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The social dynamics of suburbanization: insights from a qualitative model

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Abstract

This paper contributes to the discussion on suburban developments by way of modeling the underlying social dynamics between suburban actors in two European suburban areas: Wirral/Liverpool, UK and Leipzig, Germany. Data from questionnaires carried out in the two study areas are used to model social attraction and repulsion, i.e. social segregation processes among socio-economic groups. The model reveals that these social dynamics would, if other possible influences are ignored, lead to a situation of fluctuating residential in- and out-migration and to waves of suburbanization in the study regions. There are no persistent states: suburbanization would steadily continue until external, i.e. not modeled, forces restrict movement, impact the spatial characteristics of the suburbs or alter the social interactions among the actors. Suburban in-migration could only be reduced by strict planning regulations and/or other external forces that impact actor class constellations and interdependencies, for example by measures to restrict migration to more distant, suburban locations and provide preferential housing in the inner urban areas. The analysis further indicates that suburbs develop into independent residential areas, separate from the urban centers, since the primary source of migration to suburbs is no longer the urban centers—the vast majority of moves occur within suburbs or into suburbs from outside the region.

Introduction

Recently Phelps et al. (2010) discussed the claim of a "post-suburban world", and reflected on trends in urbanization, suburbanization and post-suburbanization in European, North American and East Asian cities. They discuss whether contemporary developments at the edge of major cities during the last 30 to 40 years "represent a break from suburbanization" (Phelps et al., 2010: 367) or whether it is merely that new terms—such as post-suburban (Wu and Phelps, 2011) or exurban developments, sprawl (Reckien and Karecha, 2007), technoburbs (Fishman, 1987), edge cities (Garreau, 1991) or edgeless cities (Lang, 2003)—are being used to describe an old phenomenon. In doing so, Phelps et al. (2010) contrast the Chicago with the Los Angeles school of urbanism. The latter claims the end of suburbia in the traditional sense; i.e. an end to the boundary growth of urban areas, and the establishment of residential areas surrounding urban centers which are, at least in a reflexive way, still connected to them, strongly motivated by social segregation and driven by people's desire to live in more 'natural', healthy and quiet surroundings (Cieslewicz, 2002; Squires, 2002; Couch and Karecha, 2003).

The theoretical debate on the nature, state, development and influences of contemporary suburban development is not new, and still dynamic. While residential actors and their common residential preferences have long been identified as the central driving forces of suburbanization (Fischer, 2004; Gaebe 2004; Werlen 1997; Scheiner, Illig, and Lichtenberg 1999; Fishman 1987), other influences are increasingly being discussed. Among them are the roles of non-residential actors—commerce, the entertainment industry, businesses, corporations, speculators—and their space-shaping powers and political influence (Gilham, 2002; Moeckel, 2009; Phelps et al., 2010). However, these new influences may do no more than superpose, combine with or reinforce pre-existing social segregation trends. There is no indication that the influence of residential preferences is diminishing (Fischer, 2004; De Decker, 2011; Lauf et al., 2012). In particular, considering residential suburbanization, the social circumstances of a neighborhood remain a strong motive for people to consider moving (see, e.g. Herfert (2003) for Leipzig, Wiest (2001) for Saxony, and Couch (2003) for Liverpool). In fact, social segregation, considered to be responsible for the emergence of suburbanization in the 18th century (Fishman 1987), remains a central driver of suburban development.

This paper provides insights into social attraction and repulsion mechanisms, which underlie social segregation, and thereby elicits information to the spatial production force of social processes. It reveals how suburban residents themselves, as one group of suburban actors, interact and how they shape the attractiveness of these areas for others. The paper assesses these interactions and their contribution to suburban development by means of empirical data collection and qualitative modeling. It interprets scenarios that arise from these interactions and evaluates their effect on future suburban growth. By singling out social processes between human actors, some conclusions about the influence of other drivers of growth on suburban or post-suburban developments can be drawn. The paper does not aim to reassess urban theory, i.e. to answer whether contemporary cities are undergoing post-suburban or other kinds of development, but rather to shed light on the spatial implications of a single facet of the process that accompanies all urban fringe developments, i.e. social segregation.

Other influential factors of suburbanization are not assessed. We use two case study regions, Leipzig, Germany and the Wirral/Liverpool, UK. For the sake of clarity and brevity, the term suburban will from hereon be used to describe all forms of development on urban fringes (post-suburban, exurban, sprawl, edge cities, or edgeless cities).

The paper is organized as follows: The next section briefly presents theoretical reflections on urban/suburban/post-suburban developments and formulates the research objectives. This is followed by a description of the methodology, employed in the empirical study (data generation) and the modeling approach. The results of the empirical study and modeling are then presented and discussed. The final section summarizes the principal conclusions.

Theoretical background

The theoretical debate on general city development, its causes and trends engaged researchers since several decades with Harris and Ullman (1945) and the earlier works of Harvey (1973) being important classical contributions. Extensive recent works include those edited by Kazepov (2005) and Marcuse and Van Kempen (2000). Phelps et al. (2010), Couch et al. (2007) and Bruegmann (2005) focus on processes at the urban fringes, while, Musterd and Ostendorf (1998) and Fischer (2004), for example, reflect specifically on urban segregation, and Andrusz et al. (1996) provide a first comprehensive analysis of change in post-socialist cities. All these studies are central to the concerns of this paper.

The case study areas, Leipzig, Germany and the Wirral/Liverpool, UK do not appear similar on the first sight; but they are both examples of suburbanization taking place in the context of a shrinking city. There is well-established literature on shrinking cities on almost all continents (see, e.g. Pallagst et al., 2009 and Martinez-Fernandez et al., 2012, and the Shrinking Cities International Research Network, 2012, in general), but little attention has been paid to the phenomenon of shrinking cities' sprawling suburbs (but see Wellner, 2002; Couch et al., 2005, Nuissl et al., 2007). The topic is interesting for at least two reasons: (1) It turns the spotlight on a previously under-researched empirical phenomenon; (2) It provides the opportunity to uncover underlying drivers and principles of suburbanization, since inherent individual dynamics and residential preferences are likely more easily detected in shrinking cities than in growing cities, i.e. in a situation where there is less intrinsic pressure towards urban expansion.

To elicit root causes of suburbanization is central to this work and contemporary residential preferences are, amongst others, studied to do so. Residential preferences are also used to increase the steering abilities of planning departments (see, for example, Lauf et al., 2012; Howie et al., 2010), which here is additionally addressed through modeling the residential segregation dynamics. The role of actors other than residents is not considered in the model. Actors' residential preferences and processes of social segregation respond to the mere presence of other actors but also to the implications of their presence on other characteristics of a location. The evaluation of spatial attractiveness by actors is therefore conditioned by factors such as apartment size, housing costs, and transport connections (more objective factors according to White, 1981) but also by attitudes towards other actors residing in the area of preference and perceptions of their impact on the objective factors (which are

sometimes referred to as subjective factors). Suburban developments can thus be analyzed as actor-based processes initiated by the comparison of the spatial attractiveness of different locations for different actors, influenced by other actors. Urban structures then are analytical constructs dependent on and formed by actions and restrictions of individuals, which implies that prominent actor classes may exist that leave an imprint that is discernable as suburban change (e.g. suburbanization will only be recognized as such if many people move in the same direction, i.e. to the suburbs). This notion is grounded in the behavioral approach to action space and action space research (*Aktionsraumforschung*) (Werlen 1995, 1997) that conceptualizes the city as a product of the cumulative actions of individuals (Gaebe 2004: 61). We assume that groups of actors have distinct preferences and socio-economic characteristics, which is not unreasonable (Fischer, 2004). An assessment of interrelationships between actor classes therefore seems appropriate.

