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The ASHA model: an alternative to the Markovian approach to housing vacancy chains.

An application to the study of population in Lille (Nord, France)

Jean-Pierre Lévy, CNRS/LATTS, France; Olivier Boisard, OB Conseil, France; Julien Salingue LATTS/CRESGE, France

Housing systems (understood here as the relations between variations in housing stocks and house moves) cannot be tackled without understanding the impact of the construction, destruction and conversion of dwellings on residential movements and population distributions. In order to reproduce these processes and evaluate their effects, we designed the ASHA^o (housing systems analysis) model, with the aim of analysing and measuring the impact of housing supply on population redistribution for a given scale and duration. The model simulates the processes linking residential mobilities, initiated either by a change in the housing stock (construction or destruction), or by a housing release that does not result in a dwelling becoming occupied in the study perimeter (e.g. departure of a household from the study area or death of a person living alone). The model takes into account the mobilities specific to each household category in terms, for example, of social position, age, size or the dwelling occupied. It provides information on trends in the population structures of the different housing types resulting from vacancies-reoccupancies.

The article will begin by describing (1) the model’s theoretical foundations (filtering process and housing vacancy chains) and (2) its design. After this, using the city of Lille (Nord, France) as our case study, we will develop (3) a data classification method that will allow comparative analysis through the ASHA model, and (4) the model will be used to understand the organization of Lille’s housing system, and finally (5) we will employ a number of examples to show how local managers can use this tool to better understand and anticipate the impact of their housing policy on urban population.

1. Theoretical framework: filtering process and housing vacancy chains

The model’s theoretical framework is based on the concept of the filtering process. This concept follows on from the urban ecology work of the Chicago school sociologists (Park, Burgess and McKenzie, 1925 ; Hoyt , 1939). Nonetheless, we have Larry.S.

Bourne (1981) to thank for a clear and succinct presentation of the concept of the filtering process. His proposal illustrates the fact that the process of renewal in occupancy of the housing stock relies on a series of interactions: relating to residential positions, relating to households flows and housing stocks, and finally relating to reciprocal residential moves. In this sense, residential settlement is a system that needs to be tackled as a whole and – going beyond the schema outlined by Bourne – to move towards a more interactive view of these dynamics.

This is not easy to do, because once we try to study population changes in terms of these processes, the usual indicators are no use. Original methods and indicators have to be employed in order to capture and interpret these combined dynamics. One of these is the housing vacancy chain method (Chase, 1991). This method entails tracking the chain of dwellings released/reallocated when a housing unit is released and not reoccupied, for example on the death of a person living alone or in the case of a new construction.

The empirical housing vacancy chain method was first applied in 1949 by Firestone (1951) within five Canadian conurbations, including Montréal and Ottawa. Subsequently, up to the 1990s, there were around 20 studies of this type, mostly conducted in Canada, the US and England. They were introduced late in France, in the 1980s, and gave rise to a dozen or so applications. The fact is that the empirical method of tracing chains back through interviews is a long and costly process, which is difficult to accomplish. Because of these problems, in 1971 H.C White proposed a simulation method for reconstructing these movements by means of Markov chains. This approach gradually replaced empirical methods, and today is becoming widespread (Emmi and Magnusson 1988 and 1994; Magnusson Turner, 2008; Ferrari, 2011).

However, it is not certain that Markov chain models are the best way to study the relations between the housing stock and residential mobility: (i) morphologically identical dwellings may be occupied by households that have neither the same characteristics nor the same mobility behaviours; (ii) the models are not good at accounting for the sociodemographic characteristics of households, whether mobile or not; (iii) they are based *only* on mobile households, ignoring stable households, and do

not take account of changes in the occupants of housing types resulting from home moves; (iiii) residential rationale influences the types of housing chosen by households throughout their residential pathways. As a result, the three Markovian criteria (homogeneity, stability, independence of the rankings in the chain) are far from verified, which raises doubts about whether the results of these models are robust (Author forthcoming).

For their part, the empirical studies on housing vacancy chains carried out over more than 40 years highlight the fact that housing vacancy chains constitute a set of relatively impermeable mobility states, which reproduce in their broad lines the hierarchies of society as a whole (Forrest and Murrie, 1994; Soullignac, 1995; Author forthcoming). The result is that a chain started by wealthy households will have little chance of culminating, at the end of the chain, in occupancy by a working-class or ethnic minority household (Sharpe, 1978).

A global approach must therefore be taken to measuring the impact of housing supply on the redistribution of urban populations, an approach that is not confined to the study of mobile households and which takes into account the characteristics of the housing stock, of mobile households, of stable households, and of chain effects.

2. Presentation of the ASHA model

Following on from – but profoundly reworking – a model produced in the late 1980s (Author forthcoming), the ASHA model employs its concepts in an approach based on a “stock-flow” matrix.

The stock-flow matrix

For the model as a whole, the stock-flow dynamic can be expressed in the form of a matrix: let $M(t)$ be the matrix of numbers (stocks) $M_{ji}(t)$ at a moment t of the simulation, and $\Delta M(t)$ the matrix of variation of those numbers $\Delta M_{ji}(t)$ during the period Δt ,

$$M(t) = \begin{bmatrix} M_{11}(t) & \dots & M_{1i}(t) & \dots & M_{1p}(t) \\ \dots & & & & \\ M_{ji}(t) & & M_{ji}(t) & & \\ \dots & & & & \\ M_{ni}(t) & \dots & M_{ni}(t) & \dots & M_{np}(t) \end{bmatrix},$$

$$\text{and: } M(t + \Delta t) = M(t) + \Delta M(t).$$

The matrix $\Delta M(t)$ describes the dynamics of the model. Its values are deduced:

- from the state of the stocks $M(t)$ at moment t ,
- from incoming flows from outside the stock, evaluated during the observation period,
- from the rotation rates – internal and external – also deduced from the observation data.

The model does not rely on a probability of moving based on a rate calculated using mobile households alone, but on the localised rate of rotation (the ratio between movers and occupants for a type of housing), which makes it possible to assign a differential mobility rate to households on the basis of their sociodemographic characteristics and the destination of their move.

