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# BEYOND GROWTH – URBAN DEVELOPMENT IN SHRINKING CITIES AS A CHALLENGE FOR MODELING APPROACHES

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## Abstract

Urban growth has been replaced by stagnation and shrinkage processes at many places in Europe during the last decades. Demographic changes and out-migration because of lack of jobs belong to the main impact factors. Urban planners are challenged by this new and dramatic development that impacts on housing markets, the utilization of infrastructure, local labor markets and the whole viability of urban structures. Urban Research is requested to elaborate new concepts and strategies for cities loosing population, facing a big amount of vacant building stock and a large-area re-use of brown-fields.

The purpose of this paper is to analyze the chances and limits of urban modeling to explain and assess urban shrinkage processes in their quantitative and qualitative dimension. First, expertise of new shrinkage processes is investigated in order to explain the need for urban modeling concepts. Second, it is discussed to what extent often misrepresented ‘fuzzy’ social science knowledge about urban shrinkage can be brought methodically together with ‘sizable’-data-based urban models. Third, variables and a prototype model structure are presented to approach to an urban shrinkage model. Finally, novel scientific questions and recommendations for further cooperation of social science and urban modeling are presented.

## Keywords

Shrinkage, demographic change, European cities, quantitative and qualitative research, urban modeling

## 1. Introduction

### 1.1. The context of urban shrinkage and demographic change in Europe

Urban shrinkage is not a new phenomenon. Historically seen, urban populations were decimated by warfare, natural hazards and epidemic plagues. A recent phase of shrinkage began after 1945. Since then, urban growth has been replaced by stagnation and shrinkage processes in many countries. Having started in Europe’s old industrial regions like Northern England, the Scottish Clyde side or Lorraine, and the “rust belt” in Northern America, these processes affect today city regions throughout Europe and world-wide. Recent shrinkage processes affect more and more Eastern European, Japanese and South African cities (Rieniets, 2004). Although if not whole urban Europe is affected by shrinkage and there are yet growing cities like most of the capitals, our paper presents empirical evidence from Eastern Germany as an especially striking example of city shrinking that is related to dramatic socio-economic changes after the reunification in 1989. We focus on this extreme example since it shows how shrinkage unhinges hitherto concepts of urban development.

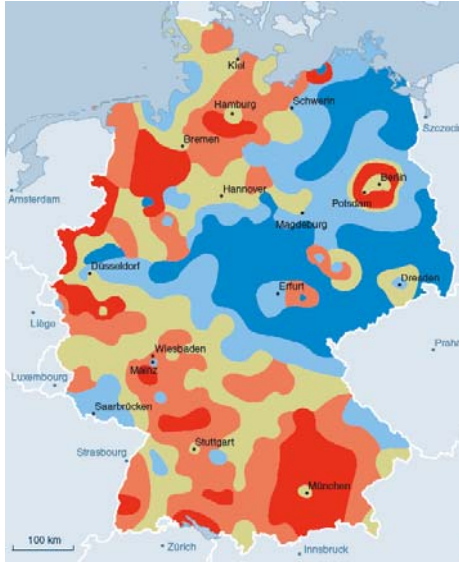
Shrinkage processes unveil that we have to deal in the future with urban regions beyond growth: with cities loosing inhabitants, housing stock falling vacant, residential and commercial areas remain empty and un-used and infrastructures getting under-used. It is mainly demographic change including decreasing birth rates, ageing, and post-

ponement of marriage and childbearing that brings about such developments on the one hand (Haase et al., 2005). On the other hand, many young and well-trained people are forced to out-migrate because of closure of companies and unemployment. As a consequence, the socio-spatial imbalances within a city corpus are rising. Deprived areas losing residents are to be found in close neighborhood with upgrading districts. Disproportions between supply and demand of housing and urban services are rising. At most places, shrinkage processes in the core city coincide with further urban sprawl and land consumption (Couch et al., 2005; Nuissl & Rink, 2005). The intra-urban differentiation is accompanied by regional differentiation. Within the country, economically sound and growing regions exist in an ocean of decline and downgrading (Fig.1).