This study has three objectives:

1) To identify the mechanisms of social interaction, specifically attraction or repulsion, between actor classes by looking at how the social, natural and economic imprints left on the neighborhood by different actor classes are perceived by other actor classes;
2) To identify possible scenarios of suburban development, when only the social dynamics between the different residential actor classes are in play;
3) On the basis of the results obtained, to assess the contribution of social interactions to the suburban development process.

Methodology

Mechanisms of social interaction (research objective 1) arise from the spatial preferences of household classes and the influence of the presence of other actors on these preferences. Spatial preferences were identified by means of household questionnaires conducted in the case areas in Leipzig, Germany and Wirral/Liverpool, United Kingdom. The results of the questionnaires were also used to characterize household classes, using cluster analysis. Summary descriptions of the case study regions, the questionnaire survey, the cluster algorithm employed, and the deduced social interdependencies are provided below. Research objective 2 is addressed by means of a Qualitative-Attractiveness-Migration model (QuAM). Since QuAM represents the nodal point and centerpiece of the methodology, the description of methodology starts out by presenting, in the following section, the basic principles of the modeling approach. Objective 3 is addressed in the 'Discussion and conclusion', where the results of the QuAM model are discussed with reference to wider research on urban development.

The QuAM model

QuAM represents the migration process by formalizing a location's attractiveness. The model applies qualitative knowledge about relations between modeled variables instead of quantitative relations.

These relations between variables in QuAM are specified as "an increase in variable 'a' induces an increase in variable 'b'" (increasing) ", an increase in variable 'a' induces a decrease in variable 'b'" (decreasing) or "variable 'a' does not affect variable 'b'"

(independent). These qualitative relations imply qualitative time courses of the variables which are defined as sequences of increasing, decreasing or indistinct trends. Qualitative modeling thus enables the formalization of interactions that are difficult to quantify and the modeling of variables that would otherwise be left out of dynamic assessments, i.e. in this case, social and socio-economic processes (such as migration) and the relation between actors and their environments.

The mathematical formalization uses Qualitative Differential Equations (QDEs) (Kuipers, 1994), which are based on dynamic systems theory, i.e. the state of a system is related to its rate of change. The method was originally developed and applied by Kuipers (1994) and his group to physics and human physiology, and goes back to similar approaches of Forrester (1969) and Roberts (1976). The dynamic qualitative modeling approach is appropriate for a number of socio-ecological systems with barely quantifiable relations, e.g. migration and household relocation (Reckien et al., 2011, Lüdeke et al., 2004; Lüdeke et al., 2007), sustainable agriculture (Eisenack et al., 2006b; Petschel-Held and Lüdeke, 2001), fisheries management (Eisenack et al., 2006a) and forest overexploitation (Eisenack et al., 2006b). Further applications exist, for example, in finance (Benaroch und Dhar, 1995), epidemiology (Heidtke and Schulze-Kremer, 1998), chemistry (Juniora and Martin, 2000), and the automotive industry (Sachenbacher, 2001). The QuAM model is fully documented by Reckien et al. (2011), but the most salient points are outlined in the following paragraph.

The main variables of QuAM are actor-class populations, i.e. the number of households belonging to a particular cluster, which migrate along attractiveness gradients from a region of lower to a region of higher attractiveness. Every move may change the attractiveness of both the sending and the receiving regions for all actor classes and cause further changes in migration fluxes. Thus, households do not only shape the city for others and influence other households by their presence, they are also influenced by their own class's and others' cumulative developments. Actor movements of homogenous classes, in term of location preferences and socio-economic attributes, result in a dynamic process.

The actor-class-specific qualitative influence (increase, decrease, not defined) on actor-class-specific location attractiveness is the main input. Relations are formalized by conditions such as "an increase in the population of actor-class 'a' leads to an increase/decrease/unclear development of the location attractiveness, i.e. the actor-class population 'b'". Relations are based on the questionnaire surveys, from which a cumulative location attractiveness per actor class can be derived using a class's social, economic, physical and environmental location preferences (similar to Garvill et al. 1992; explanation in more detail below). Those relations are visualized in a matrix and the matrix is the main input to QuAM.

The model output comprises documented sequences, with actor classes leading or following each other and giving rise to networks of the (changing) actor-class population trends. Those sequences represent scenarios of suburban development and regularities that arise can be interpreted, for example, in terms of phase transitions, lock-ins, or circular behavior (as explained in more detail in the results section). The output is not quantitative and no exact figures are given that specify the degree of change. Instead, qualitative graphs display the

changes of actor population trends (a population increases or decreases). One can draw conclusions about the state of the system, possible and impossible trend sequences, scenario developments and pathways, possible imminent developments, as well as system states further away in the future. For model specifics and mathematical reasoning see Reckien et al. (2011) and Reckien (2007).

Questionnaire survey

Responses to postal questionnaire surveys provided the input data for QuAM. They were conducted in the most dynamically developing suburban regions of Leipzig, Germany and Wirral/Liverpool, UK to elicit suburban residents' location preferences. The questionnaires were addressed to all newly registered households in the selected suburbs of the Wirral (Upton, Moreton, Hoylake and Roydon), and to a random sample of newly registered households in Eastern suburban Leipzig, representative in age and number of people across 10 districts (Ortsteile) selected for the study (Seehausen, Plaußig-Portitz, Thekla, Heiterblick, Engelsdorf, Mölkau, Baalsdorf, Althen-Kleinpösna, Holzhausen, Liebertwolkwitz). Newly registered households refer to those that moved to the suburbs within six years prior to the survey. This approach thus relies on retrospective data and circumvents critical aspects associated with hypothetical moving (Garvill et al. 1992; Fuguitt and Brown 1990; Lindberg, Gärling, and Montgomery 1989).

The questionnaire had three foci and was semi-closed (providing respondents with a list of variables to choose from plus a field for comments or additions). Respondents were asked to indicate (1) the importance of the reasons for choosing the current place of residence (pull-factors, such as 'being near to place of work', 'having good road connections', 'being near to good schools', etc.) on a Likert scale from 1 to 5; (2) the importance of the reasons for leaving the former place of residence (push-factors, such as 'previous home was too small', 'previous neighborhood too noisy' or 'lacked greenery', 'my personal circumstances changed because of a relationship breakdown', etc.) on a scale from 1 to 5; and (3) a number of socio-economic characteristics (family status, household type, age) and socio-economic features (occupation, number of cars in the household). The questionnaire accounted for the differences between location features, such as neighborhood appearance and personal reasons for moving, and was adjusted to the local situation with respect to differences in the political and housing history of the areas (socialist vs. capitalist history; homeownership vs. renting).