Definitions and rotation rate:

The model is made up of n types of housing Seg_j , ($j = 1, 2, \dots, n$). For each type of housing Seg_j , the *total rotation rate* r_{ji} of a household group G_{ji} is defined by:

$$r_{ji} = \frac{S_{ji}}{M_{ji}}$$

where S_{ji} is the total number of exits from the household group G_{ji} during the elementary time step Δt , and M_{ji} is the total number of households in housing type Seg_j

With the ASHA model, the housing stock can be segmented into sets of units – occupied or not – characterised by their *socio-residential* status, within which the resident population is itself subdivided into *household groupings* defined by their social profiles. The model simulates the changes in these “stocks” by evaluating, through iterations on elementary time steps, the “flows” corresponding to household moves, both internal (exchanges between segments, and in terms of the different household groupings) and external (system entries/exits):

- Each *household grouping*, within a *housing type*, receives households coming from outside the system within a given time step.
- At the same time, households are mobile within the system, either from or to other types of housing. These internal flows are evaluated, for each group of households, by applying *internal rotation rates* (assumed to be constant) to the number of households in the groupings. These flows are variable, since they are indexed on the numbers of households at a given moment in the simulation.
- Finally, households can exit the system, and these flows are calculated in the same way by applying *external rotation rates* (assumed to be constant) to the “stocks” of household groupings.

The initial stocks, as well as the internal and external rotation rates, are deduced from the information collected by survey during an observation period. In this sense, as it currently stands, ASHA should not be considered a predictive model. Its purpose is primarily to reveal – by amplifying them through simulations – the structural tendencies of the system at the time of the observation.

Two types of simulation are proposed:

- *non-conditional simulations*: these do not take into account the number of free housing units in each segment of the housing stock, which is assumed to be unlimited. This is a first approach, where the dynamics of the model are developed without constraint.
- *conditional simulations*: these take into account the *saturation rates* of the housing types, deduced from the numbers of households and housing units available. The latter can vary over time and the user can introduce constructions and destructions at set points in the simulation. The model adjusts the flows depending on the occupancy saturation rates. It shows the change in occupancy of the housing types following variations in the housing stocks, distinguishing between global occupancy and internal and external entry rates. By comparing with a simulation where there is no housing variation, it also calculates the length of the vacancy chains initiated by the housing variations introduced by the user. This calculation therefore differs significantly from Markovian approaches, in that it gives the global lengths of the chain for each of the segments, without taking into account the ranking in which the housing release is located. More specifically, ASHA calculates a rate that assesses the number of households living in each segment of the system, as a result of the constructions introduced into the model, including in segments where destructions or constructions take place.

Conditional simulation

Conditional simulations introduce the numbers of units L_j in each segment Seg_j . The number of unoccupied units $d_j(t)$ at moment t in this segment is:

$$\begin{aligned}d_j(t) &= L_j - M_j(t) \\ &= L_j - \sum_{i=1}^p M_{ji}(t)\end{aligned}$$

The saturation rate $sat_j(t)$ of segment Seg_j on day t is defined by: $sat_j(t) = \frac{d_j(t)}{L_j}$

If $sat_j(t)$ is less than or equal to 0, this segment has reached or gone beyond its saturation threshold (number of households higher than the number of dwellings). Conversely, if $sat_j(t)$ is positive, the segment contains free dwellings.

Over a simulation cycle, from day t to day $t+\Delta t$, the following principle is applied. It contains two phases of calculation: a "preliminary calculation" which makes an initial estimate of the flows and identifies the segments where the saturation threshold has been crossed; in the second phase, the flows are redistributed in order to prevent saturations.

3 The socio-residential system: application to the city of Lille (Nord, France)

This model was used to analyse the housing system in Lille, the biggest city in northern France. With a population of almost 228,000, it is at the heart of France's fourth-largest conurbation (1.2 million inhabitants). Lille is well suited to an empirical study that will demonstrate the usefulness of ASHA. Since the 1990s, a large-scale policy of urban renovation has been underway, notably in the central part of the city, in parallel with the development of a university cluster. This habitat transformation has caused a significant movement of population and gentrification, leading to the departure of the most precarious residents, who have been replaced in the old central districts by a young middle-class population or students.

However, other studies we have conducted over the last decade or so (Author forthcoming) show that it is difficult to run a study of housing occupancy by looking solely at the morphological characteristics of apartment buildings. This observation requires us to reconsider the traditional categories of habitat, taking more account of the forms of occupancy that characterise them, and notably the links between the morphological characteristics of the habitat and the social morphology of the residents in different spatial contexts. To do this, we used a method that has been extensively described elsewhere, which associates household types with housing types, where the housing types express distributions of social groups and the household types express the dominant forms of occupancy. With regard to the city of Lille, we used the 2006

General Population Census, the most recent comprehensive database available, to construct these types.

By way of reminder, the method entails three steps. First, 72 housing types were defined to characterise the local housing stock. These types were based on a combination of the construction dates of buildings (pre-1948, 1949 to 1974, 1975 and later), building types (individual or collective), unit size (1 or 2 rooms, 3 or 4 rooms, 5 rooms and above), legal status of occupancy (private ownership, private rental, social rental and equivalent, free of charge). We set a threshold of 300 housing units present in the unweighted database for a unit to constitute a type. Groupings were then applied, based on a tree structure, with the result that only 34 housing types remained (Table 2).

At the next step, we used two indicators to form the housing types. The first identifies social specialisations in the occupancy of the 34 housing types (social index). It relates the proportion of reference individuals who, in their working life, exercise or have exercised (retired) a higher profession (tradespeople and shopkeepers, executives, self-employed professionals and higher intellectual professions) or mid-level profession, to the proportion of unskilled and clerical workers.¹ Finally, the housing type indices were related to the value of the Lille index on the date of the survey.

The second indicator is an precariousness index. It relates the proportion of reference individuals in occupancy who exercise or who have exercised a higher profession to the population of unemployed people and/or foreigners.² As with the previous indicator, it was related to the value of the city's index on the date of the survey.

¹ In order to limit the sample to populations with an urban way of life, farm owners, agricultural workers (in both cases retired or working) and tenant farmers were excluded.

² The two indices will not be used independently, but in a complementary fashion. The calculation of the precariousness index is based on the observation, made recurrently in previous studies (Author forthcoming), of an opposition between dwellings occupied by people in mid-level and higher professions, and those occupied by the unemployed, foreigners and unskilled workers. Other studies have also shown the existence of dwellings occupied by unskilled and clerical workers, which are highly prohibitive to foreign households and those in which the reference individual is unemployed (Author forthcoming). Neither the social position index nor the precariousness index could identify the latter, who only showed up when they were cross-referenced. We could have simply used the proportion of foreigners or unemployed people to complete the social position index, but in this case, the two indicators would have had incompatible values. That is why we created a link between the two calculations,

Finally, by combining these two indices we can define five types of habitat (Table 1).

		Social index		
		< 0.8	[0.8-1.2]	> 1.2
Precariousness index	< 0.8	Open working-class habitat	Mixed habitat	Open superior habitat
	[0.8-1.2]	Filtering working-class habitat		Closed superior habitat
	> 1.2			

Table 1. Method of constructing the five categories of habitat

- *Open working-class habitat* attracts working-class households and precarious households, but is rejected by higher social categories.
- *Filtering working-class habitat* is unattractive to higher social categories, attracts working-class households and excludes precarious households.
- *Mixed habitat* attracts all social categories.
- *Open superior habitat* is occupied by households belonging to the higher social categories, but also precarious households, while still excluding working-class households.
- *Closed superior habitat* is occupied by higher social categories and filters out working-class and precarious households.

including a social position index in the precariousness index (the higher professions), and of course being aware that part of the two indices measures the same effects, but their cross-referencing significantly refines our understanding of the forms of occupancy measured by one index or the other.

