Assessing the Impact of Individual Attitude towards Otherness on the Structure of Urban Residential Space: a Multi-Actor Model

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Abstract. One of the main challenges of today's analytical geography is the back-linking of observed phenomena to individual actions, as not determined by individuals' structural situation in a one-goal society but by their very choice of spatial goals, i.e. by what shall be called individuals' actor-dimension. In this paper we present an actor-based model of urban residential mobility. Results show that public policies in urban development must take into account and act on this actor-dimension if they are not to obtain effects opposite to their aims.

Key words: actor-based modeling, urban development, residential space, theory of action

1 Introduction

1.1 Towards an actor-based model

One of the main challenges of today's analytical geography is the back-linking of observed phenomena to individual and institutional actions. We have managed to record spatial information at very high resolutions for a sufficient time, now, so as to be able to produce precise descriptions of longer-term spatial processes. We have also been able to produce statistical and dynamic models allowing us to make short-term predictions about the future of these processes, within the limits of defined ontologies. But what we are lacking is the capability to understand these processes in terms of results of the preference-based actions of individuals and public policy-makers. This lack, in turn, leads us to misconceive the methods in which these processes can be steered with regard to their sustainability.

In this paper, we shall call the preference- or choice-making-dimension of individuals their actor-dimension. We wish to distinguish it from what has been identified as their *agent*-dimension [14], predominantly integrated in dynamic models. Let us remind, in that scope, that only two main types of individual-based models constitute the current state of the art of dynamic modeling:

– *cellular automata*, whose individuals are material *actants* [14,27], such as houses or land-use units, with type-dependent neighborhood-impact and

– *multi-agent models*, whose individuals are either mono-strategic agents with physical-like schemes of behavior (*e.g.* members of a moving crowd [12]) or agents of homogenous groups of interest whose spatial strategies (including those based on beliefs and values) depend not on their choices but on their social-group-membership (*e.g.* tenants, landlords and store-owners [13]).

These types of models have of course produced very interesting results and the recent implementation of sophisticated calibration methods, especially in the case of cellular automata, has turned them into efficient predictive tools [26,28]. Nevertheless, by their structuralistic preference for material actants and for the agent-dimension of human individuals, they give only limited insight into the complex balance between individual and institutional responsibility in the production of space.

To fill this gap, we have tried to set up a multi-actor model of this production. The specific model that we have built in that scope is aimed at examining the link between a) individual preferences as to their residential environment and b) the structure of residential space. The model has been constructed according to the following guidelines, which represent, for us, the fundaments of actor-based modeling [20,21]:

– Individual behaviors have to be not only simulated but also defined in a bottom-up (and not in a top-down) manner. This means that they are not determined with regard to an expected *global result*, but with regard to existing theoretical knowledge about *individual* action schemes.
– An actor-based model (ActBM) should be aimed at evaluating the impact of conscious and constraint-free individual behavior. Agent-constraints, such as an individual's financial situation, as well as the spatial and political context, must be implemented, of course, but precisely as a *context* of action. The model must allow for the testing of a *plurality of action-schemes independent from individuals' agent-dimension.*
– Modeled context-changing interventions must be politically decidable.
– An ActBM space should be defined based on theoretical knowledge of spatial structures.
– An ActBM's results should not be evaluated primarily by the similarity between statistical properties of simulated and empirical global data but by their ability to explicitate the divergence between different action schemes, in terms of their impact on the global spatial process. Prediction, in that sense, is less of a goal than the construction of plausible scenarios that can be directly linked to existing individual options.

Formalizing our understanding of urban processes. While no model is in stand to incorporate all aspects of a spatial phenomenon, the above guidelines allow us to select those aspects susceptible to provide a heuristic gain. What we expect is above all a clarification of the formal link existing between processes at diverse spatial scales, of which we have gained previous, more intuitive, understanding by the means of empirical observation. The modeling approach constitutes, in that sense, a logical exploration of our own knowledge of the urban phenomenon as a system. It forces us to formalize these intuitions by making them compatible with an algorithmic representation, itself submitted (as a Turing machine) to the rules of constructibility[1]. In the scope of this explicitly constructivist modeling stance [15], the model-making process itself is of heuristic relevance and we have thus carefully recorded each of its steps. This gave us the possibility to evaluate the implementation of every new aspect of our knowledge of individuals' spatial action schemes as to the possibility to link this aspect to the divergence of outcomes in the simulation of residential mobility. Among considered aspects, we evaluated for example the impact of individuals' memory or that of the difference between perceived and objective place diversity. This construction process, unfortunately, cannot be presented in this paper but is available in its totality on `http://ois.choros.ch/model`. A multi-OS executable of our model is also available on the same web site. What we present here is the model to which we have converged at the end of the construction process.