Urban policy makers are challenged by this new and very complex development – the paradigm of growth has to be replaced also in practice-related thinking and in developing new strategic goals for urban futures, treating shrinkage not only as a menace but also as a chance for re-shaping urban spaces (Hannemann, 2000).

During the last years, research discovered shrinkage as a blind spot that urged to be lightened. A body of inter- and transdisciplinary expertise on shrinkage has developed. Whilst studies on Eastern Germany where urban shrinkage appears in its most dramatic form occupy a kind of ‘forerunner’ role (Kabisch, 2006), the comparative view on shrinking European cityscapes suffers still from a lack of empirical evidence except from rare examples (Bernt & Kabisch, 2003). Knowledge on shrinkage processes, their

origins and consequences for urban systems gains more importance in particular for modeling since modelers are challenged to develop new approaches, indicator sets and rule systems (Haase et al., 2006).



Legend: dark blue = strong decrease, light blue = smooth decrease, beige = stable, light red = smooth growth, dark red = strong growth.

**Figure 1:** “Islands of growth in shrinking landscapes” – spatial simulation of population development in Germany until 2020, BBR-prognosis (BBR 2005).

### 1.2. Research objectives

Set against this background, this paper analyses the chances and limits of urban modeling to develop an approach to explain and assess urban shrinkage processes in their quantitative and qualitative dimension. After having identified predictor variables for the new ‘process quality’ of shrinkage in the areas of population, housing, urban pattern, land use and response from urban planning, it discusses to what extend social science knowledge can be brought together with quantitatively based urban model concepts. Methodically, the paper figures out

- (1) in what way shrinkage processes challenge hitherto existing urban modeling approaches,
- (2) why this shrinkage phenomenon demands both, updated prognostic and observation instruments as well as procedures,
- (3) what kind of methodical implications for the development of an urban model that includes shrinkage as an accepted urban development strategy are required.

To allow for a more detailed picture, the paper draws on empirical evidence from Eastern Germany where dramatic shrinkage processes pre-dominate the urban presence and future alike.

### 1.3. Case study: Eastern Germany

The recent development in Eastern Germany is a case in point to show an ‘advanced’ or even ‘extreme’ stage of shrinkage and its impact on urban development, housing markets and usage of infrastructures. Shrinkage is pushed by three reasons: Firstly by a sharp decrease in birth rates after the political change in 1990 that brought Eastern Germany lowest-low birth rates in Europe (0.77 children per woman in 1995; INKAR, 2003). Secondly, most of Eastern German cities have been facing dramatic losses of inhabitants due to job-driven out-migration to the western part of the country. And a third reason is the wide-spread suburbanization during the 1990s (Haase & Nuissl, 2006; Couch et al., 2005).

Eastern Germany was faced with loss of population after 1989 of about 1.2 million people (8% of whole stock). Most cities lost between 10 and 20% of their residents (mean for big cities 1990-1999 16%). Extreme cases such as Weißwasser, Hoyerswerda and Wolfen lost between 30-40% of their inhabitants. Such type of city was mostly dominated by one major enterprise or administrative authority which was closed down after 1990. As result, economic base and local identity of these places eroded dramatically.

In consequence, flats and houses are falling vacant. Vacancy is no more restricted to uninhabitable housing but also to completely renovated building stock. The supply outweighs the demand even if at present household numbers still continue to rise. Whole residential districts exhibit vacancy rates higher than 30 or even 50%.

In this vein, demolition came into serious discussion. As a new strategy, a federal program of urban restructuring (BMVBW, 2003) operates in terms of a guideline to organize and finance the demolition of overhang of housing stock and revaluation of the remaining residential areas. It further represents a scientific approach to deal with urban development under the conditions of non-growth and shrinkage.

The dramatic appearance of shrinkage in Eastern Germany produced a flurry of scholarly activities in different social sciences. Conceptual frameworks such as gentrification or regeneration are about to be modified and adapted to local settings, rarely used approaches like reurbanisation are suggested as explanatory frames and strategies to counteract inner-urban shrinkage. In case of cities that are loosing considerable parts of their housing stock and inhabitants, brand-new ideas like the one of ‘temporary residential areas’ that still exist but will see a complete demolition in a foreseeable future have entered the scientific debate.