Habitat type	Housing type	Inprecariousness index	Social index	Inprecariousness index	Social index
Closed Working-Class Habitat	Tenant low-rent Collective 1 to 2 rooms built before 75	0,2	0,3	0,3	0,3
	Tenant low-rent Collective 1 to 2 rooms built 75 - 89	0,4	0,5		
	Tenant low-rent Collective 3 to 4 rooms built before 75	0,2	0,2		
	Tenant low-rent Collective 3 to 4 rooms built 75 - 89	0,4	0,4		
	Tenant low-rent Collective 3 to 4 rooms built after 1990	0,8	0,7		
	Tenant low-rent Collective 5 rooms or more built after 75	0,3	0,3		
	Tenant low-rent Collective 5 rooms or more built before 75	0,1	0,2		
	Tenant low-rent Individual built before 75	0,3	0,2		
	Tenant low-rent Individual built after 75	0,4	0,2		
	Private tenant Individual 1 to 2 rooms	0,2	0,5		
working-class filtering habitat	Private tenant Individual 3 to 4 rooms	0,6	0,6	1,3	0,7
	Private tenant Individual 5 rooms or more	0,9	0,7		
Mixed habitat	Private owner Individual 5 rooms or more built before 1975	1,9	0,7	1,1	1,1
	Tenant low-rent Collective 1 to 2 rooms built after 1990	1,1	0,8		
	Private Collective tenant of 1 to 2 rooms built before 1975	0,7	1,1		
	Individual free accommodation	6,7	0,9		
	Owner Individual, 5 rooms or more built before 1975	2,6	1,2		
	Owner Individual, 5 rooms or more built before 1975 - 1989	2,5	1,0		
Closed superior habitat	Owner Individual, less than 5 rooms built after 1975	2,5	1,2	2,1	2,3
	Private tenant Collective, 1-2 rooms built 1975 - 1989	1,5	2,0		
	Private tenant Collective, 1-2 rooms built after 1990	1,4	2,3		
	Private tenant Collective, 3 rooms or more built before 75	1,2	1,5		
	Private tenant Collective, 3 rooms or more built 75 - 89	1,6	1,5		
	Private tenant Collective, 3 rooms or more built after 1990	2,3	3,4		
	Free Collective accommodation, 1 to 2 rooms	1,6	2,2		
	Free Collective accommodation, 3 rooms or more	1,9	1,4		
	Owner Collective, 1 – 2 rooms built before 75	3,4	2,9		
	Owner Collective, 1 – 2 rooms built 75 - 89	4,1	2,4		
	Owner Collective, 1 – 2 rooms built after 1990	5,3	2,7		
	Owner Collective, 3 – 4 rooms built before 75	7,0	2,6		
	Owner Collective, 3 – 4 rooms built 75 -90	9,1	3,0		
	Owner Collective, 3 – 4 rooms built after 90	8,5	3,8		
	Owner Collective, 5 rooms or more built after 1990	7,5	5,8		
Owner individual, 5 rooms or more built after 1990	3,6	2,2			

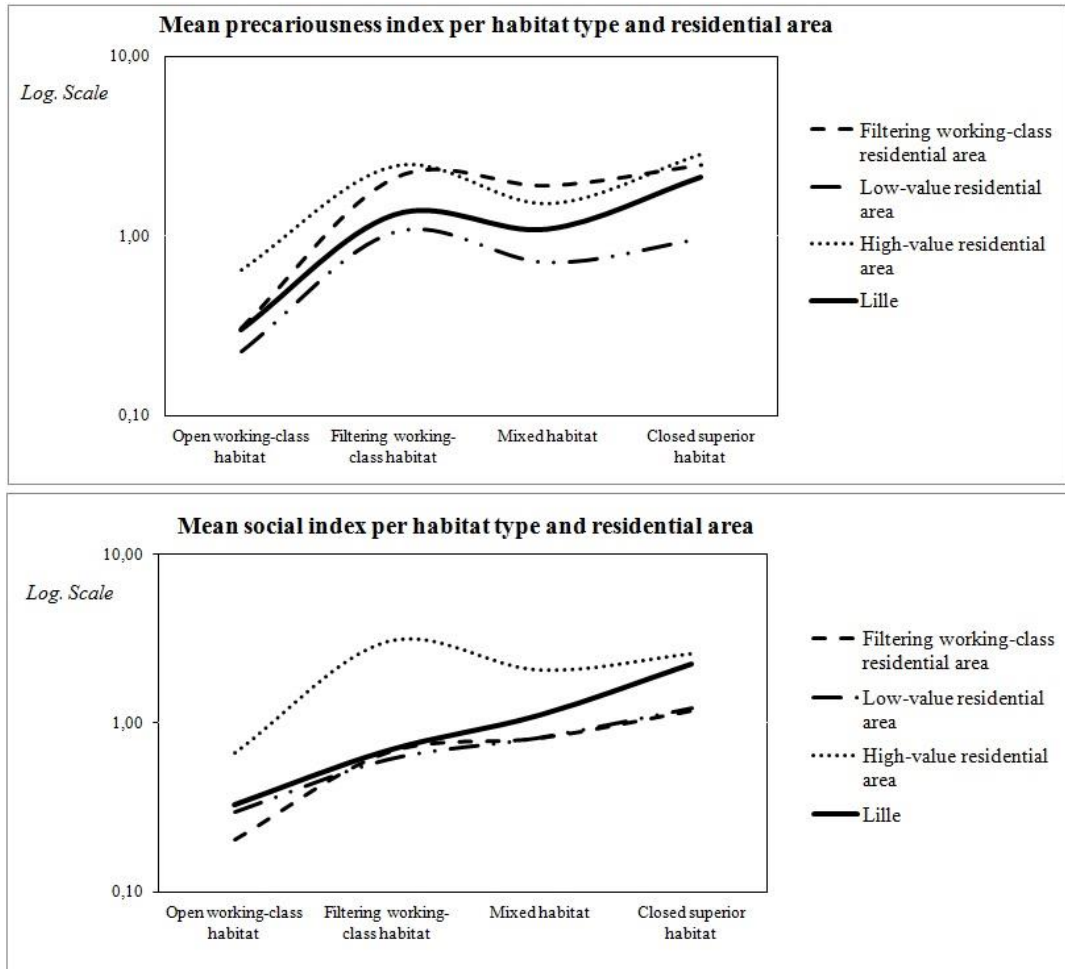
Table 2: housing types, indices and habitat types in Lille

What is particular about Lille’s housing stock is that (unlike other French sites) it contains no open superior habitat. Open working-class habitat and closed superior habitat each account for 35% of the housing stock, mixed habitat 23% and filtering working-class habitat 7%.