2 A multi-actor model of the residential space

2.1 An action-ready set of initial conditions

As in any individual-based model, we have defined four aspects: a set of elements (individuals and places) with their attributes, a model space, a set of transition rules and a set of initial conditions defining element-positions and attribute values [2].

Two issues have oriented our definition of the initial conditions. First, we wished our model to reflect a clearly identified metropolitan region. But we also wished to conserve the theoretical pertinence of our model in the general understanding of the urban phenomenon. We have finally based our initial conditions on the empirical observations of diverse metropolitan regions in Switzerland: the "Métropole Lémanique"[2] , with 1.8 million residents and an area of 8,900 km^2 or the "Grossregion Zürich", with 1.2 to 1.9 millions of residents, depending on the region definition [5]. In our model, we work with a population of 1.26 millions, distributed on a territory of only 2,500 km^2 but deprived of lakes, forests, mountains and other non-residential areas. Every km^2 constitutes a place.

The effectively modeled amount of residents is 1,033,070, but these include only actors. Children, associated to parent households (whose average number is of 0.223 children per actor [18]) are "included" in these active residents. This means that they are not modeled as such, as they represent only a choice-factor of their parents' residential behavior rather than independent choice-makers.

[1] To say it with the words of Epstein and Axtel [7]: "you understand it if you can 'grow' it".

[2] Including the Swiss cantons Genève and Vaud, the Valais districts Monthey and Saint-Maurice, the Fribourg district Broye and the French departments Haute Savoie and Ain.

Considering the “dissolved” presence of these children, the model takes into account 1,263,444 human individuals.

To each place has been assigned a type (table 1), according to the theoretical urbanity gradient model of J. Lévy [16]. According to this model, adapted to empirical data of the Swiss Federal Census in consultation with J. Lévy, we have defined a) the total number of residents per urban type and b) an initial residential density of each type. The total number of places of each type has been deduced from these two definitions (table 1, last column). Fig. 1 shows the spatial distribution of these types, in the way it has been modeled in an ESRI.shp point layer. The initial social structure of each place, in terms of income-classes, has been defined in a similar manner. There are in all 162,653 high-income, 286,960 middle-high-income, 334,824 middle-low-income and 248,633 low-income individuals.

Table 1. Population distribution in the initial conditions. Letters A, B, C etc. identify different cities, with descending city ranks (*cf.* fig. 1).

Urban type	Sum of residents per type	Social structure by income class (high, mid.-high, mid.-low, low)	Residential density per km^2	Number of km^2 of this type
A Hypercentre	56000	20% , 40% , 20% , 20%	8000	7
A Center	150000	15% , 30% , 25% , 30%	10000	15
A High-income suburbs	100000	30% , 40% , 20% , 10%	2000	50
A Middle-income suburbs	100000	15% , 25% , 40% , 20%	4000	25
A Low-income suburbs	102000	5% , 15% , 40% , 40%	6000	17
A Periurban	100000	25% , 30% , 35% , 10%	500	200
B Hypercenter	21000	15% , 35% , 30% , 20%	3000	7
B Center	72000	10% , 30% , 35% , 25%	8000	9
B High-income suburbs	51000	25% , 40% , 25% , 10%	1500	34
B Middle-income suburbs	51000	10% , 20% , 45% , 25%	3000	17
B Low-income suburbs	52000	5% , 10% , 35% , 50%	4000	13
B Periurban	60000	20% , 35% , 35% , 10%	500	120
C Centre	12000	10% , 25% , 40% , 25%	6000	2
C Suburbs	24000	10% , 20% , 45% , 25%	2000	12
C Periurban	10000	15% , 25% , 40% , 20%	500	20
D City	12000	10% , 20% , 40% , 30%	4000	3
E Tourist station	10000	20% , 30% , 20% , 30%	2000	5
F Tourist station	5000	10% , 20% , 35% , 35%	1000	5
G Tourist station	1000	5% , 20% , 35% , 40%	1000	1
Hypo-urban	18000	5% , 15% , 35% , 45%	90	200
Infra-urban	26070	5% , 15% , 35% , 45%	15	1738
TOTAL	1033070	16% , 28% , 32% , 24%	NA	2500

While the social structure of places shall be of great importance in our model, we have also defined the following residential-choice-relevant attributes, depending on urban type and city rank (still with reference to the urbanity-gradients-model) [3]:

The **presence of non-residents**, which constitutes above all a limit to the number of residential places, the total number of residents and non-residents

