Land use and density in the European city: monocentric analysis and scaling

Rémi Lemoy and Geoffrey Caruso
University of Luxembourg, Maison des Sciences Humaines,
11 Porte des Sciences, L-4366 Esch-Belval, Luxembourg
e-mail: remilemoy@gmail.com, geoffrey.caruso@uni.lu

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In this work we study the profile of land use and population density in European cities with respect to the distance to the city centre. More specifically we address the scaling of land use and density curves with respect to city population and rely on fine grained land use data. Our main objective is to retrieve generic laws that can support the calibration of monocentric urban economic models for European cities.

We use the GMES Urban Atlas database, providing a precise description of land use at 5m resolution in the 305 major European urban areas (more than 100.000 inhabitants). We combine this dataset with population density from the Geostat population grid, which covers the whole of European Union (EU) with a $1km^2$ resolution. Population is allocated proportionally to surface and weighted by soil sealing and density classes of the GMES data.

We analyse the evolution with distance to the city centre, which we define for convenience as the location of the city hall, of population density and of the share of land used for different purposes: housing, roads, railways, urban green, water, agriculture, forest. To this end, we define concentric rings of fixed width around the city centre, in which we average each land use and population.

In order to compare different cities and to identify a global picture, i.e. a standard representative European city, we study scaling relationships for the obtained monocentric land use shares and density curves. We analyse the scaling of these curves with respect to city population, following similar approaches conducted in the literature for different parameters (such as income or road space). The total population for each city is computed from the population grid.

We find that land use curves, in particular housing and roads shares, tend to scale like the square root of city population. Population curves have roughly exponential shapes, as it has been widely modelled in the literature, although usually not based on land use and soil sealing data. Population curves tend to scale like the city population to a power close to 1/3.

These results allow us to propose a simple monocentric description of land use shares and population curves in a representative European city, whose size can be chosen based on the scaling relationships we obtain. This result is especially interesting, and of practical use, for the purpose of calibration and validation of monocentric urban models, that can differentiate (or not) housing from land and include interactions between non-developed and developed land.