Using these types, we can build a map of the districts based on “habitat zones”: superior, mixed, working-class. These zones are defined according to the proportion of each type of habitat in the districts of Lille. To obtain this definition, we group the districts by ascending hierarchical order on the basis of the combination (in proportion) of the 5 types of habitat (Map 1).

We can then use the spatial variations in the values of the precariousness and social indices to divide the districts into “residential areas”, in order to identify the social markers that influence the housing occupancy characteristics one way or another. In order to form the residential areas, we recalculate the two habitat type indices for every

district in Lille. Next, we group them into three categories in ascending hierarchical order using the combinations of the index values (Figure 1).



Sources: RGP 2006 IRIS – Accord CASD

Figures 1: Lille’s residential areas

Finally, by comparing the habitat zones and residential areas, we can measure the differences between the expected forms of occupancy of the habitat types,³ and the

³ For which location in a working-class area would promote the presence of precarious or working-class households, and location in a superior area would promote occupancy of the entire housing stock in the district.

actual occupancies in a given district.⁴ On the assumption that the occupancy of the types of habitat in each of the districts is influenced by the composition of the housing stock, by comparing the residential area with the habitat zone to which the district belongs, we can identify three types of local effect (defined as social markers that do not relate to the structure of the district's housing stock) (Figure 2):

- positive effects corresponding to types of habitat situated in districts where occupancy (residential area) is valued more highly than would be suggested by the composition of the housing stock (habitat zone);
- negative effects corresponding to types of habitat situated in districts where occupancy (residential area) is valued less highly than would be suggested by the composition of the housing stock (habitat zone);
- neutral local effects corresponding to types of habitat situated in districts where occupancy (residential area) is consonant with the composition of the housing stock (habitat zone).

4. Use of the ASHA model: understanding the organization of Lille's housing system

By contrast with the previous studies, the use of the ASHA model now allows to answer important questions raised by this global process. One question relates to the fact is that Lille contains districts where old housing continues to be occupied by working-class and precarious households (superior habitat zones with a negative local effect). Does this signify that gentrification in these districts is blocked, or that it is gradually underway? These questions should be answered through observation of residential mobility between the fractions of the Lille housing stock simulated by the ASHA model.

⁴ Defined by a district's membership of a residential area.

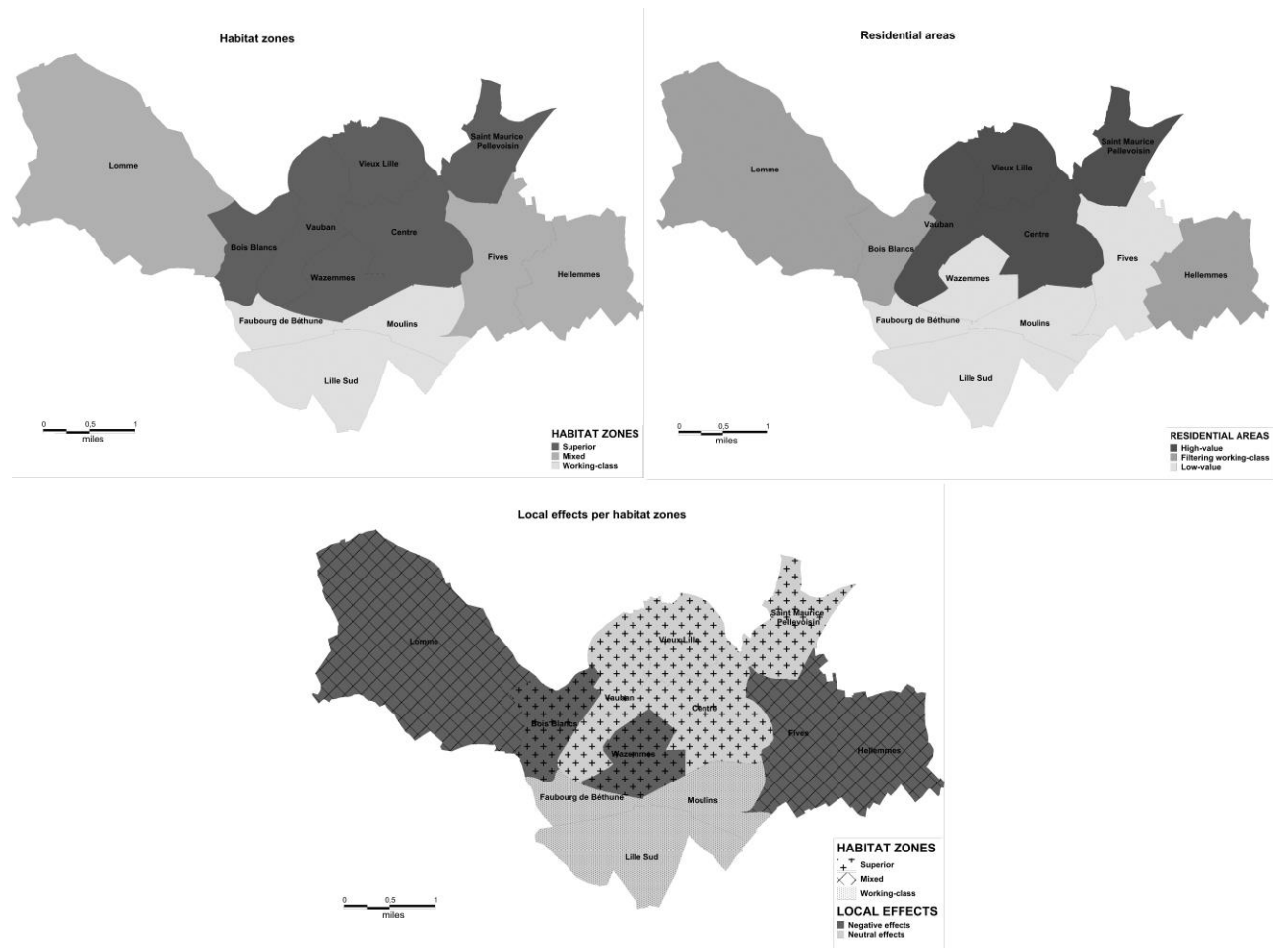


Figure 2. Habitat zones, residential areas and local effects per habitat zones.

Source: RGP 2006 IRIS – Agreement CASD.