The surveys were undertaken in spring 2003 (Liverpool area) and September 2005 (Leipzig). The age of the data in this case does not debase its quality as it is used for scenario analysis and opens up an opportunity to validate the research results by way of empirical data afterwards. The response rate was 34% (203 returned and completed questionnaires) in the Wirral and 14% in Leipzig (194 returned and completed questionnaires). The questionnaire surveys are documented in detail in Reckien (2007) and Reckien & Martinez-Fernandez (2011).

The case study areas were chosen because of their similarity, i.e. because both had experienced strong suburbanization processes in the years prior the investigations and belong to cities that were for a long time both sprawling and shrinking simultaneously (Lauf et al,

2012; Reckien and Martinez-Fernandez, 2011; Couch et al, 2005; Nuissl et al, 2007; Reckien and Karecha, 2007). Further similarities included their economic history (a strongly industrialized economy that went abruptly into decline at some point in history) and urban governance (Liverpool had been governed by left-wing politicians in the 1980s and the Communist Party in the 1920; it also shows strong social movement and workers unionism (Couch, 2003); Leipzig was under socialist rule until 1989). These in turn gave rise to further similarities, for example in the housing market (provision of workmen's dwellings) and the role of industrial elites in urban politics (Hudson, 2005; Lichtenberger, 1995a, c; Couch, 2003; Fassmann, 1995). Both case study areas are introduced briefly in the following sections.

Introduction to Case Study 1: Leipzig

Leipzig is situated at the heart of the densely populated Leipzig-Halle conurbation. The population was just under half a million in 2001 and had been in steep decline after 1989, mainly due to suburbanization and emigration to former West Germany (Nuissl and Rink, 2005), like many cities in eastern Germany after reunification (Ott, 2001). Since 2001, Leipzig's population has been rising; it amounted to 531,809 inhabitants in December 2011 (Statistisches Landesamt Sachsen, 2012).

Leipzig was almost unaffected by the problem of urban sprawl until the Berlin wall came down, but has experienced several strong phases of sprawl since then (Nuissl and Rink, 2005). Soon after reunification, thousands of West German investors took advantage of the new market and initiated commercial sprawl with, amongst others, construction of big retail centers on the fringes of the city. Between 1992 and 1997, a period of rapid residential development followed as households forsook the qualitatively poor inner-city housing in favor of the newly-built modern amenities on the fringes. Restitution problems (i.e. in returning properties to their former owners) and lack of funding severely limited the rate at which inner-city housing could be improved, and financial incentives also favored suburban development. After 1997, the trend of moving to the suburbs started to decline as restitution claims were increasingly resolved and investments started to flow into urban regeneration. Only single-family (detached) houses continued to sprawl in Leipzig's surrounding countryside.

Introduction to Case Study 2: Liverpool

Liverpool is at the heart of Merseyside County, which also contains Wirral, and is located in the North West region of the United Kingdom. The Merseyside region has a much longer history of suburbanization and sprawling than Leipzig, but has experienced a steep decline in industry-related jobs and related population since about the 1960s. Population numbers peaked at over 1.8 million in the mid 20th century and decreased to about 1.35 million in 2010 (Statistics UK, 2011). Moreover, the proportion of the population living in the city of Liverpool fell from about 43% in 1961 to 33% in 2001.

The suburban areas of the Wirral on the other side of the River Mersey from Liverpool are the focus of this investigation. Suburban settlements in Wirral have developed over the last 100 years. They were an early result of the railways and later developed further in response to improved regional accessibility by car. The combination of severe restrictions on peripheral

development through the 'green-belt' policy (adopted in 1983) and the implementation of powerful urban regeneration programs have reduced the rate of sprawl in recent years (Reckien and Karecha, 2007). In a number of suburban areas, however, residential sprawl is dynamic and continuing, driven by the desire for 'social improvement'.

Cluster Analysis

The assumption underlying cluster analysis is that the city and any change in its structure is a product of the cumulative actions of individuals (see action space research; Gaebe, 2004). Part (1) of the questionnaires provided a total of 38-39 variables (depending on the case study region) used for clustering. The responses were used to form clusters of households that were similar in location preferences, defined through the pull-factors of residential areas that were identified, and location imprint, a function of socio-economic characteristics. Cluster analysis is based on a hierarchical, binary cluster procedure (see Everitt et al., 2001), i.e. the average linkage clustering method, with a similarity index based on a simple proximity measure that is set individually to fit the case study sample. The algorithm used for this study is documented in Reckien (2007).

Results

In accordance with the objectives, the results section is divided into sub-sections covering (1) social attraction and repulsion, and (2) future scenarios and social dynamics and (3) the contribution of social interactions to the suburban development process.

(1) Social attraction and repulsion

Identification of household clusters and actor classes

The cluster analysis (Figure 1 and 2) revealed that suburbanization was driven by different household types in the two regions, although in both regions five actor class populations (P1–P5) were identified as the best fit. Clusters mainly formed around age bands and family status, indicating that those qualities condition similar location preferences. Families (well-off and less well-off) represented a large proportion of the population of both regions and accounted for approximately 46% of the respondents in Leipzig (young families and middle-aged families; N = 75) and 43% in the Wirral (middle-aged, middle-class families and middle-aged, more wealthy families; N = 68). With regard to age, the most prominent group was retired people. In Leipzig, the number of retirees was equal to the number of middle-aged, well-off families. In the Wirral retired people far outnumbered wealthy, middle-aged families. Taken together, retirees and well-off families formed the majority of respondents in both regions. There was also a distinct class of one-person households in both the suburban case study regions—a group not previously documented as prominent suburbanites. This actor class mainly comprised young singles (<34 years of age) in Leipzig and middle-aged singles (35-59 years of age) in the Wirral. In general, in Leipzig the clusters were less distinct and more widely spread across age than in the Wirral. Figures 1 and 2 show the cluster results in detail.