[3] These attributes all remain constant throughout any simulation

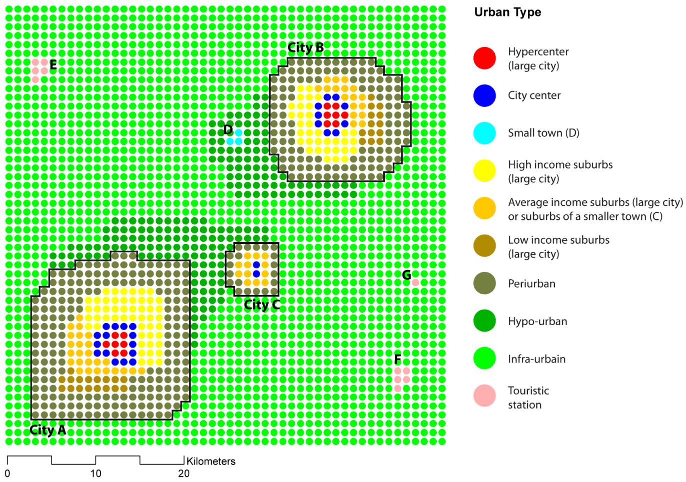

Fig. 1. Metropolitan space constructed with regard to table 1 (last column) and used as model base.

per place being limited to 20,000. There is a total of 59,155 non-residents in the system.

The **rent value** ($\in$ [1, 9]), which determines the financial affordability of places. (*This and the following attributes will be further explained below.*)

The **functional diversity** ($\in$ [1, 9]), which shows to which extent a place allows for other activities than residing. It raises its allophile-attractiveness.

The **car accessibility** ($\in$ [1, 5]), which raises its allophobe-attractiveness.

The **pedestrian accessibility** ($\in$ [1, 8]), which raises its allophile-attractiveness.

2.2 Allophiles, allophobes and ascending individuals: three types of actors

The residential mobility of our model is triggered by differences between place attributes but the actor-based character of our model resides in the fact that it also depends on a *perception* of these attributes by individual actors (and that this perception is totally orthogonal to social class or other structural agent-attributes). Three different perception/action-schemes have been defined. We have called the first two **allophile** and **allophobe**[4], differentiating individuals as to their positive or negative appreciation of an exposition to *otherness*. Allophile individuals seek such an exposition, while the allophobes try to avoid it. This ideal-typical differentiation has been defined on the basis of existing empirical works [16,17,11,23] and converges with the more recent analysis of Z. Bauman [1], in which the used terminology is *mixophile* and *mixophobe*.

[4] Both terms' construction is based on the Greek ἄλλος, the "other".

Table 2. Place attributes.

Type	Nb. of non-residents per km^2	Rent value	Functional diversity	Car accessibility	Pedestrian accessibility
A Hypercentre	12000	9	9	1	8
A Centre	5000	8	9	2	7
A High-income suburbs	1000	7	6	4	3
A Middle-income sub.	1000	6	6	4	3
A Low-income suburbs	1000	5	6	4	3
A Peri-urban	100	5	3	5	2
B Hypercentre	10000	8	8	2	6
B Centre	4000	7	8	3	5
B High-income suburbs	750	6	5	4	3
B Middle-income sub.	750	5	5	4	3
B High-income suburbs	750	4	5	4	3
B Peri-urban	100	4	3	5	2
C Center	3000	4	7	4	4
C Suburbs	500	3	4	5	3
C Peri-urban	100	3	3	5	2
D Ville	1000	5	5	5	3
E Station	10000	8	7	5	5
F Station	5000	6	4	5	3
G Station	3000	4	3	4	3
Hypo-urban	90	2	2	5	2
Infra-urban	15	1	1	4	1
TOTAL	59155	NA	NA	NA	NA

A third perception/action-scheme, which we call **ascending**, denotes individuals whose only criteria is a higher income average in the immediate residential environment.

2.3 Synthetic place attributes

While the ascending perception/action-scheme can be modeled by a simple comparison of income averages of places, the creation of more complex synthetic criteria is needed for the other two schemes. For this reason, we have defined two synthetic place attributes: an allophilie-score and an allophobe-score. The main aspects taken into account in these scores is place-density, -diversity, and -accessibility.

The density×diversity index (*D*) and the "basic otherness score" (*B*). The first synthetic aspect of a place we consider is its social density and diversity. Both imply exposure to otherness and we do not treat them separately but multiply them, as they reinforce each other (imagine a crowded room of unknown people in comparison with another room, containing only two).