4.1. Sources

The 2006 General Population Census gives us information, for each home, on the number and characteristics of the incoming households originating outside the city, young people leaving the parental home and households originating from another home in Lille. By cross-referencing with the dwelling occupancy characteristics provided by the 2002 General Population Census, we can deduce the number and characteristics of households that have left a dwelling to move outside Lille.

However, we have no data that tells us the dwelling type and district of origin of households coming from another residence in Lille. To make up for this lack, in 2010 we conducted a survey with 1100 households which had moved home within the city in the four years preceding the survey, in order to find out the origins and destinations – together with the sociodemographic characteristics – of households (excluding young people leaving the parental home) that had changed residence within the city. In consequence, from the perspective of people moving into a dwelling from another residence in the city:

- the census tells us:
 - the number of households entering a particular type of habitat,
 - the characteristics of newly constituted households originating in Lille (which therefore release no housing in the city),
 - the characteristics of already constituted households that released a dwelling in Lille.
- As for the survey, it enables us to specify the original habitat type of these households, including their number and characteristics (data provided by the census).

On the basis of this information, the ASHA model provides a graphic representation of Lille's habitat system, reconstructing internal and external entries (those which do not release homes in the city, including newly constituted households). In this case, we employ a 12 type classification combining the 4 types of habitat and the 3 residential areas (Table 3).

12 habitat types/residential areas

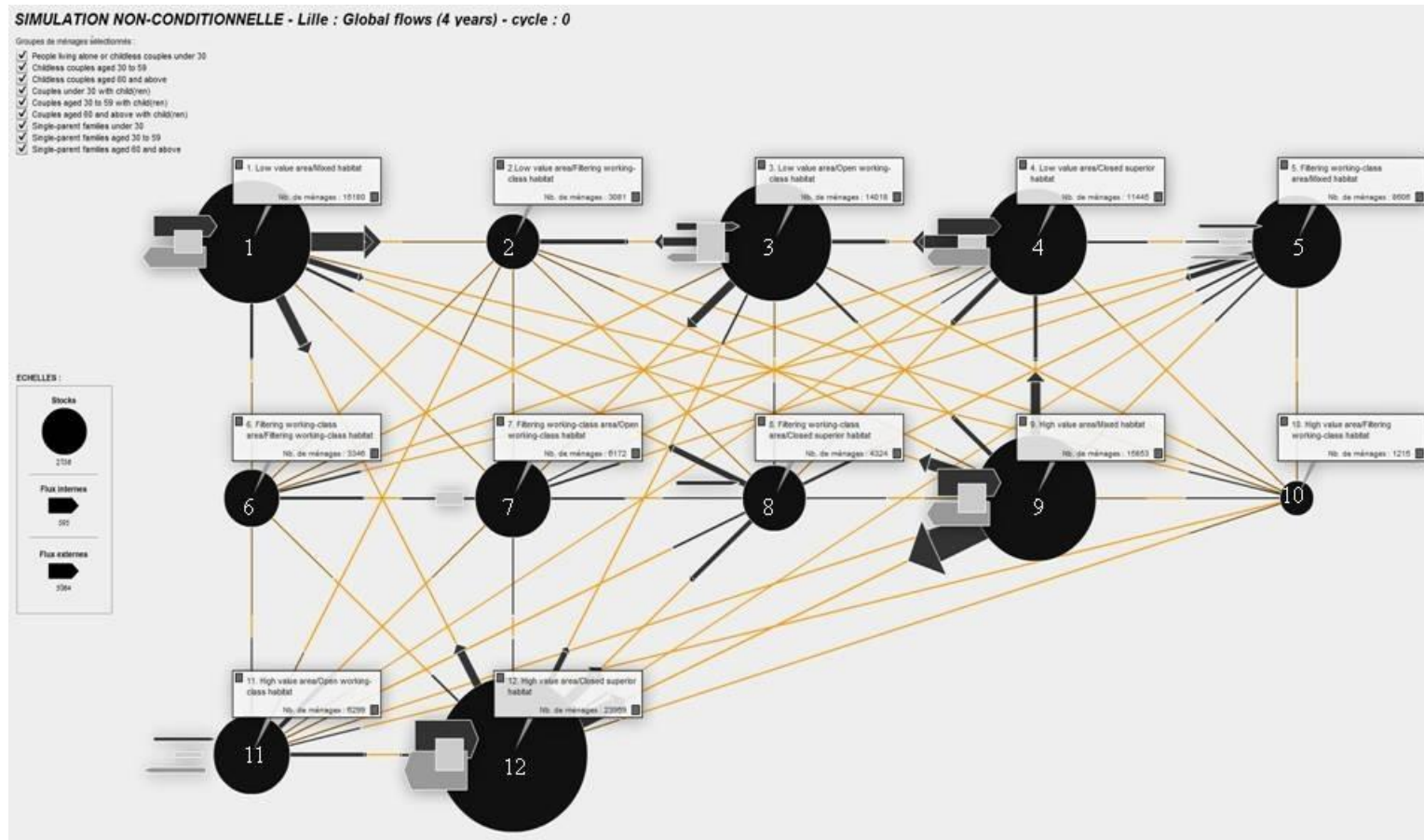
- 1 Low value area/Mixed habitat
- 2 Low value area/Filtering working-class habitat
- 3 Low value area/Open working-class habitat
- 4 Low value area/Closed superior habitat
- 5 Filtering working-class area/Mixed habitat
- 6 Filtering working-class area/Filtering working-class habitat
- 7 Filtering working-class area/Open working-class habitat
- 8 Filtering working-class area/Closed superior habitat
- 9 High value area/Mixed habitat
- 10 High value area/Filtering working-class habitat
- 11 High value area/Open working-class habitat
- 12 High value area/Closed superior habitat

Number of internal links: 144

Table 3

These mobilities are presented in Figure 2 over four years. This figure shows the external entries and exits, the internal circulations within each habitat type and the 144 switches between habitat types.

The reconstruction of these movements reveals a complex picture, which is hard to interpret. To understand the organization better we need to determine the function of each of the habitat types in the local system and also measure the impact of internal and external movements in each of the residential areas and each of the habitat types.



Source: ASHA.

Figure 2 Lille's housing system according to the ASHA model (four years' mobilities)

Note: The circles correspond to the housing stocks in the habitat types and are proportional to their number. The arrows going out from the circles correspond to moves between habitat types in the local system. The arrows that are not linked to the other habitat types correspond to the entries (arrows pointing to the type) or the exits (arrows pointing away from the type) originating from or heading to the exterior of the system, including entries by young people leaving the parental home which do not release housing. The rectangles associated with the types correspond to circular mobilities (moves within the habitat types).