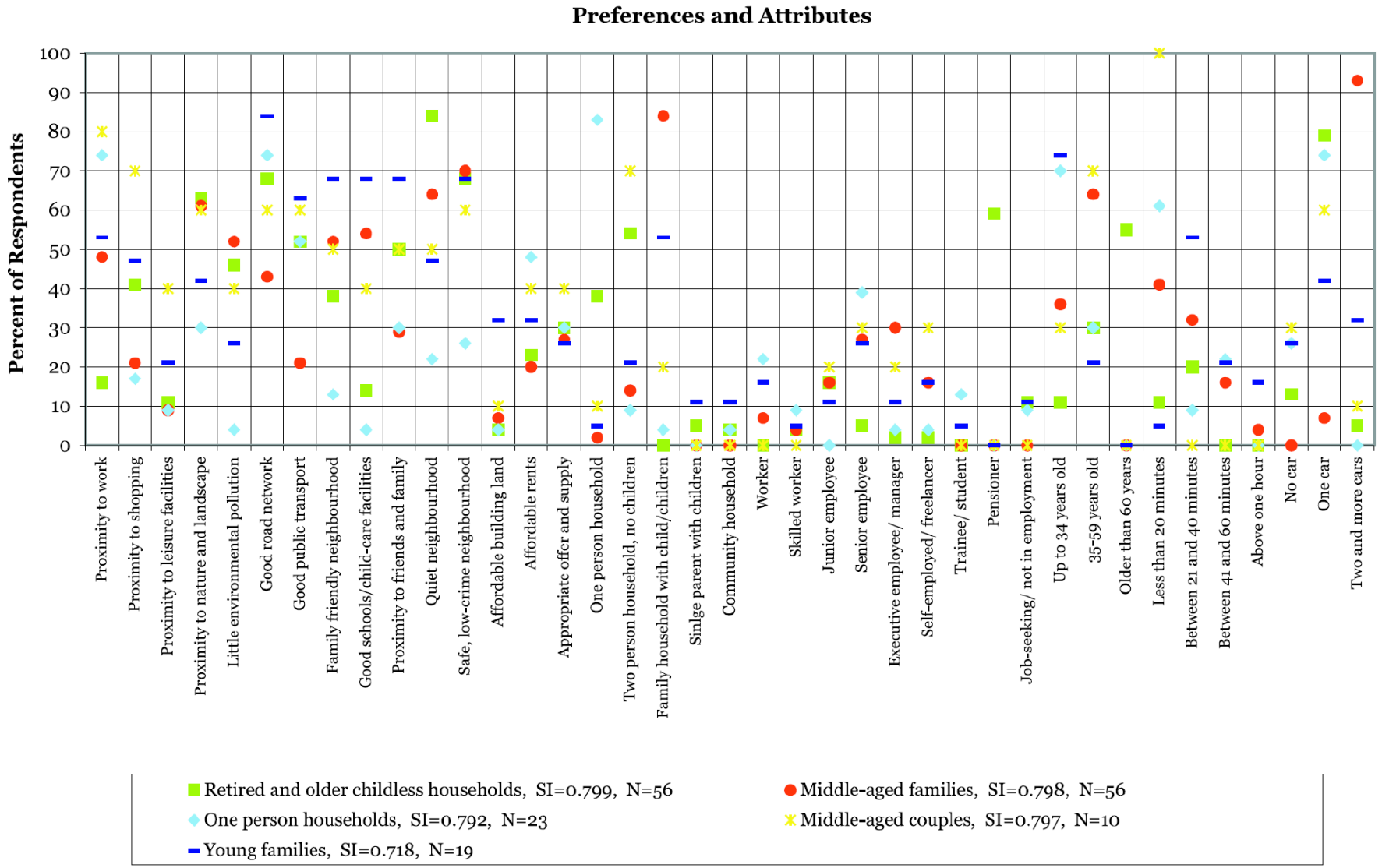

Figure 1: Cluster result for eastern suburban Leipzig. Key: N - number of respondents/actors in the cluster; SI - Similarity Index. The SI is an indicator for the similarity of all actors in one class.

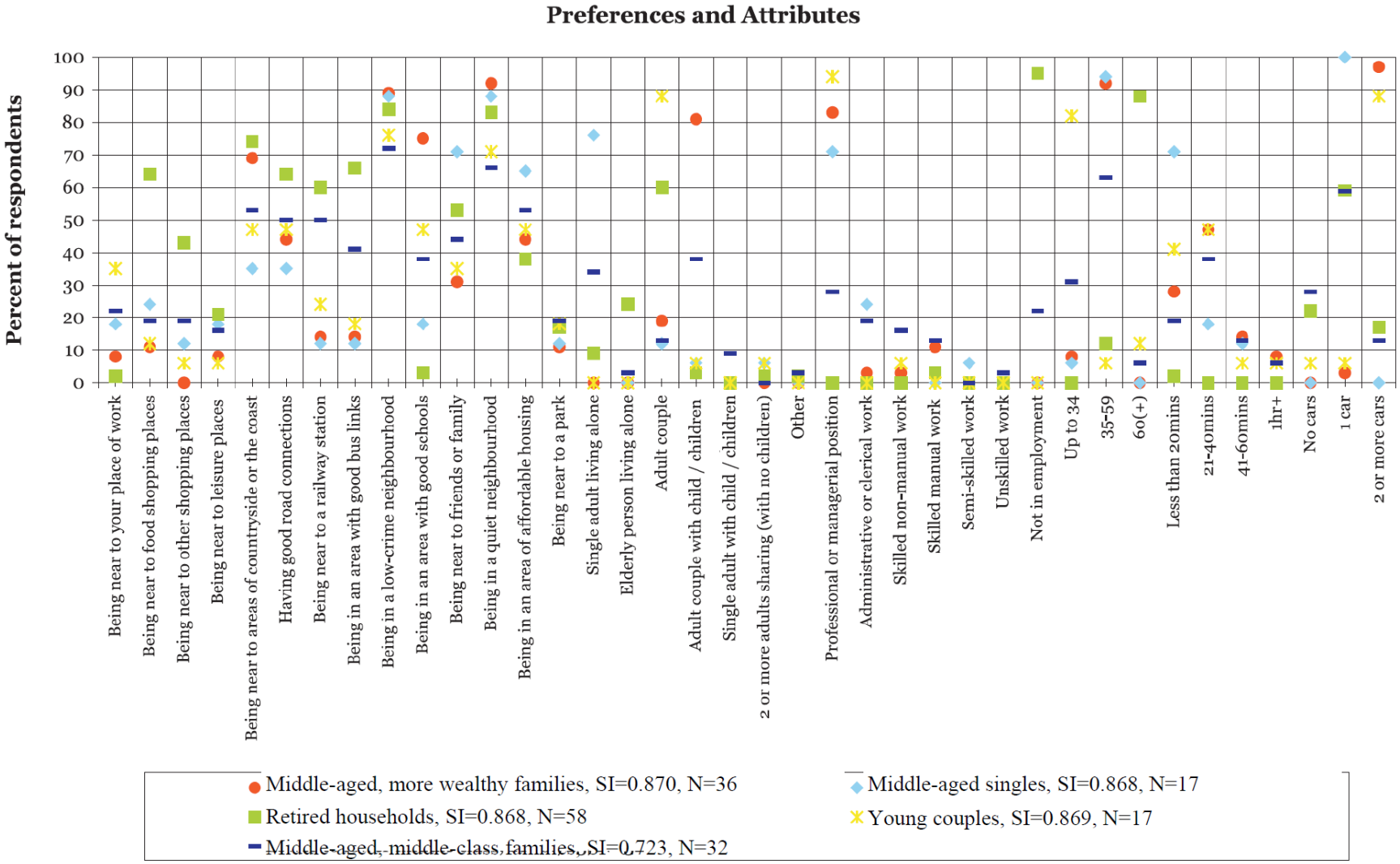

Figure 2: Cluster result for western suburban Wirral. Key: N - number of respondents/actors in the cluster; SI - Similarity Index. The SI is an indicator for the similarity of all actors in one class.