For the **social diversity component** (d_1), we use the diversity indicator of Simpson [24][5], redefined by us so as to return 0 for minimal and 1 for maximal diversity: $d_1 = 1 - (\sum n_i(n_i - 1)/N(N-1))$.

[5] The advantage of Simpson's indicator in comparison with Shannon entropy (H'), more frequently used in diversity measurements, is that it can be directly interpreted as the probability that any two individuals chosen from a place have a different social class. It can thus be considered as an indicator of inter-income-class encounters in ratio to a total number of possible encounters [4]. Nevertheless, upon the testing of

The **density component** (d_2) of the density×diversity index is measured as a ratio of the counted population over maximum possible population (*i.e.*, 20,000 individuals)[6].

In a next calculation step, we combine the density×diversity index to functional diversity (F), obtaining a "*basic otherness score*": $B = (100D + F/9)/101$. As $\max(D) = 1$ and $\max(F) = 9$ (*cf.* table 2), B comprised between 0 and 1. D is weighted by 100 in this calculation with the aim of not giving too much weight to F. In effect, we have observed that, while potentially attaining 1, the values of the density×diverstiy index rarely rise about 0.01 in simulations, which can only be overcome by the 100 multiplicaiton factor.

Car and pedestrian accessibility as choice factors. While this fact might not seem obvious at first sight, mobility *modi* can be considered as an expression of allo-philia or -phobia. In effect, the main possibility offered by a car in a urban area is mobility without exposure to otherness [16] and car accessibility (A_c) can thus be considered as a positive place attribute in an allophobe p./a.-scheme. Pedestrian mobility, on the other hand, necessarily exposes its practitioner to otherness. Places with high pedestrian accessibility (A_p) thus have an advantage in the allophile scheme. As these urbanistically relevant (and politically modifiable) accessibility-attributes are the last two that we take into account in the actor dimension of our model, they can be directly incorporated into final allophile and allophobe place-scores:

$$allophileScore = (B + A_p/16)/1.5 \quad (1)$$

$$allophobeScore = ((1 - B) + A_c/10)/1.5 \quad (2)$$

As one can see, both A_p and A_c account for 1/3 in the final scores. In effect, as $\max(A_p) = 8$ and $\max(A_c) = 5$ (*cf.* table 2), division by 16 and 10 respectively gives both factors a weight of 0.5. B, on the other hand, has a factor of 1.0, as it "contains" both the social density×diversity index D and the functional diversity index F. The total is divided by 1.5, in order to obtain final scores comprised between 0 and 1.

Note that the allophobe score is not just the complementary of the allophile score, as accessibilities are treated separately. The reason for this is the non-symetricity of both factors. In effect, while it is important for an allophobe to access a place in a car, the pedestrian accessibility of the same place must not necessarily be perceived as a problem. Conversely, car accessibility of a place can add to, rather than deteriorate, its mixity, as long as pedestrian accessibility is preserved. It is thus not perceived as a negative factor by allophiles.

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other indicators (Shannon's H' and Gibbs/Martin [9]) we have obtained equivalent simulation results.

[6] Note that we can speak of density by counting each places' population, as all place surfaces are equivalent ($= 1km^2$).

2.4 Income-class: the agent-dimension of individuals

As we have mentioned in our introduction, taking into account the actor-dimension of individuals does not imply creating a model free of constraints to individual action. In our model, place accessibility has been limited by a financial factor, modeled by the consideration of diverse income classes.

As stated earlier, each individual is a member of a particular income-class: low income (1), middle-low income (2), middle-high income (3) and high income (4). Class-membership determines place-accessibility according to place rent value (R).

High-income individuals can access any place. Middle-high income individuals cannot access places with $R \geq 8$ (the hyper-center and the center of A, the hyper-center of B and the touristic station E). For middle-low income class members, the high-income suburbs of city A and the center of city B are added to the list of inaccessible places. For low income class members, finally, middle-income suburbs of A, high-income suburbs of B and the touristic station F also become inaccessible, as well as places with lower rent value but low pedestrian accessibility (≤ 2), as low-income individuals in our model do not possess a car.

There is an important thing to note, here, with regard to the initial state: at the beginning of each simulation, all social classes are represented in every urban type, despite the economic effect of exclusion explained here. This is made so in order to take into account residential latency effects, empirically observed, for example, when low-income tenants do not move for a sufficient period of time, in which average rent value of their neighborhood exceeds their financial means, without forcing them to leave, thanks to legal regulations on rent-increase-rates[7]. Place non-affordability thus only touches potential tenants. As we shall see, this effect leads to a certain fixity in the structure of the residential space, notably in simulations with a majority of ascending individuals (*cf.* 3.3).

