Bid-auction framework for microsimulation of location choice with endogenous real estate prices

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Land use models are an increasingly used tool for evaluation and forecasting of the effects of urban interventions such as real estate developments, modifications to the transport system and changes in urban policy. Among these, microsimulation and agent-based models are becoming more relevant due to the possibility of representing individual agents and their complex interactions in a simple, yet robust and flexible, way.

Location choice models are a fundamental component of any land use model. They describe the spatial distribution of agents and activities within a city and, by extension, the corresponding travel demand, use of built space and general consumption of resources. There are two major aspects that characterize a location choice model: the type of market and the market clearing mechanism.

The type of market refers to the assumption on how agents (households or firms) and locations (building, parcels or zones in the city) are matched. The coupling of agents and locations is usually understood under two major paradigms: agents choose the location that provides maximum utility and behave as price takers (the Choice approach) or agents bid their willingness to pay for locations, where an auction determines both the located agent and the transaction price (the Bid-auction approach).

The market clearing mechanism refers to how prices are adjusted in order account for the competition between agents for relatively scarce and quasi unique real estate goods. In equilibrium models market clearing is usually achieved by imposing equality between supply

and demand and finding the vector of prices that solves the condition. Examples of equilibrium models are RELU-TRAN [1], characterized by using a choice approach and MUSSA [2] which is based on a bid-auction approach to location choice.

Disaggregated models deal with market clearing in different ways. Some models rely on the use hedonic price models, where the market value of a location is assumed to be a function of its attributes as implemented, for example, in UrbanSim [3]. The use of hedonic models simplifies the implementation of a microsimulation location choice model, but oversimplifies the price formation mechanism, making it exogenous to the location problem and independent of the market conditions. Other land use models like ILUTE [4] simulate individual transactions for each real estate good, finding the price that satisfies each seller and buyer. This approach is realistic but is difficult to implement and requires an extremely high computational effort.

We propose a framework for location choice models with a market clearing mechanism that is consistent with economic theory and feasible to implement in a (dynamic) microsimulation or agent-based model. We choose to use the Bid-auction approach, where the market prices are reactive to market conditions and depend on the preferences of (and competition between) agents. However, given the disaggregate nature of the model, traditional equilibrium conditions cannot be imposed and market clearing must be solved in a different way. To achieve this we divide the problem in two parts:

First, for each simulation period, a quasi-equilibrium model clears the market partially. In this process the agents observe the market conditions and adjust the level of their bids in order to make their perceived probability of locating (winning at least one bid) equal to one. The bid adjustment to attempt ensuring a location makes sense in the real estate market because goods are unique and agents need to get at least one location (and not more than one). The market conditions are perceived through the observation of prices in the previous period. Since prices are the outcome of auctions they reflect other market conditions such as the supply or demand surplus for the different locations in the city. Once the individual level bids have been adjusted, prices and location probabilities are re-calculated, taking into account all the transactions that take place in the simulation period simultaneously.

A second component of the model takes the resulting prices and location distributions from the quasi equilibrium model and, through a Monte Carlo simulation, determines locations at an individual level (matching agents and real estate goods). The simulated location choices and prices are used as an input to the quasi equilibrium model in the next period.

Since in the quasi-equilibrium model each agent adjusts the bid level based only on their own perceived location probability, it is possible to estimate an adjustment for each agent instead of the aggregate (and computationally expensive) simultaneous adjustment for all agents required in an equilibrium approach. This also generates a location distribution that does not clear the market completely, because the perceived probabilities that would ensure the location of the agents are different from the final probability distributions that describe the actual interaction between all agents at each period. Therefore, the model achieves absolute market clearing (location of all agents) only through the simulation process. This introduces some instability in the simulation that is compensated by the fact that prices and location distributions are calculated in the (higher level) quasi-equilibrium model.

The framework is tested for a case study of the city of Brussels. Results are compared with the location distribution and prices obtained with a (non-dynamic) traditional equilibrium model and with those obtained with a simplified (no market clearing) location choice simulation.

References

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