The unknown variable – integrating intra-urban migration into demographic projections

A large portion of internal migration of Hungary is happening between urban centres, their commuting zones and remote areas, and can be described as flows of suburbanisation, amenity migration, economic outmigration and reurbanisation. Suburbanisation is directed from the urban cores of the large (or in some cases, even medium-sized) urban centres to their catchment areas is one of the most visible spatial processes of post-socialist Hungary, therefore it is well researched. Amenity migration, driven by people who can make themselves largely independent from the urban centres (e.g. atypical employees, retirees) is often directed to remote rural areas high in natural amenities. This process is not as well-developed as the counter-urban migration in some western countries, but in some destinations (e.g. Balaton Uplands) it can lead to observable changes. Economic outmigrants leave urban centres in favour of remoter locations for completely different reasons. This process was the most prevalent after the political transition, when many existences were crumbled, but has not ceased since. And while after the transition, the shrinkage of urban centres was dominant, due to the significant influx of people from lagging (and often remoter) areas, some of the more dynamic centres could be described with reurbanisation.

These processes significantly changed the demographic profile of the affected areas, increased the demographic imbalance of Hungary, and also made an impact on land cover changes. These topics are frequently researched. Naturally, the future outlook of these processes is also at the forefront of interest. Most demographic forecasts give projections at country or regional level, but some methodological approaches enable reliable forecasts in microregional or municipal level too. The demographic forecast I prepared in a preceding research also aimed for high spatial resolution. It examined multiple scenarios, which differed in their fertility and mortality assumptions, their climatic predictions, and their anticipated socioeconomic paradigm. According to the low natural movement scenarios, the Hungarian population may shrink to 8 342 thousand inhabitants to 2051, while the high natural movement scenarios anticipate 9 138 thousand inhabitants. A drastic shift in the age structure can also be expected: the old-age-dependency ratio will increase from 25% (2011) to 61–65%.

The projections reveal big spatial differences. Due to the continuing suburbanisation, the commuting settlements around Budapest and the regional centres preserve or may even increase their population, despite the general decrease. The territorial differences in ageing will also deepen. In amenity migration destinations, the old-age-dependency ratio may increase over 100%, which will pose serious social sustainability challenges. Demographic projections may also serve as an input for land use change modelling, e.g. as layers to provide a constraint or incentive for the transformation to built-up areas.

However, this preceding projection, as well as similar others, has a shortcoming: they take only migration crossing municipality boundaries into account. This is not a minor flaw: according to Gábor Vasárus, more than 40% of the population increase of the Hungarian agglomerations (minus Budapest) went to the outskirt and former incorporated villages belonging to the municipal area of the urban centre. In this sense intra-urban suburbanisation is the most significant, but economic outmigration also drives people from the core to the outskirts. Even amenity migrants can find their fitting niche-s without crossing city limits.

The main reasons for the neglection of these processes are the methodological hardship and lack of useable original data source. However, with an update of my earlier projection methodology, I make an attempt the overcome this shortcoming.

I use agent-based modelling method for demographic projections. The fundamental building blocks of the agent-based methods are the autonomous agents, which each possess a unique set of attributes and rules of behaviour. Based on their attributes and behavioural rules, the agents show different behavioural patterns, make (stochastic or deterministic) decisions, interact with each other and their environment and have an influence on them. The heterogeneity of the agents is crucial to study emergence phenomena: observable only at macro-level, but develop from micro-level interactions. The presence of emergence phenomena is a key characteristic of complex systems such as the human society. The course of an agent-based simulation usually contains several cycles, which represent a certain amount of time. During each cycle, the agents can participate in a similar set of actions, while the overall state of the simulated system is continuously changing. Due to its characteristics, agent-based methodology can be excellently paired with scenario-based modelling approach: with setting different parameters and rules of behaviour, different runs can be executed.

To reach my research goals I created an own agent-based model coded in Python language. In order to integrate intra-urban migration into demographic projection, my methodology have to meet certain key criteria. Most importantly, the agents representing the Hungarian inhabitants must have an attribute, which describes the location of their household within a municipality. Moreover, pull and push factors of the migration (attraction for different social groups, accessibility) also have to be determined under city level. This is especially true for dwelling prices, which is a key factor in managing intra-urban migration flows.

To meet these criteria, different components (individual inhabitants, household and family connections, dwellings, plots of land, labour markets) have to be integrated into a unified model. The model requires detailed agent attribute values to be determined. While the population census contains the necessary data as individual records, naturally, the record level data of the census cannot be used directly to build up the agent attribute database. So the publicly available aggregated data tables of the population census are used, and an iterative statistical matching procedure has to be utilized. In a nutshell, the procedure is the following: borrowing some terms from set theory, the (not publicly available) record level database of the census can be viewed as an universe. The different public aggregated publications divide the same universe to disjoint sets in multiple different ways (e.g. the population based on gender, economic activity and municipality or the population based on family status, education, economic activity, and county). The initial, wildly unrealistic (e.g. filled with random attribute values) agent attribute database can be considered an other universe in a same manner. The rules that divisions of the census universe into disjoint sets is based on can be applied into this agent universe too. The resulting additional series of disjoint sets can be paired with the originals – each original "census" set has an image set (e.g. the unemployed men of Kecskemét). In this initial phase, the element count of the original and image sets will significantly differ from each other. However, if we change an attribute value of an agent, it may cause an indirect change in the element count in two disjoint sets in case of every different division rule. In case of a given original and image set pair, it may increase or decrease the difference between their element count. An algorithm can be formulated, which changes attribute values during a regulated iteration, repeated through multiple cycles, and only accept the modifications if the sum of the changes between the element count of the original and image sets points toward the reduction of the overall difference. Running enough cycles, a high accuracy agent based table can be achieved, with probabilistic agent attribute values.

With the integration of intra-urban migration into the model, I am able to provide a more refined picture not just about the processes of the fringe of the urban cores, but the demographic outlook of the Hungarian agglomerations as a whole as well. The results also contribute to the better understanding of the environmental and land cover impact of the preceding demographic processes as well.