## 2. Shrinkage processes and pattern as a challenge for urban modeling

### 2.1 Urban modeling: debate and approaches

In order to analyze land conversion and decline of the urban fabric in cities caused by the processes described above, models can be used as innovative tools to support spatial urban planning. Frequently used approaches in urban modeling are agent-based models (Miller et al., 2004; Waddell, 2002), logit models of discrete choice (Landis & Zhang, 1998a; 1998b) and complex cellular automata (CA) models (Silva & Clarke, 2002; Clarke et al., 1997; White et al., 1997; Wu & Webster, 1998).

Urban models that deal with interactions between urban land-use change and its socioeconomic driving forces are mainly implemented as agent-based models (ABM). These models often incorporate discrete choice theory (Ben-Akiva & Lerman, 1985). The application of agent-based models is reshaping agents' activities from immobile decision to mobile action within a virtual space (Loibl & Tötzer, 2003). Most CA and ABM model-applications however deal with urban growth as the predominant form of urban development whereas the process of urban shrinkage remains still out of focus (Haase, 2006).

The determining factors of shrinkage and the agents of this change, e.g. new household compositions, are only partly sizable as 'quantifiable items'. Urban modeling faces the necessity to find new approaches that anticipate future development trends on condition of simultaneous processes of growth and shrinkage.

### 2.2 Pre-requisites to model urban shrinkage

In order to approach to an urban shrinkage model the following aspects have to be considered:

- (1) Shrinkage as an urban phenomenon seeks for additional experience-based and agent-, i.e. household-related, knowledge to explain the process.
- (2) A model approach has to focus on the development of predictor variables and indicators for shrinkage.
- (3) The model concept needs to use evidence provided by quantitative social surveys and statistics.
- (4) The model has to incorporate variables that are not simply sizable or to draw them from statistics in form of proxy, fuzzy or probability data (e.g. household structures, mobility behavior, decisions by housing market players, interview panel data).
- (5) In doing so, social scientists have to accept that dependent (=specific) data are taken as 'pattern' for a development to be simulated as an 'ordinary or standard case' (e.g. household structure per 'urban fabric type' or 'typical mobility behavior per household type').
- (6) Social scientists are requested to provide modelers with quantitative and qualitative proxy-data that could be classified, (dis)aggregated or translated into model rules. Our experience with self-administered, household based questionnaire surveys shows that it is indispensable to

base models not only on proxy-data. If models intend to reflect household behaviour, households have to be the subjects of a prerequisite empirical database.

Reasonable results for all social scientists, modellers and practitioners are only to be expected when the procedure and the model concept are very clear in terms of objective of the modeling, set of predictor variables and their inter-play as well as probable directions and dimension of changes.

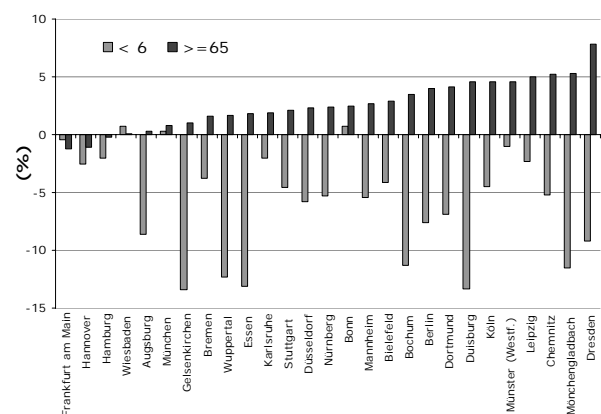
Due to the newness of the shrinkage process, (semi-) quantification at local urban level interdisciplinary modeling approaches offer a promising way to improve our knowledge and to illustrate different scenarios for the 'future with shrinkage'. Especially there, where complex processes are about to pass, a view on both imaginable and desirable scenarios is important to shape future policies and its instruments (Caruso et al., 2005).