2.5 Multipliers of place-rent-value: children and ownership

While individual's capacity to economically access specific types of places must be considered as an agent-attribute, we must also take into account actor-aspects that have impact on this capacity. Only in this manner can we understand situations in which individuals do not pick what could be considered their best option from one perspective, because of their consideration of other priorities. In the case of residential choice, among the most important of such self-chosen factors are the *wish to be the owner of one's accommodation* [11] and the *wish to have children*. Both factors raise the rent-value of places by lowering the spending power of individuals and are thus modeled as multipliers of this value.

The impact of children is modeled by the rent-value multiplier E. Its value is difficult to define, as both actual and "opportunity" costs of children [10] should be considered. Many factors, such as age, the number of siblings, family structure

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[7] Such regulations exist in the case of Switzerland, which is the empirical reference of this model.

(*e.g.* monoparental or not) or the price of schools [3] also influence the impact per child. Thus, various authors [3,6,8] give a per-child cost (C) varying btw. 15% and 50% of revenue. For our use, we have defined the following costs: 1 child $\rightarrow C = 25\%$; 2 children $\rightarrow C = 45\%$; 3 children $\rightarrow C = 60\%$. As only $100 - C\%$ of revenue is available for a parent, we can consider that rent-value is multiplied by a factor $E = 100\%/(100\% - C)$, *i.e.*, $E = 1$ with no child, $E = 1.33$ with one child, $E = 1.81$ with two children and $E = 2.5$ with three children.

The extra costs of ownership (multiplier P) have been estimated to be equal to the interests of a mortgage repayment over 20 years. With the average mortgage interest rate of Swiss banks of 3.25%, the ratio between *total costs* and *initial loan* can be calculated as $\frac{20 \cdot 0.0325}{1-(1+0.0325)^{-20}} = 1.38$. We thus have $P = 1$ for tenants and $P = 1.38$ for owners.

2.6 Model dynamics

Model simulation proceeds stepwise. With each step, a subset of 100 individuals is randomly chosen. A new residential place (β) is proposed to each. An individual i moves if all the following conditions are satisfied by both β and the individuals' current residential place (α):

- (i is allophile AND $allophileScore(\alpha) < allophileScore(\beta)$) OR ($i$ is allophobe AND $allophobeScore(\alpha) < allophobeScore(\beta)$) OR ($i$ is ascending AND $averageIncome(\alpha) < averageIncome(\beta)$).
- $E \cdot P \cdot rentValue(\beta)$ is smaller or equal to the *allowed price* for that income class: (high $\rightarrow \infty$; high-middle $\rightarrow 9$; low-middle $\rightarrow 8$; low $\rightarrow 7$).
- (the $incomeClass(i)$ is NOT "low") OR ($pedestrianAccessibility(\beta) > 2$).

2.7 Model parameters

Initial parameters. There are two sets of user-defined model parameters. The first set has to be defined before initialization and consists of three parameters:

The **dominant scheme** and the **degree of its domination**, which determines which of the three p./a.-schemes is most represented in the population. By default, 80% of individuals (independently of their location and income class) adopt the dominant scheme, while the other 20% adopt one of both remaining schemes. This degree of domination can be altered ($\in [33\%, 100\%]$).

The **proportion of owners** ($\in [0\%, 100\%]$).

The **modal number of children** ($\in [0, 3]$), which gives for 70% of individuals, the number of children they have. The other three numbers are each represented in 10% of the population.

Liveparameters. Live parameters can be modified during simulation and serve to model political interventions in the urban system. There are two such parameters:

A **subsidy to places** ($\in [0\%, 100\%]$), which reduces residential costs in targeted urban types. *E.g.*, if centers are subsidized to 30%, rent values of the center of A sinks to 5.6, that of B to 4.9 and that of C to 2.8. Even low-income individuals can thus reside in the centre of A, raising its social mixity.

A **subsidy to individuals** (true/false), which applies to child costs. It can reduce the E multiplier to 1, thus determining whether or not the fact of having children plays a role in the economical accessibility of residential places.

2.8 Graphical Output

The model has two gauges of model state: population distribution graphs, and a graphic output showing the spatial distribution of the population. We use colored circles to represent places (*cf.* fig. 1). The total size of a circle represents the total population (residents + non-residents). The outer circle represents the population of non-residents [fig. 2].

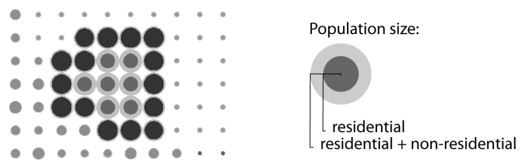

Fig. 2. Graphical output example. (The Repast/OpenMap GIS interface [22] that has been used for this model allows for scale variations.) Note: touching circles indicate that population maximum has been reached.

