A LUTI agent-based model of Lyon area: welfare analysis of some scenarios

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Introduction

The earth population is now predominantly urban, and urban areas are expanding fast (Seto et al. (2011)). Empirical evidence shows that various urban development patterns significantly influence carbon dioxide emissions (Glaeser and Kahn (2010)). Low density brings about increasing vehicle usage while both low density and increased vehicle usage bring about increasing fuel consumption (Brownstone and Golob (2009)). Compact urban development would be the natural answer to these issues but the debate regarding welfare, distributive and environmental aspects is fierce between opponents and promoters of compact cities (see e.g. Gordon and Richardson (1997); Ewing (1997)). The issue of spatial and social structure and operation of cities has never been so acute, and there is an obvious need to better understand city spatial development (Anas et al. (1998)).

We use the Alonso-Muth-Mills (AMM) urban economics model which is based upon the location choices of economic agents in an urban space, with agents competing for housing. However, introducing polycentrism, income heterogeneity or multi-worker households in the AMM model proves difficult from the point of view of analytical tractability. Thus we have developed an agent-based model built upon microeconomic interactions between agents on an urban housing market.

Methodology

Agent-based models in the field of urban modelling are still in the infancy. Basically, agent-based models include three main components, i.e. agents, an environment and rules of behavior. The agents have internal states, some fixed and others that can change, like their preferences, and follow rules of

behavior. The environment is defined as a two-dimensional space supporting resources and can include a communication network. Rules of behavior determine the interactions between agents, between agents and the environment and within the environment. In our model these rules are grounded in the urban microeconomic framework.

The agent-based simulation framework is used to define microeconomic interactions between agents (households) and shown to reproduce the results of the AMM model (Lemoy et al, 2010). The simulated model is dynamic: starting from a random initial state, interactions between agents on an urban housing market lead progressively the whole system to an equilibrium state.

Three kinds of outcomes are provided: economic with the utility of the agents; social by comparing the variation of utility of “poor” and “rich” agents and social segregation within the city; and environmental through the commuting distances travelled by the agents, given the current transport technologie, and the size of the houses.

Findings

The data used for the calibration is based on the agglomeration of Lyon containing 303 communes. The study area contains 1,770,000 habitants with an average density of 798 inhabitants per km^2 in 2008. A dozen parameters determine the microeconomic behaviour of agents and are taken from various data sources: share of housing in consumption (utility function), relative shares of land and capital in housing production function, income, transport cost, population, household size and agricultural land price.

The results of the agent-based simulation are compared to density and housing prices gradients observed on the urban area. The comparison shows a good fit of simulation to actual data.

Various scenarios of urban spatial developments are studied. They include compact city versus sprawled city, and monocentric versus various polycentric patterns (Bertaud, 2004). Welfare, social and environmental diagnoses are made on these patterns.

For instance, it is shown that the economic outcome of multiple job centers is positive when they are sufficiently set apart. However, pollution linked to commuting distances decreases first when centers are taken away from each other but then increases again. At the same time, the decreasing competition for land results in increasing housing surfaces and thus city size.

With two-worker households whose partners may work in different job centers, it is shown that regarding welfare polycentrism is desirable, as long as centers are not moved too far apart from each other. The environmental outcome is also positive for small values of this distance but this positive effect is mitigated by the fact that housing surfaces increase, which may increase emissions of greenhouse gases.

Implications for policy regarding various urban and transport planning options are drawn from these results.

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