## 3. Model approach

### 3.1 Predictor variables for shrinkage

#### *Population and households*

Urban shrinkage is driven by demographic changes including new household types and decreasing birth rates as well as out-migration as the Eastern German example explicitly shows. Changes related to the concept of the Second Demographic Transition (SDT; van de Kaa, 1987, 2004) imply a coincidence of (i) sharp decrease in birth rates, (ii) ageing (Fig.2), (iii) smaller and less stable households (Fig.4) and (iv) societal changes in terms of a diversification of lifestyles.



**Figure 2:** Demographic change in German Cities 1995-2003: age classes <6 and >65 years (INKAR, 2003).

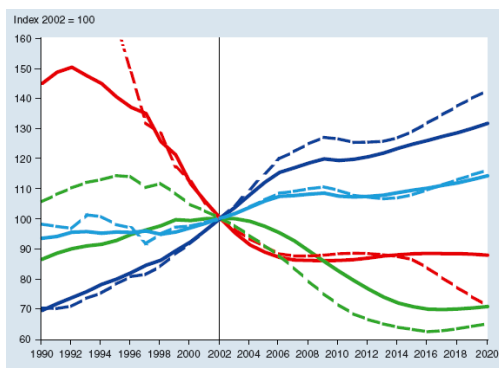
Recent research brought up that households act as nexus between changing demographics and residents' housing preferences and thus households are the 'subjects' and 'agents' of housing markets (Buzar et al., 2005). Figure 3 gives an idea on the social-science based household type classification of Leipzig distributed over cohorts.



\*choice of household types context-related, the age group 40-50 was therefore not included

**Figure 3:** Household types\* and their age-class distribution of Leipzig, 2003 (Haase et al., 2005; Stadt Leipzig, 2004a)

A simulation of the household development in Germany until 2020 (BBR, 2005) suggests that in particular elderly one- and two-person households (pensioner couples, widows) will increase (Fig.4). Further, diverse multi-person households such as cohabitation households, patchwork families and flat-sharers will get more importance for the housing market of a city. Subsequently, as Fig.5 implies, a considerable turn of the overall household development in Germany has started to pass recently (2002).



Legend: dark blue = pensioner couples, light blue = widows, green = families, red = young families.

**Figure 4:** Household development in Germany 1990-2020, BBR-prognosis (BBR 2005).

Correlations between selected variables and share of residential vacancy and correlations among variables were tested to select statistically significant socio-demographic variables that are listed in the municipal statistics and are related to the above discussed household types. Here, e.g. the variable “age group >65” represents elderly one- and two-person households and the variable “% married people” represents families and single parent households. Unemployment rates were not included into the first model prototype even if showing a significant correlation to vacancy. They will, however, impact more on residential mobility in future because recent reforms of the social welfare system in Germany will force affected households to seek for smaller flats. Due to the fact that statistical data on household structures are not sufficiently recorded, such proxy variables with representative character are used to calibrate the shrinkage model.

The correlation coefficients in Table 1 give an idea of how housing vacancy can be interpreted by social fea-

tures. Based on these outcomes, the variables ‘out-migration’ and ‘share of population above 65 years’ were identified as crucial for the model, as they have the strongest correlations with vacancy and are not correlated to each other.

**Table 1:** Correlations between residential vacancy and social predictor variables for the city of Leipzig

Variable	R <sup>2</sup> to vacancy
Out-migration (no)	0.7*
Foreigners (%)	0.4
Married people (%)	- 0.6*
Unemployment (%)	0.6*
Car owner (%)	- 0.6*
Age group >65 years (%)	0.8**
Age group <15 years (%)	0.1*
Social welfare recipients (%)	0.6*

\*\* 1% ; \* 5% significance level (Pearson's r<sup>2</sup>)

### Housing vacancy and demolition

Residential vacancies of 1.3 million flats (15% of whole housing stock; Bernt, 2004) in Eastern Germany prove that an extreme supply outweighs demand significantly in the long run. In the city of Leipzig, approximately 50.000 apartments are empty, 16% of the whole housing stock.

Prefabricated blocks on the outskirts predominantly demolished due to big amount of apartments owned by one housing enterprise. For Leipzig-Grünau, one of the biggest prefab estates in Eastern Germany, population decreased from 85,000 to 49,000 from 1989 to 2004. From the former 35.000 apartments 2,700 already demolished and further 2.700 are foreseen for demolition until 2007 (Stadt Leipzig, 2004b).