Actor class location preferences

The cluster analyses reveal the location preferences specific to each actor class and location (Table 1). A location characteristic is called a location preference when at least 30-59% (weak preference) or 60-100% (strong preference) of the respondents in one class indicated it to be very or most important in choosing this place of residence. There are a number of location preferences that do not intensively or directly relate to the presence of others, e.g. proximity to place of work, shopping centers, leisure facilities, and (in the case of the Wirral) the coast, good road connections, railways stations, and public parks, but many others do. The most frequently mentioned location preferences influenced by the presence of others are shown in Table 1.

Leipzig					
Household clusters	Retired and older childless households; N = 56	Middle-aged families; N = 56	Middle-aged couples; N = 10	Young families; N = 19	Young one-person households; N = 23
Actor class populations	P1	P2	P3	P4	P5
Location preferences that are influenced by the presence of others	•Proximity to nature and scenery •Quiet neighborhood •Family-friendly neighborhood •Proximity to friends and family	•Proximity to nature and scenery •Quiet neighborhood •Family-friendly neighborhood	•Proximity to nature and scenery •Quiet neighborhood •Family-friendly neighborhood •Proximity to friends and family •Affordable rents	•Proximity to nature and scenery •Quiet neighborhood •Family-friendly neighborhood •Proximity to friends and family •Affordable rents	•Proximity to nature and scenery •Proximity to friends and family •Affordable rents
Wirral/Liverpool					
Household clusters	Retired households; N = 58	Middle-aged, more wealthy families; N = 36	Middle-aged single households; N = 17	Middle-aged, middle-class families; N = 32	Young couples; N = 17
Actor class populations	P1	P2	P3	P4	P5
Location preferenc	•Good bus links	•Good schools •Quiet	•Quiet neighborhood	•Good bus links	•Good schools •Quiet

es that are influenced by the presence of others	•Quiet neighborhood •Being near to friends or family •Affordable housing	neighborhood •Being near to friends or family •Affordable housing	•Being near to friends or family •Affordable housing	•Good schools •Quiet neighborhood •Being near to friends and family •Affordable housing	neighborhood •Being near to friends and family •Affordable housing

Table 1: Location preferences of actor classes (household clusters) in Leipzig and the Wirral. The table lists only the most frequently mentioned location characteristics, i.e. those mentioned by at least 30% of the actors in one class—then called a location preference—, and those that are influenced by the presence of others (members of the same or other actor classes). Black and grey fonts denote preferences shared by 60-100% and 30-59% of the respondents, respectively, based on the number of respondents who regarded the characteristic as 'important' or 'very important' based on the Likert scale in the questionnaire.

Actor classes' impacts on location attractiveness

The location attractiveness consists of (a) the fixed characteristics of the respective region, e.g. proximity to services, housing prices, etc., and (b) the presence of other actor classes, such as being near to friends and/or being in a quiet neighborhood. Both, (a) and (b) can be influenced by the presence of other actors, giving rise to social attraction and repulsion. Socio-economic characteristics and evidence from other sources were analyzed to identify these influences. The analysis of impacts focused on location preferences that respondents indicated were of high importance in the decision to move (Table 1), giving greater weight to preferences shared by more than 60% of members of a class and lesser weight to preferences shared by 30 to 59% of members.

If the presence of other actors has an impact, resulting in social attraction and repulsion, it is often one of the following three kinds:

- Environmental density effects, for example, less proximity to and availability of nature and scenery if households move in that favor newly-built houses; less tranquility if more (multi-)car households move into suburban Leipzig (traffic noise is the most problematic factor in Germany; Umweltbundesamt, 2006) or if young couples move into suburban Wirral (domestic noise from neighbors, such as amplified music, is the most frequently reported annoyance in British cities; DEFRA, 2003; Grimwood and Ling, 1999);
- Social proximity effects, if more households of the same actor class move in (documented by results of the questionnaire; see also, for example, Prime et al., 2002); and
- Economic agglomeration effects, for example reduced housing affordability if the proportion of wealthy households increases (Atkinson, 2002); increased reliability of public transport if more people move in who use it (Metz, 2000; Gilhooly et al., 2002), or an increase in the quality of schools, particularly in Britain, when wealthy

households move in (Lupton, 2005).

These influences can be formalized as positive or negative impact relations for modeling purposes, as shown in Table 2 and Table 3.

	Impact relations
Leipzig	- Proximity to nature and scenery decreases with an in-migration of young families, which are the actor class that most likely builds new houses (see Figure 1). Thus actor class P4 has a negative impact on other classes with respect to this preference (P4: negative) - The neighborhood becomes more family friendly when families move in (P2 and P4: positive) - Proximity to friends and family increases with the increased presence of the same actor class: the presence of the same actor class has a positive impact - Quietness in a neighborhood decreases with an in-migration of people with many cars and those with older children, i.e. middle-aged families (P2: negative) - Affordable rents (lower segment): an increase in one-person households would have a negative impact on rents, because this group demands low rents and their presence reduces the availability of cheap apartments (P5: negative)
Wirral/Liverpool	- Being in an area with good bus links is positively influenced by an increase in retired people, because it is important to them and their demand increases the financial incentive for transport companies to provide bus services (P1: positive) - Being near to friends or family will increase with an in-migration of the same actor class: the presence of the same actor class has a positive impact - Being in a quiet neighborhood is negatively influenced by an increased presence of young couples (P5: negative) - Affordable housing is negatively influenced by an in-migration of middle-aged, more wealthy families, because they drive the housing prices upwards (P2: negative)

Table 2: Formalization of impact relations

Table 2 shows some of the most important impact relations identified, which were included in the model, particularly those where the presence of a particular class has a positive or negative impact on all the other classes, and where the presence of one class motivated more people from the same class to move in. These observations reveal that, in the suburbs of Leipzig, young families are often disliked because they are associated with building new houses and decreasing proximity to nature, which is important for all households. Middle-aged families (multi-car households with older children) decrease the quietness of the neighborhood, which is another strong motive for moving among all households except young singles. By contrast, young families are attracted by the presence of other families because of

their wish to be near friends and families. Middle-aged couples like no-one but people from their own group and are indifferent towards the retired. Together with the young families and the young one-person households, they show sensitivity to rising house prices, which seems mostly caused by the in-migration of young singles that target the same section of the residential market.

In the Wirral, young couple households are generally disliked by all others because of their potential impact on the noise level in the neighborhood. Similarly disliked are very well-off family households, who increase market prices and lower affordability of housing for many. It is also notable that in the Wirral, unlike in Leipzig, people like to live among their own class. Therefore, in the Wirral the dynamic towards social segregation is more pronounced.