	Length of chains	Mobility rate in the habitat type
1. Low value area/Mixed habitat	1,73	0,77
2. Low value area/Filtering working-class habitat	1,56	0,63
3. Low value area/Open working-class habitat	2,06	0,73
4. Low value area/Closed superior habitat	1,67	0,77
5. Filtering working-class area/Mixed habitat	1,55	0,74
6. Filtering working-class area/Filtering working-class habitat	1,38	0,70
7. Filtering working-class area/Open working-class habitat	1,75	0,77
8. Filtering working-class area/Closed superior habitat	1,58	0,78
9. High value area/Mixed habitat	1,61	0,89
10. High value area/Filtering working-class habitat	1,29	0,72
11. High value area/Open working-class habitat	1,91	0,64
12. High value area/Closed superior habitat	1,61	0,79

Source: ASHA model

Note: An increase of 1000 units (over 2 cycles) in mixed habitat in the low value area can house 1730 households (1.73×1000). 70% of these households enter mixed habitat in the low value area (moves into the same housing category).

Table 4: Lengths of housing vacancy chains resulting from an increase of 1000 dwellings over two years.

The calculation of the chain effects (Table 4) produced by these constructions reveals lengths varying between 1.3 (high value area/filtering working-class habitat) and 2.1 (low value area/open working-class habitat). The amplitude of the lengths varies according to the intensity of the internal polarisations of each habitat type (which continue the spread of releases-reoccupancies in the city), and the attraction they represent for young people leaving the parental home and households from other localities (external arrivals which stop the spread of the chains). However, these simulations above all reveal one important piece of information: the intensity of mobilities within a single type of habitat. The rates of moves into the same category of newly built housing (circular mobilities) vary from 63% to 89%.

Circular mobilities would seem to be structural to habitat systems, in that they confirm the findings of recent French studies (Author forthcoming) as well as older North American studies (Caplow, 1948), which show that the majority of individuals move between areas with the same social status. In other words, the releases-reallocations resulting from constructions spread first within the habitat type in which a housing supply is created, then propagate to the other parts of the housing stock. This observation confirms the high level of compartmentalisation between residential states, also identified in the dynamics of Lille's local habitat system. In order to better understand the function of each of the localised habitat types in the structure of the local residential system, it is therefore useful to analyse the spread of chain effects, leaving out the impact of constructions on circular mobilities (Table 5).

If we ignore circular mobilities (moves into the same housing category), we observe (Table 5) that the chain effects caused by constructions in each of the habitat types primarily affect mixed habitat and superior closed habitat in high-value and low-value residential areas. On average, these types of habitat attract 12% to 18% of new entries caused by the production of dwellings in other sectors of the housing stock. This means, firstly, that their occupants are attracted by the supply of dwellings generated in the other habitat types; and secondly that, by moving, they release homes which will be reoccupied by households from outside the city (on average they receive between 13% and 23% of external entries attributable to housing construction), but also by households which leave the other types of habitat in Lille (on average they attract between 11% and 17% of internal entries attributable to housing constructions). In other words, in the organization of Lille's habitat system, these types of localised habitat have a role in attracting newcomers to the city and some of their occupants will extend their residential trajectory in Lille.

%	Mean of total entries	Mean of external entries	Mean of internal entries
1. Low value area/Mixed habitat	17,7	18,2	16,9
2. Low value area/Filtering working-class habitat	<i>1,0</i>	<i>0,7</i>	<i>1,6</i>
3. Low value area/Open working-class habitat	9,0	6,0	14,3
4. Low value area/Closed superior habitat	12,1	13,0	10,8
5. Filtering working-class area/Mixed habitat	4,6	4,3	5,3
6. Filtering working-class area/Filtering working-class habitat	2,2	<i>1,9</i>	<i>2,7</i>
7. Filtering working-class area/Open working-class habitat	5,4	3,7	8,3
8. Filtering working-class area/Closed superior habitat	6,8	7,3	5,9
9. High value area/Mixed habitat	20,0	23,4	13,7
10. High value area/Filtering working-class habitat	<i>0,8</i>	<i>0,8</i>	<i>0,8</i>
11. High value area/Open working-class habitat	6,1	4,9	8,4
12. High value area/Closed superior habitat	14,3	15,8	11,5

Sources: ASHA model.

Note: When the other habitat types are increased by 1000 dwellings (over 2 cycles), the mixed habitat in low-value areas receives on average (in percentage) 16.9% of total internal incoming moves caused by constructions (excluding moves into the same housing category).

Table 5: Average distribution (in percentage) of incoming moves (excluding moves into the same housing category) caused by an increase of 1000 dwellings (2 years) in each of the habitat types.

However, they also enable the occupants of the other habitat types to move home within the city. In this sense, they simultaneously play a reception and pivotal role within the local system. Figure 3 allows us to see these functions clearly. It also provides an additional piece of information, that the pivotal role essentially operates between these 4 habitat types and their links with the rest of the housing stock are fewer.

Outside these four types, the table reveals a smaller – but real – degree of sensitivity in open working-class habitat in low-value areas (on average 9% of all the entries attributable to constructions). This time, the increase in housing supply essentially impacts on internal entries (14%), with little impact on external entries (6%). Situated in a pivotal position in the system, this habitat plays an interface role between reception

habitat types and the others. In other words, constructions lead to exits (internal or external) which will be replaced by households coming from reception habitats. Here again, Figure 3 provides a clear view of this role as pivotal habitat in the local system.

As for the other seven habitat types (habitat types situated in filtering working-class areas or filtering working-class habitat in other residential areas), they are little affected by variations in the housing stock in the other habitat types (they receive between 0.8% and 6.8% of entries caused by constructions). They appear to be not much integrated into the local system and function endogenously (circular mobilities), being renewed by a low level of external input. This function also appears very clearly in Figure 3.