3 Results

The six parameters of our model allow for many combinations and are related in a complex manner. Upon numerous simulations of the model, though, we have been able to identify some major tendencies. What follows are simulation examples classified by the dominant perception/action-scheme.

3.1 Domination of allophiles

In the case of a dominance of allophiles, at first, one can observe a clear tendency to urban centralization. Depending on the degree of allophile domination, certain urban types, such as the infra-, hypo- and peri-urban, are totally abandoned, while central zones are occupied up to the maximum of their capacity, but also within the limits of their financial accessibility. Financial constraints, thus, play an important role in allophile-dominated urban societies.

A first example of this can be given with a 100% allophile simulation, a mode of 3 children per individual and 0% owners (figs. 3a and 4). During model simulation, at the 750$^{\text{th}}$ step, we activate the subsidy for children. The result shows a clear influence of this state-driven abolishment of the financial child-related constraint. From the moment of subsidy-activation, in effect, the peri- and hypo- urban places, as well as suburbs of small towns are emptied to the profit of centers and large-city-suburbs.

Following this "return to the city", made possible by the subsidy, more subtle dynamics take place. Population growth in middle-income suburbs, for example, declines, then inverts, due to a plurality of factors. Firstly, this decline is due to the new competition with centers and hypercentres, now accessible to a part of the population "condemned to suburbs" up to the point of subsidy activation. After the saturation of the center (approx. 2,400$^{\text{th}}$ step), nevertheless, this decline goes on, as high- and middle-income suburbs loose population to low-income suburbs, who, because of their better financial accessibility, show a greater social mixity, with equal functional diversity and pedestrian accessibility. We also note that, even within low-income suburbs, population concentrations occur, forming suburban centers (most clearly visible in city B).

Subsidy activation also triggers a revival of the small town D and of the tourist stations F and G, due to the fact that the small town and the G station, have rent values inferior to 6, coupled with good pedestrian accessibility ($\geq$ 2), thus being affordable by all social classes and, consequently, having a high social mixity. As to the F station, its comparable advantage with middle-income suburbs is to offer a five times higher population of non-residents, with equal rent value and pedestrian accessibility.

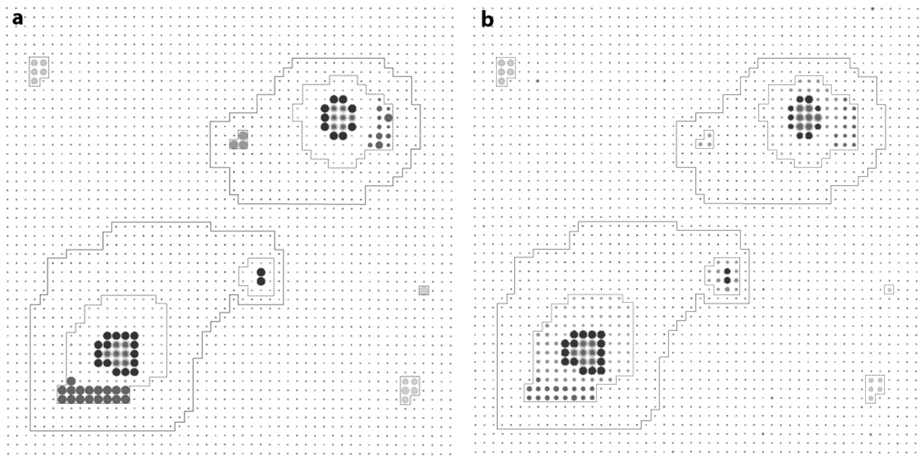

Fig. 3. a. 3700$^{\text{th}}$ step of a simulation with 100% allophiles, 70% individuals with 3 children and 0% owners. Children-subsidy active. **b**. 90% allophiles, 1 child per most individuals, 0% owners. Hyper-center subsidy at 60%. (In this B&W version, full lines mark the boundary of metropolitan regions, including hypo-urban. Dotted lines mark the boundaries of cities – including suburbs – and touristic stations.)