The influence of the impact relations shown in Table 2 on other actor classes can best be visualized by listing the location preferences and the impact relations in a cross table. Table 3 shows an example for one actor class (P1) in Leipzig. The left hand column lists the location preferences of this actor class, identified from questionnaire responses. The remaining columns show the impact of the presence of each actor class (P1–P5) on each location preference. The bottom line the column sum shows the aggregated effect of the presence of each actor class on the attractiveness of the location for actor class P1. The full tables of interdependency relations can be provided upon request.

	Influencing actor class				
Location preferences of actor class population P1	P1 Retired and older childless households	P2 Middle-aged families	P3 Middle-aged couples	P4 Young families	P5 Young one-person households
- Proximity to nature and scenery				-	
- Quiet neighborhood		- +			
- Family-friendly neighborhood				+	
- Proximity to friends and family	+				
Aggregated effect on actor class P1	**+**	**-**	**0**	**-**	**0**

Table 3: Example of the social attraction and repulsion appreciation for one actor class, i.e. interdependencies between P1 and other actor classes in the suburbs of eastern Leipzig. Location preferences are those regarded as important or very important by 60-100% (black font) or 30-59% (grey font) of the respondents from actor class P1. Positive (attraction) and negative (repulsion) signs show the influence of each actor class on the location preferences of actor class P1. Black numbers were given higher weights in calculating the aggregated effect (positive, negative or no effect) shown in the bottom row.

(2) Scenarios of social dynamics

The aggregated effects of all interdependency relations and actor class populations P_i, as shown in the example for P1 in Table 3, can be transformed into aggregated attractiveness matrices, as shown for Leipzig and Wirral/Liverpool in Table 4. The third row in Table 4 shows the aggregated effect of all actor classes on the attractiveness of the location for actor class P1 (denoted A1), i.e. the bottom line of Table 3.

	Influencing actor class in Leipzig				
Attractiveness (A) for actor classes P1–P5	P1 Retired and older childless households	P2 Middle-aged families	P3 Middle-aged couples	P4 Young families	P5 Young one-person households
A1	+	-	**0**	-	**0**
A2	**0**	-	**0**	-	**0**
A3	**0**	-	+	-	-
A4	**0**	+	**0**	+	-
A5	**0**	**0**	**0**	-	-
	Influencing actor class in Wirral/Liverpool				
Attractiveness (A) for actor classes P1–P5	P1 Retired households; N = 58	P2 Middle-aged, more wealthy families; N = 36	P3 Middle-aged single households; N = 17	P4 Middle-aged, middle-class families; N = 32	P5 Young couples; N = 17
A1	+	-	**0**	**0**	-
A2	**0**	+	**0**	**0**	-
A3	**0**	-	+	**0**	-
A4	+	-	**0**	+	-
A5	**0**	+	**0**	**0**	-

Table 4: Aggregated attractiveness matrix for the household classes in eastern Leipzig. Code numbers A1–A5 represent the aggregated attractiveness of the location for classes P1–P5 respectively. The table shows how the attractiveness of the location is modified by the presence of members of the same actor class and the other actor classes: (+) positive impact; (-) negative impact; (0) no overall impact.

Matrices like the one shown in Table 4 are the final input into QuAM. The output of a qualitative model is a qualitative graph with states of the modeled system and their relations, as shown below in Fig. 3 (Leipzig) and Fig. 4 (Wirral).

QuAM results for Leipzig

Figure 3 shows the output of QuAM for Leipzig. Each of the ellipses is a qualitative state of population trends in the suburban system. States are distinguished by the relative population movements in actor classes P1–P5. For example, Ellipse 1 shows a situation where the

populations of actor classes P1, P2 and P4 are increasing, that of actor class P5 is decreasing, and that of P3 is indistinct. Arrows connect states that differ from each other by containing exactly one reversed trend (i.e. from positive to negative or vice versa), although other classes may alternate between indistinct and positive or negative between states. For example, between states 1 and 3, actor class 2 changes from positive to negative, while actor classes 1 and 4 change from positive to indistinct (this is because 'indistinct' comprises both positive and negative). This feature makes it possible to track who is following whom. Moving from one ellipse to the next, one can follow the suburban household dynamics (i.e. relative growth or decline in the number of households belonging to different actor classes), and in this case follow independent scenario cycles (the left and right pane).

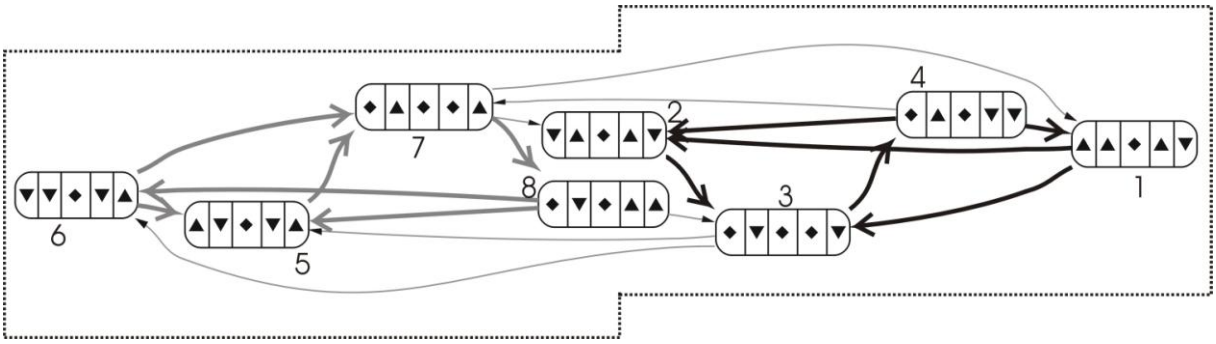

Figure 3: QuAM results for eastern suburban Leipzig. Each of the ellipses is a qualitative state of the suburban system. Every partition/column in the ellipse stands for a different actor class and bears the symbol for its population trend (upward arrow = increasing; downward arrow = decreasing; rhombus = indistinct, could be increasing or decreasing). Key:

P1	P2	P3	P4	P5
Retired and older childless households	Middle-aged families	Middle-aged couples	Young families	Young one-person households

The thick arrows connecting the ellipses in the left and right panes represent two distinct circles (i.e. scenario cycles) with different properties. The thin arrows indicate possible pathways of change from one circle to another. However, it is possible that the urban system will stay in one or the other circle. If one of the circles were considered preferable, for example in terms of sustainability, than the other, policy and planning could look for opportunities to keep the household movement within the more sustainable one. However, neither circle represents a very sustainable development, which in this case is defined as a steady state or circle of many decreasing trends, i.e. the state most likely representing a halt or decrease of newly built houses in the suburbs. However, the total number of decreasing actor classes is slightly lower in the right pane. As an additional feature, all ellipses on the black path in the right pane (states #1 to #4) feature a decrease in young one-person households, which is also the more realistic scenario with regard to the trend of re-urbanization in Leipzig as of the end of the 1990s. In other study areas sustainability might be defined differently.