Demolition of the urban fabric produces new spatial pattern such as perforated structures with decreasing house density, demolition along the urban periphery, demolition corridors within a city or, respectively, ‘housing islands’. For the model approach, variables such as land parcel, housing unit and flat for the residential sector are decisive. Threshold values such as demand-supply-relations for different housing estates at the residential market and house density values could serve as decision rules for construction and demolition in the model.

### Urban planning and policies as constraints

Administrative urban planning was focused up to present on growth. Today, urban shrinkage presents a new challenge forcing hitherto developed strategies and policies to be adapted. First empirical studies on social consequences of shrinkage in medium-sized cities came up with recommendations highlighting interests and opinions of involved actors (Kabisch et al., 2004). Diverse patterns of owner structures in both old built-up areas and prefab estates make planning processes complicated and less transparent. Here, in particular, social science-based empirical knowledge is indispensable for modeling tools which seek to support planning.

Urban policy delivers contextual constraints for the model approach which could be spatially implicit such as verbal arguments and guidelines (e.g. shrinkage starting from the urban periphery to the core city) as well as spatially explicit in form of planning maps. As one pathway of urban shrinkage the following ‘compact city concept’ is preferred by regional policy makers: The centre of the city is foreseen to be preserved as functional core to maintain urban quality of life in compact structures and to avoid perforation. Demolition activities should be concentrated at the periphery. In fact, not in all cases, the concepts of the policy makers are in line with those of the housing enterprises who take the final decision regarding demolition of their housing stock. But nevertheless, the mentioned scenario could be coded in the model by setting demolition priority  $D$  equal to distance to city centre  $D = I_{cc}$  with  $I(z)$  is the predictor variable at location  $z$ . Municipal strategies to counteract shrinkage are to be incorporated more explicitly into the compiled model.

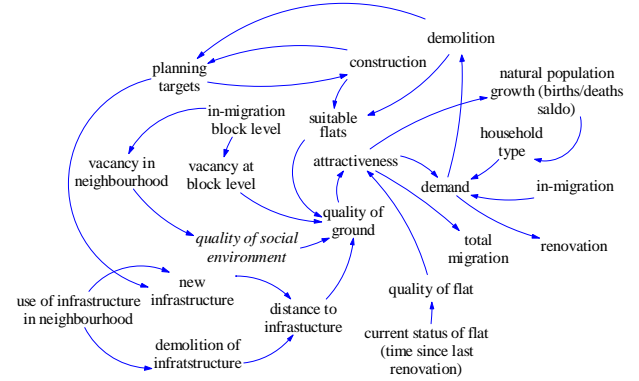
Shrinkage and demolition of housing estates provide new place for other uses such as spacious living, less density and more greenery in the neighborhoods which is equal to typical suburban advantages of housing. Thus, the city administration of Leipzig plans single family housing in the inner city. Based on policy expert knowledge the following additional variables and rules could be selected. These include the two spatial variables ‘distance to urban sub-centre’, ‘distance to main roads’ and ‘adjacent open areas’ to represent the hypothesis that proximity to local facilities and green spaces is preferred. Furthermore, the variable ‘urban structure type’ was included following expert interviews that stated the importance of incorporating housing preferences and ownership issues (Tab.2).

**Table 2:** Spatial predictor variables and model rules

Variable $I$	Rule and calculation proposal
Mean distance to sub-centre (providing admin. functionality)	Maintenance of urban cores. $D = I_{cc}$ where $D$ is the demolition rate.
Mean share of urban green in the direct neighborhood ( $UG_{grenz}$ )	Demolition occurs adjacent to already existing green. $UG_{grenz} = \sum_{n=1}^n wBUG_n$ where $UG$ is urban greenery cells and $B$ the weighted bordering cells/polygons.
Mean distance to main roads ( $dr$ )	No demolition along main roads. $D = f\left(dr = \frac{\left(\frac{\sum_{i=0}^n (d_{min,i} \cdot c_i)}{\sum_{i=0}^n c_i}\right)}{R}\right)$ where $D$ is demolition rate and $dr$ is the mean distance to a main road ( $R$ ).
Urban structure type (UST)	Old-built up housing estates are more valuable than prefab houses. $St_{grenz} = \sum_{n=1}^n wBSt_n$ where $St$ is the urban structure type and $B$ the weighted bordering cells/polygons.