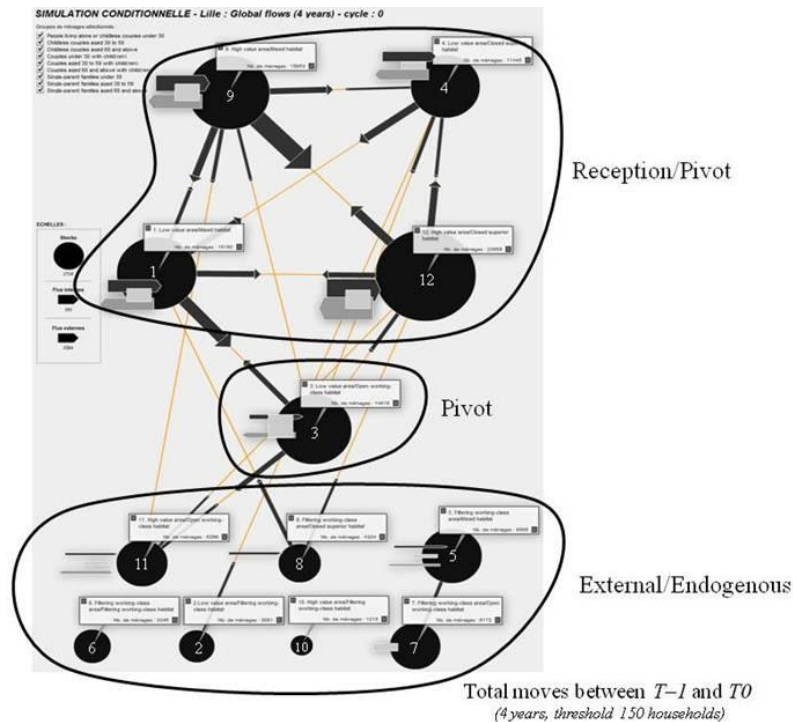


Figure 3

Source: ASHA

Explanation: The circles correspond to the housing stocks in the habitat types and are proportional to their number. The arrows going out from the circles correspond to moves between habitat types in the local system. The arrows that are not linked to the other habitat types correspond to the entries (arrows pointing to the type) or the exits (arrows pointing away from the type) originating from or heading to the exterior of the system, including including entries by young people leaving the parental home which do not release housing. The rectangles associated with the types correspond to circular mobilities (moves within the habitat types).

5. Changes in the habitat system.

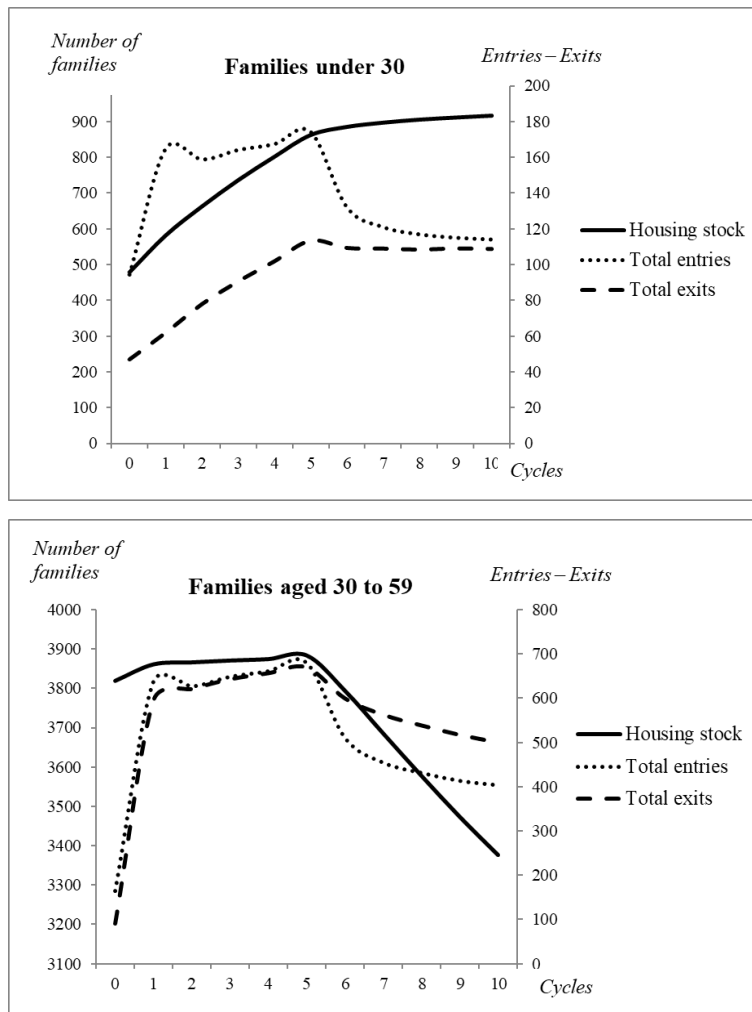
Knowing the organization of the local system, we are in a better position to understand the results of the simulations carried out with the ASHA model. Beyond knowledge of the system, these simulations are intended to help the local actors to anticipate possible blockages in the system and the impact of their housing policy. From this point of view, two important questions arose during the analysis of Lille's socio-residential system: the first concerns the small number of families in the local population, the second relates to the spread of gentrification in two of the city's districts.

5.1. Attracting families?

The analysis of the population of Lille's local system revealed a structure of residential flows that does not keep families in the city. Would it be possible to devise a homebuilding policy that would persuade families to live in the city? In trying to answer this question, we focus not on habitat types, but on a typology that is more consonant with the rationales behind the actions of local actors. A close analysis of the local system shows that social housing apartments with more than 3 rooms attract families. To what extent would the building of such apartments contribute to attracting them and keeping them in the city? While bearing in mind that the residential flows of young families (under 30) do not necessarily match those of older families (aged 30 to 59), we simulated a hypothetical increase of 5000 social rental apartments over 5 years (1000 per year) and observed the impact (at the end of 10 simulation cycles, i.e. 10 years) on occupancy by the two categories of families in housing types for which constructions were simulated.

The simulation of an increase in social apartments of 3 rooms or more (Figure 4) reveals two distinct trends. Logically, the number of young families in social housing during the construction period (first 5 cycles) increases following an increase in entries into new dwellings. Then, as shown by the stabilisation of exits over the last 5 cycles, they remain in the same home. By contrast, housing construction does not stop the outflow of older families. During the period of delivery of the new dwellings, we see an increase in entries combined with an increase in exits. This two-way movement stabilises the number of families aged 30 to 59. As soon as new dwellings cease to be delivered, the

entries logically diminish whereas the exits continue. The result is a shortage of families in social housing. We therefore observed that, because of the structure of the local system that does not allow families to continue their residential trajectories in Lille, the building of homes specifically intended for them would only have a small impact on increasing and maintaining their numbers in the city.