With regard to the interpretation of single states, the results reveal that a highly dynamic phase and increase in all household classes (i.e. all actor classes ‘increasing’ or ‘indistinct’) in

the suburbs is possible (state #7). If a strong wave of in-migration from all classes occurs, as for example after re-unification until the second half of the 1990s, three resulting states (#1, #2 and #8) are possible. Either the suburban realm becomes strongly family-oriented (#1 or #2), with or without an increase in the retired, or highly attractive to the younger cohorts (#8). Looking back at the development in the late 1990s and onwards, the first scenarios were more likely, and became reality. Except for rather traditional family suburbanization, sprawl in Leipzig decreased, and many households moved back to the center, first the younger generation (#1) and later the retirees (#2).

From state #1 or #2 onward to state #3, the number of middle-aged families is likely to fall as well. In fact, in state #3 there is the possibility of a phase with very low demand as all actor classes might decrease (i.e. be 'decreasing' or 'indistinct'). This leads on to state #4, when the middle-aged families increase again and a new circle is started: the suburbs of Leipzig are attractive for families again. This was a highly probable scenario for Leipzig and occurred a few years after the survey was conducted (Nuissl and Rink, 2005; Reckien et al., 2011). Note that from states #3 and #4 it would be possible to change to the circle in the left pane (to states #5, #6, or #7)—the even less sustainable path, where all households might be increasing simultaneously at some point. It is not possible to cross back to the slightly more sustainable path in the right pane without passing through the highly dynamic state #7. Planning authorities are advised to exercise particular attention to the suburban development when the household classes undergo trends as shown in state #3 and #4, and if necessary act with appropriate incentives/measures to steer the development. .

The main social divide seems to be between families and younger, one-person households. A free flow of forces would keep these classes apart. However, as the younger people are already living mainly in the centre and outside the suburban area, family households could well follow their own cyclical movements in the suburbs (circle in the right pane) without the need to move further out into the countryside (middle-aged families mostly move away from the single households and young families seem to follow older ones). This suggests that forces other than social interaction might be at play when people do move even further out. The planning department of Leipzig should increase incentives for middle-aged families to move to the suburbs (preferably, onto formerly developed land and into existing houses) to keep the system in the right pane. Attempts to plan according to the location preferences of the young one-person households should be avoided as this would shift the development into the left pane, where a high demand for suburban areas is manifest.

It is observable in the model that the suburbs in Leipzig remain attractive to different household classes and that the development does not come to a halt. If regarded as a self-organizing social system, suburbanization would continue evolving in waves; household classes would keep moving in and out of the model area. This means that policy and planning or other forms of interventions are needed to break this cycle either through regulatory measures that directly affect migration, and/or through a change in the social components of the dynamics, i.e. to reduce the attraction and repulsion mechanisms through community groups, neighborhood programs, social education etc.

QuAM results for Wirral

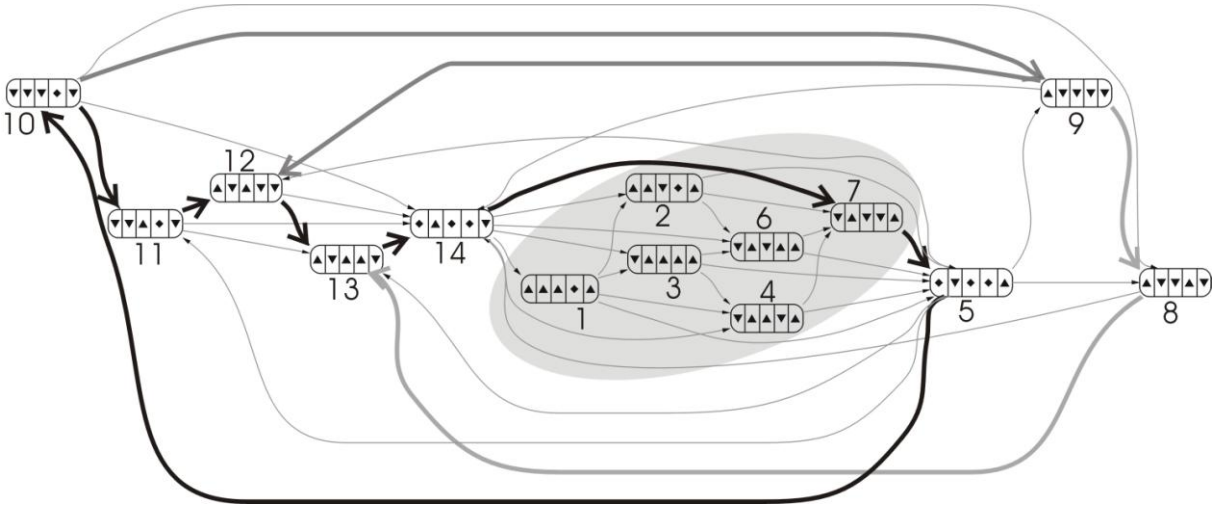

Figure 4: QuAM results for western suburban Wirral. For key to symbols see Figure 3 and the commentary in the text. The shaded area in the middle signifies a high demand phase for suburban living- the boom phase.

Key:

P1	P2	P3	P4	P5
Retired people households	Middle-aged, more wealthy families	Middle-aged single households	Middle-aged, middle class families	Young couple households

In the Wirral there is a possible configuration where all actor classes in the suburban area are increasing (or 'indistinct') at the same time (state #1 in the shaded area). From this state onwards, the Wirral experiences a highly dynamic phase, shaded in grey. Either the retired households or middle-aged singles will start to move out first. At the end of the highly dynamic phase, the Wirral passes to a state (state #7) where the young couples move in, as well as the more wealthy families (while other groups shrink). This point in time is a turning point as now a relatively low-demand phase follows. A common characteristic of the states outside the center is the trend toward a decreasing presence of middle-aged families and young couples. These are the residents most likely to buy or build new houses. If one wants to limit suburban land-use change, then development should remain outside the center as long as possible and as briefly as possible within it.

Six states exist after state #5 (states #8 to #13). There are three long pathways, all leading back to #1 with five intermediate steps (from #5 to #10, 11, 12, 13, 14—path 1—, or from #5 to #10, 9, 8, 13, 14—path 2— or #10, 9, 12,13,14—path 3), shown as thick lines in Figure 4. Staying on the prolonged paths can only be achieved if the trends of the retired households (path 2 and 3) or the middle-aged singles (path 1) first increase after the low demand phase in #10. Their preferences with regard to the characteristics of spatial attractiveness are therefore of particular importance for planners. These should be met through adequate investment in the suburban areas. In general, efforts should be made to avoid a situation where wealthy families

move to the suburbs first or at an early stage, since this shifts the development directly to the start of a new boom phase (arrow from #10 to #14). However, whatever measures are taken, suburban Wirral will gradually regain its former attractiveness, thus creating the conditions for a renewed boom in suburban development. Moreover, it would be difficult to keep the wealthy families out of the suburban development, since an influx of wealthy families has often been the predominant pattern in suburbanization. In these respects, the model results closely reflect real-world patterns.