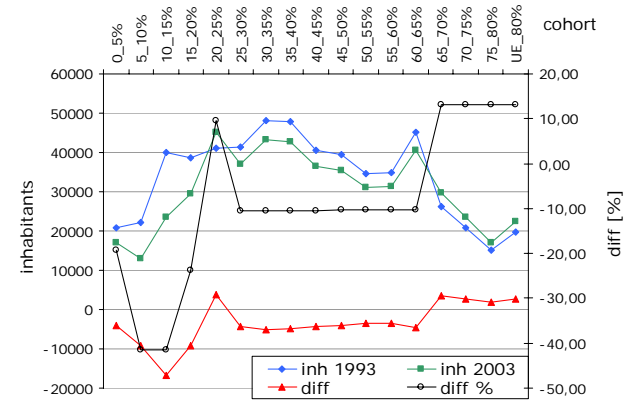
### 3.2 Model structure and example equations

A concept model for setting up spatio-temporal and thematic causal-feedback-loops had been formulated in order to draw a first sketch of the complex housing sector under conditions of shrinkage based on household types (Fig.6).



**Figure 6:** Concept model of residential preferences, related construction, residential vacancy and demolition

In the first prototype of the shrinkage model a population growth approach works in line with a Leslie population model to simulate population dynamics (cohorts; for the city of Leipzig Fig.7; Sharov, 1996). Based on a set of weightings ( $w$ ) the residents are assigned to the household types relevant for the SDT given in Figure 3 for the example of Leipzig.



**Figure 7:** Simulation results for the age cohorts 1993 and 2003 related to the differences (diff no, %) to real numbers of Leipzig.

In the model, households act as agents. They are derived from recent socio-demographic findings (Fig.3). Each household type holds a residential mobility  $M_h$  that is related to the preferred surrounding social structure  $St_h$  (at the moment in the first prototype restricted to the household type structure; marked in *italics* in Figure 6), the urban land use type and facilities such as green space or transport infrastructure accessibility. Eqs. 1 and 2 show first examples of the calculation of the social structure variable (variable from the concept model in Fig.6, respectively).

$$M_h(i, j) = f(St_h(i, U(j, k))) \quad (1)$$

$U$  is the variable expression for the surrounding social structure  $St_h$  for a household  $h$  at locations  $i$  and  $j$ . The weighted ( $w$ ) social milieu for every location  $i$  and household type is calculated as follows:

$$St_h(i, U) = \frac{1}{\sum_{h=0}^n n(h, U)} \sum_{h=0}^n (wSt_{h,i,h} \cdot n(h, U)) \quad (2)$$

Migration occurs between land parcels that contain housing estates and flats. For every urban land use type, a mean housing stock density and a mean total number of flats had been derived. Further, to every household type had been assigned a land use type in terms of moving preferences (Preference  $h$   $i$  for UST  $j = 0.01$  and  $1.0$ ). Currently, all relationships of Figure 6 are translated into similar equations.

#### 4. Conclusions

To conclude from this study, shrinkage, population losses and vacancies unbalance the balance of existing urban structures, and produce new patterns of cityscapes. An innovative model approach that takes into consideration the consequences of demographic change needs to be developed to come to a better understanding of the complex interactions of the included variables. The model structure and the relationships base on relevant predictor variables as well as urban policy contextual constraints. To allow for a more comprehensive look at shrinkage, weightings of model variables as well as proxy-data for 'not-sizable' variables have to be integrated. For a start, the model to be finally developed should be able to give an idea to scientists what kinds of future scenarios are imaginable, how desirable ones can be reached or supported respective inconvenient trends being omitted. With this approach, new insights and knowledge could be generated which needs further accompanying empirical research which mirrors the model results. Discussing the strengths and weaknesses of such a combined research strategy and find a common language for modelling shrinkage is an exciting challenge.

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