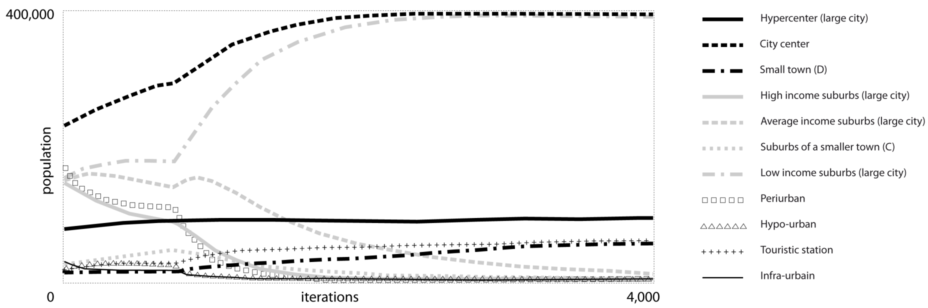

Fig. 4. 100% allophiles, 70% individuals with 3 children and 0% owners. Activation of the child-subsidy at the 750$^{\text{th}}$ step.

In a second simulation, we have brought the modal number of children down to 1 and the degree of domination of allophiles down to 90%. In these conditions, we have activated a 60% subsidy of the hyper-centers at the 400$^{\text{th}}$ step, (which implies that even low-income individuals with children can access them) (figs. 3b and 5). The first thing to observe, in comparison with the preceding simulation, is that a part of the population remains in the peri-, hypo- an infra-urban (Fig. 7). This phenomenon can be explained by the presence of 60,000 allophobes, who find "refuge" in these urban types, and of another 60,000 ascending individuals, which group in the peri-urban.

The effect of the activation of hyper-center subvention is less spectacular than that of children subsidy. The growth of this types' population accelerates slightly, though, up to the 3,000$^{\text{th}}$ step, where all hyper-centers are saturated. An auxiliary control simulation has shown that this growth takes place to the detriment of suburbs.

In the absence of other subsidies, financial accessibility dominates population distribution. Consequently, low-income suburbs do not show the best mixity in this second simulation, as low-income populations (2 children and more) are confined in them after the saturation of subsidized hyper-centers.

3.2 Domination of allophobes

To study the allophobe urban society, we consider a case with 100% dominance, 0% owners and a mode of 3 children (figs. 6 and 7).

At the very opposite of the allophile case, this configuration quickly leads to a homogenization of densities over all urban types, within the limits of financial affordability. What we observe is an "exocity" [25], as allophobes spread in the $340km^2$ of peri-urban space. At the 200$^{\text{th}}$ and 400$^{\text{th}}$ step, we have tried to deflect this tendency by activating first a 100% subsidy of hyper-centers and then a 100% subsidy for the centers. Both political measures, however, have an effect opposite to the aims of the political intervention: already "unpopular" in the allophobe p./a.-scheme, due to their high functional diversity, their weak

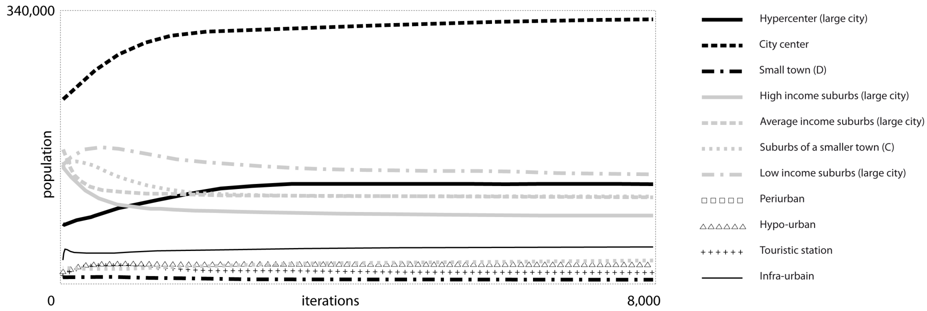

Fig. 5. 90% allophiles, child modus: 1, 0% owners. Hyper-center subsidy at 60% in the 400^{th} step (cf. fig. 3b).

car-accessibility and their large non-resident population, subsidies to centers and hyper-centers have only raised their potential mixity, thus lowering even further their attractiveness in the allophobe p./a.-scheme.

The only political intervention that did slightly deflect the city-flight tendency was child-subsidy. At its activation, it had for effect the rise of the periurban and the hypo-urban to the detriment of the infra-urban. Another effect was the movement of low-income individuals from middle- and low-income suburbs of larger cities (A and B) to the small town D and to the suburbs of C, whose advantage from the point of view of low-income allophobes is a low rent-value combined with low functional diversity, and good car-accessibility. Child-subsidy can thus trigger a return to more urban place-types, even in the allophobe case.