In order for the Wirral to achieve greater sustainability, additional measures should be taken with the aim of shortening the boom phase depicted in the center of the diagram. This could occur if the wealthy families would first move out of the suburbs during a boom phase (from #1 directly to #5) or the retired households, the middle-aged singles and the less wealthy families jointly start to decrease—leaving the wealthy families increase with the young couples (#14 to #7). In such a state the wealthier families might move out shortly afterwards as they are repelled by the higher noise level of the young. These are the only circumstances that could mitigate the severity of ongoing land-use changes.

The model shows that, as in Leipzig, there is no persistent development state that would stabilize the household class trends over time. Rather, suburban development is a cyclical process. Both case studies show that no one sustainable development path exists and that all scenarios identified involve trade-offs, not least because the development will not stop—states of a relatively low demand will not persist.

(3) Implications on the contribution of social interactions in the suburban development process

Responses to questionnaires reveal that few households (13% in Leipzig and 15% in the Wirral) moved from the inner urban areas to the suburbs. More than 80% of the respondents moved within the suburbs or into the suburbs from outside the region in both cases. Assuming representative samples, the analysis shows that the traditional form of suburbanization, i.e. defined as the fringe area development from and around a strong urban center, is no longer the predominant direction of movement.

Furthermore, the model suggests that the interactions between actors lead to a complex, temporal dynamism in the suburban space. Different actor classes move in and out, following or fleeing from each other. There are no stable states of segregation or mixing; the same suburban region could lose and gain attractiveness again and again as long as the model characteristics do not change. Thus suburban development occurs in waves, which could continue indefinitely if only the social interactions of actors are taken into account.

These dynamics lead to the conclusion that successive waves of suburbanization or the establishment of new suburban areas can only be prevented by ‘external’, not modeled forces. This could be achieved, for example, through policy and planning measures that affect the attractiveness of a location, and/or the imprint of certain actor classes, and/or the actors'

preferences. The latter may also change in response to other societal forces, e.g. changes in values, social norms, economic conditions, or other powerful actors, such as industries or businesses. However, this study does not consider the potential influence of the numerous other actors and forces that potentially play a role in suburbanization processes (see e.g. Marcuse and Van Kempen, 2000, Kazepov, 2005).

Discussion and conclusion

The two suburban regions investigated in this study, Wirral/Liverpool in England and Leipzig in Germany, were used to reflect on the contribution of social interdependencies, i.e. social attraction and repulsion and segregation processes between different suburban actor classes to the processes of suburbanization. Social segregation was found to be stronger in the Wirral/ Liverpool, household clusters more distinct, and preferences and actor-class characteristics more clearly separated and discrete than in Leipzig. These differences are perhaps not surprising and reflect the different political histories and related social policies in the two cities. However, interestingly, in both case study regions traditional patterns of family and retirement suburbanization are accompanied by a newly identified form of suburbanization, i.e. the in-migration of single-person households.

Both household surveys were conducted in highly dynamic suburban areas; therefore the relatively high numbers of elderly respondents to the questionnaires is remarkable. However, as retirees have often more time, they might be more likely to answer the questionnaire—therefore introducing a bias into the results. Additional studies are needed to clarify their contribution to recent residential suburbanization. The questionnaire did not address or elicit information about ethnicity, which according to the classical model is one of the three factors of residential differentiation (family status, socio-economic status and ethnicity)(Fischer et al., 2004). Although ethnicity might still be important in many cities, Omer (2010) found that, in Western cities, socio-economic status is a more powerful determinant of residential location and that ethnicity is more important in traditional societies. This omission should therefore not seriously affect the validity of the results.

The modeling results show that substantial similarities in the case study areas exist. In both regions, social interdependencies lead to a fluctuation of residential in- and out-migration and waves of suburbanization. The social dynamics are mainly fueled by a desire to live in quiet and green surroundings, to be near to friends and family and to have access to affordable housing—all important drivers for suburbanization in both regions. Actor classes that reduce those qualities are avoided; those that increase them are sought for. In the model, these social attraction and repulsion processes continue until the dynamics are altered through external forces affecting either the physical characteristics of a place or the social dynamics directly. This means that it is very challenging to initiate more sustainable suburban processes, i.e. leading to less land-use change and/or reduced demand for suburban housing, as no persistent, sustainable qualitative state exists. Suburbanization can only be reduced by external forces, e.g., strict planning regulations and other external measures that impact actor class constellations and interdependencies or that restrict movement further out and provide preferential housing in the inner urban areas.

The model has a number of limitations. It differs from reality with respect to the legacy left by actor classes in the areas they have left. The model assumes perfect conditions of moving, i.e. that actor classes leave no mark, physical or otherwise, on an area after they have left. This is seldom the case in reality; for example, residential spaces are rarely converted into greenfield land. Perfect conditions of moving further imply instant reactions of households when changes occur in the neighborhood, which is little realistic. Buying or selling a house is often a long process and preceded by intensive considerations. The model is unspecific with regard to time. It cannot be determined when or how quickly the model situation will move from one state to the next. However, as no stable states exist, the development has to move on at some point in time. Cohort effects, i.e. people's changing of preferences over time, are represented in the model as moves by people from one cluster to the next. However, the model does not allow for preferences and characteristics to change to a distinct, new household cluster, which is not incorporated. Monitoring how household preferences change, in terms of both numbers of households and the nature of their preferences, is therefore vital to detect changes that may occur.

The model simulates processes in one model region. So, if a certain actor class shows a decreasing trend, the out-migrating households have to look for appropriate accommodation elsewhere, i.e. in the urban center, the suburban zone or further away from it. The social dynamics does not necessarily push people to outer localities if adequate housing that matches their preferences is available in central neighborhoods (e.g. see the Leipzig case). However, if urban regions become more dispersed, new areas with the same social dynamics could be born. These new areas would be independent of the former neighborhood, but could show the same internal characteristics with regard to repulsion and attraction between actors. New development on formerly undeveloped land seems therefore a result of (a) (weak) planning forces, i.e. inadequate restrictions to prevent suburbanization, (b) a lack of preferential inner urban housing (i.e. for a particular class), (c) the presence of 'disliked' actor classes in the inner urban area and/or (d) actors' expectations that the drawbacks of the old region will not be present at the new location.

The study proves that modeling actor dependencies and resulting social dynamics in contemporary suburbanization is vital for planning for more sustainable cities and suburbs. While covering only certain aspects of the suburbanization process and its forces—thereby accepting a radical reduction of complexity of the real world— it shows that the social dynamics between actors would not lead to a persistent, sustainable trajectory.

However, the change in suburbs over time keeps being an important research subject in itself. At this studies' point in time suburban movements in the case regions took predominantly place within and between suburbs or to them from outside the region indicating that suburban dynamics are no longer largely rooted in and dependent on the urban core, thereby confirming some of the degree of independence signaled in the L.A. school of urbanism and the post-suburbanization literature.

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