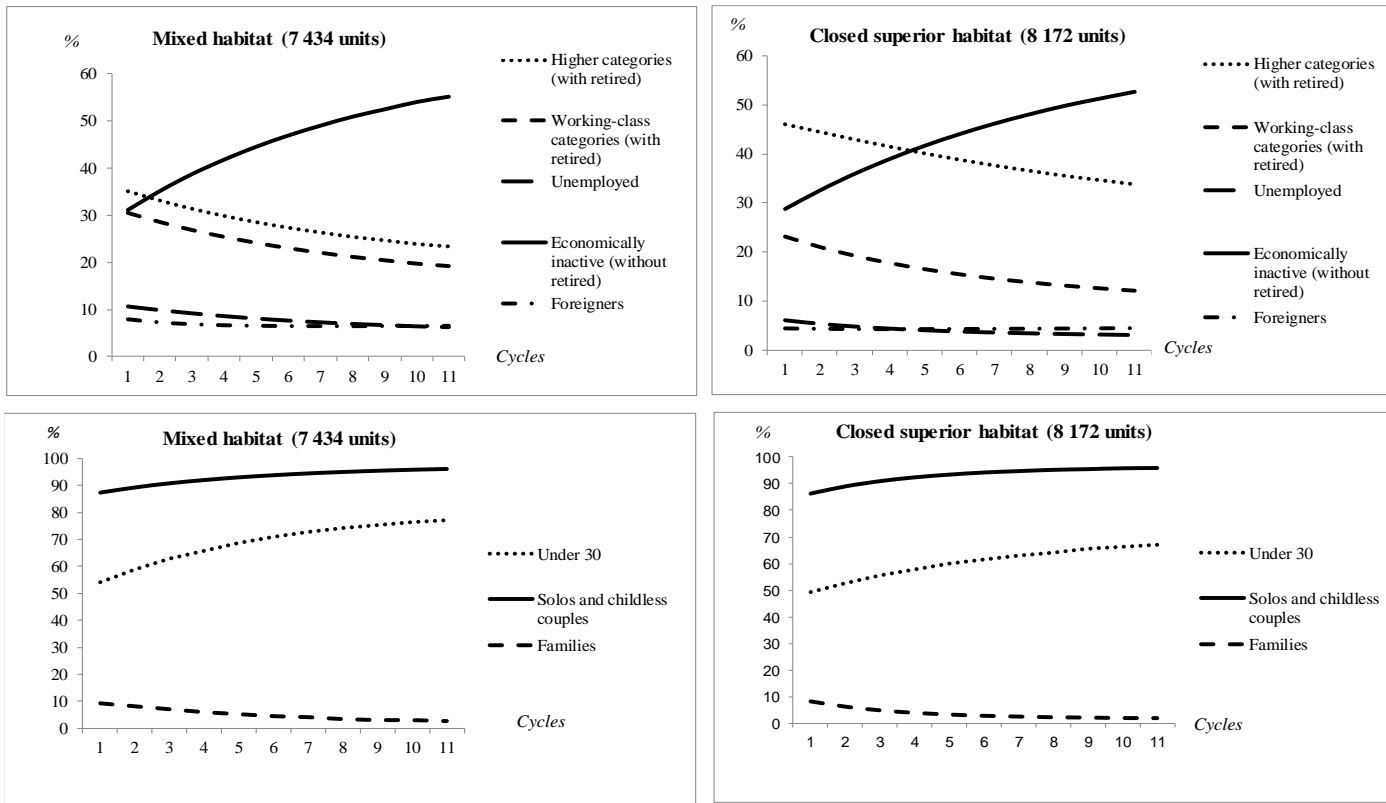
Source: ASHA

Figure 4 - Trends in the number of families in social housing apartments of three rooms or more, following an increase by 5000 such apartments (1000 apartments a year over 5 years).

5.2. *Blocked gentrification or delayed gentrification?*

Vacancy chain modelling has already been used to study gentrification processes (Millard-Ball, 2002). One of the questions that emerged in the analysis of local effects impacting on the population of Lille's districts was the future of the two districts where the local effect is negative (Map 1). The housing stock in these sectors is characterised by a significant proportion of superior housing, yet the presence of higher socio-economic categories is not much greater than the city average. This mechanism means that the population change that took place in the old housing (rented or privately owned apartments) in the central district did not occur in these areas. This raises the question of whether the spread of the gentrification process (old housing previously occupied by working-class categories and now housing students and young working people in higher socio-economic categories) observed in the central districts is blocked, scattered and impeded, or delayed, in these two districts?

To answer this question, we used ASHA to model the population trends for habitat types in these sectors, by running a conditional simulation (10 cycles, i.e. 10 years) without increasing the number of dwellings. We will not present here the sociodemographic changes in all habitat types. We will illustrate the change in the population from mixed and closed superior habitat types whose development is representative of what was observed across the two districts (Figure 5). From a demographic point of view, the simulations show that the structures already in place are becoming consolidated. At the start of the cycles, young people (54%; 49%), people living alone and childless couples (87%; 86%) account for a large majority of the occupancy of both habitat types, and this situation obtains even more at the end of the simulation. For their part, families are very much a minority (respectively 9% and 8%), and their proportions diminish in the course of the simulation (-7 and -6 points). The transformations in the occupancy structures are even more significant when we observe the changing trends in social categories. In both types of housing, the simulation shows a fall in the occupancy rate of the higher socio-economic categories (-12 points, though they remain very present) and working-class categories (-12 points) in favour of nonworking populations (essentially students, +24 points), to the point that the latter constitute a large majority at the end of the simulation cycle (10 years).



Source: ASHA

Figure 5: Changes in social and demographic characteristics of mixed and closed superior housing in superior habitat areas with a negative local effect in a conditional simulation of 10 cycles without increasing numbers of dwellings.

Ultimately, a continuation of the trends would rather seem to show gentrification spreading slowly but surely, rather than being blocked within these districts. It can therefore be expected that the arrival of young students living alone or in childless couples, combined with the retention of a high proportion of people from higher socio-economic categories, will lead to a shift in the occupancy characteristics from mixed habitat and filtering working-class habitat. To sum up, if current trends continue, the population characteristics of these two districts should be close to those of the central districts and the “negative effect” on the population of these districts should eventually disappear. It remains to be seen where the working-class populations are going (or will go), when they have less and less access to these residential districts.

Conclusion

By offering an alternative to Markovian approaches, the ASHA model constitutes a global approach to the calculation of vacancy chains, treating them not as isolated flows in a local housing system, but as a process that evolves in relation to the population renewals that they generate. The model is therefore a way of effecting a study that is centred simultaneously on changes in habitat types, in territories and in overall population. In this respect, it would seem to offer an innovative and effective tool for guiding decisions and achieving a global and dynamic understanding of the operation of habitat systems.

Its application to the way that housing functions in the city of Lille has demonstrated its robustness. The different simulations show the existence of a housing system structured by the gentrification of the city’s old central districts, which ultimately encourages the influx of students and young working people from outside the city. This process is taking place to the detriment of families, who remain neither in their homes nor in their locality. The ASHA model also showed that, far from having come to a halt, gentrification is now spreading into the old districts occupied by working-class households, which have not yet been affected by the population change.

One of the great strengths of the model is therefore to make complex housing systems understandable. The example of Lille illustrates the inertia of such systems. Without a

fine-grained understanding of how they work, it would seem difficult to establish a policy capable of changing current trends.

Nonetheless, the model requires improvement. The approach based on time steps can be improved, because it is currently too restrictive and does not take account of the ageing of stable households. The model also needs to be calibrated in time and space in order to be fully validated. The city centred approach is probably not very suitable for this exercise, which requires longitudinal simulations over a long period and over a wider perimeter.

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