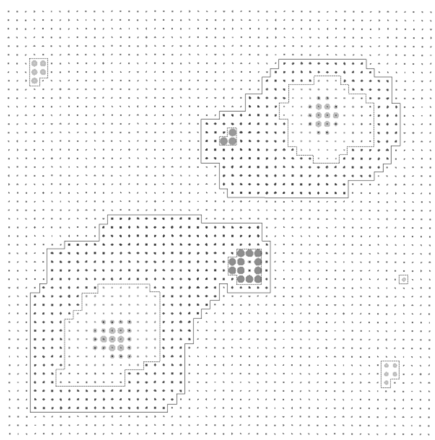

Fig. 6. 100% allophobes, 3 children (mode), 0% owners, 100% hyper-center and center subsidy, active child-subsidy.

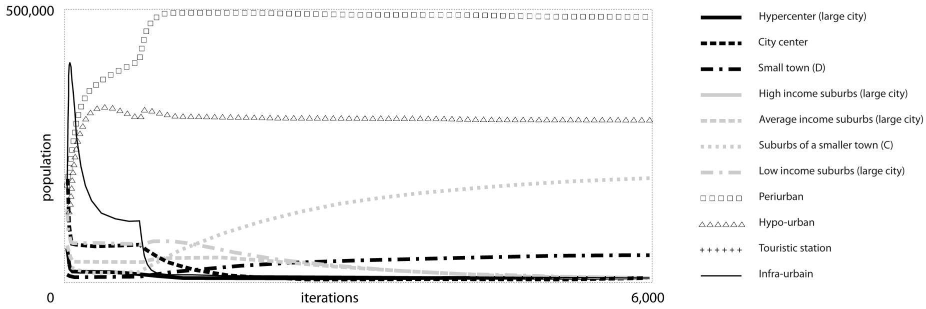

Fig. 7. 100% allophobes, 3 children (mode), 0% owners, 100% hyper-center subsidy activation at the 200th step and 100% centre subsidy activation at the 400th step, child-subsidy activation at the 750$^{\text{th}}$ step.

3.3 Domination of the ascending

The ascending case has been studied in two simulations with 100% domination, a mode of 0 children and either 0% or 70% owners (fig. 8).

In both cases, high-income suburbs have been revealed to be the most attractive urban type, concentrating all individuals that can afford it, the infra-urban being the second best choice. The latter unites a large proportion of population in the simulation with 70% of owners, case in which the desire to own one's accommodation supersedes the preference for high-income suburbs (who, with a rent value of 9.66 once multiplied by the P factor, can be accessed only by high-income individuals). Besides these observations, the 100% ascending simulation has also shown an interesting emerging phenomenon: the apparition of high-density zones in the infra-urban. We shall further study this effect in next model versions.

4 Conclusions and further considerations

What we have presented here is only a small part of simulations made possible by our model, whose results can be resumed to three main points:

1. We have succeeded in showing the link between individuals' perception/action-schemes and the production of urban space. Empirically founded schemes have been tested and we have been able to assess major divergences in resulting space-structures, in function of dominant schemes.

2. We have been able to show that, depending on the dominant p./a.-scheme of a urban society, public policies can yield highly divergent results. While public interventions can successfully reinforce existing tendencies (such as the allophile tendency to live in the more central places), they cannot deflect them. In some cases, such as the allophobe one, misconceived public policies, which would not take into account the actor-dimension of individuals, can yield results opposite to their aims.

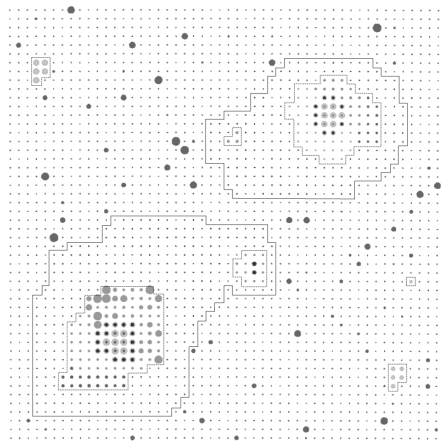

Fig. 8. 100% ascending, 70% owner, 0 children (mode), no intervention.

3. From the two preceding points, we conclude that sustainable urban planning cannot restrain itself to financial incentive policies but must also act on the level of individuals. It should strive for deflection of non-sustainable residential p./a.-schemes by the means of public information and by trying to work on those aspects of urban life which lead to the very construction of non-sustainable schemes, such as the allophobe one.

While our model's actual setting is a generic urban space, its use of an ESRI.shape data type for the initial settings allows for a fast implementation of concrete situations. In further work, we shall test such implementations. We also consider setting up the model in a public interface, so as to give individuals from the general public the possibility to test the global impacts of their action-schemes. This type of public interface could also be used to collect valuable data about the actual distribution of action schemes in today's population.

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