beginning of a simulation, each modelled individual is located at his/her residential place. Then a spatial interaction model is applied to determine the destination of each individual (e.g. their work place). Because of the specific spatial organization of commuting flows in the metropolitan area of Luxembourg, we assume that a simple spatial interaction model will not give good results. Consequently, in the PhD project we propose to adapt MobiSim to the case of Luxembourg by introducing a Gravity model with barrier effect. Moreover, the calibration of MobiSim for the Luxembourg will be based on the MOEBIUS' library of mobility behaviours, which is being created starting from the MOBILLUX outcomes (FNR/06/35/03: project on the link between daily and residential mobility in Luxembourg, see Gerber2008).

Note:

This paper presented the PhD project and the presentation which will be given the ERSA seminar is also going to include some elements from MUP-City project. As they are not from a personal work, and waiting for publication, they have not been included to the current paper. The future implementation of PhD project results in MUP-City project will be published later.

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