Derivation of predictor variables for spatial explicit modelling of 'urban shrinkage' at different scales

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Abstract

Demographic change has become a major topic for Central, Eastern and Western European cities and urban regions which will be on a "non-growth or decline path" for at least the coming 25 years. Growing and shrinking communities will exist simultaneously side by side within densely urbanised regions. The trend towards further suburbanisation and dispersion observed in the 1980s in Western Europe and the 1990s also in Central (Eastern) Europe accompanying the transition process will decrease without being balanced by a sustained re-urbanisation. This urgently requires rethinking on the growth-oriented approaches of urban development and alike modelling. They must be enhanced by a "decline or shrinkage paradigm."

The paper focuses on the discussion of predictor variables that explain urban shrinkage and residential decline in form of residential vacancy. In the first part the phenomenon of urban shrinkage will be embedded into the historic and current European urban development, most of all looking at examples of the demographic situation in Eastern Germany. In a second part, the paper expands briefly on discussing obvious spatial effects of 'non-growth' and 'shrinkage' in the urban landscape. The major part of the paper concentrates on the identification and testing of predictor variables that explain the quantity and spatial distribution of residential vacancy. The statistical analysis proves that out-migration, share of aged people, unemployment rate and share of social welfare recipients as social variables as well as spatial pattern of urban structural type, distance to the urban (sub-)centers and to urban green explain the spatial distribution of residential vacancy in the city of Leipzig. The paper ends with some initial ideas on the integration them into a GIS-based spatial explicit rule-based model.

Keywords: demographic change, residential vacancy, predictor variables, urban shrinkage model

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1 Introduction

Currently, we observe diverging processes of growth and shrinkage in many Central and Eastern European Cities (Eastern Germany, Poland, Baltic States, Austria). Whereas in the 80ies and 90ies partially accelerated through the crash of the socialist system mostly urban growth and suburban development occurred, today European cities are faced with a general decline of population as well as an increase life expectancy ('aging') as results of a considerable demographic change in whole Europe and worldwide (Figure 1, Antrop 2004, Cloet 2003, Lutz 2001). These processes and derived pressures such as changes in age group spectra and migration influence current land use pattern taken as the 'state of the environment' and drive future land use changes in urban areas enormously (Deutsch et al. 2003, Ekins et al. 2003, Haase et al. 2005).

Most evident here is the occurrence of residential vacancy and industrial 'brownfields' or fallow lands in the cities which are in combination with the population decline stand for the phenomenon of 'urban shrinkage'. In spite of the urgency to tackle this problem and to improve spatial planning policies towards acknowledging non-growth and shrinkage as current urban phenomena in many parts of Europe still the paradigm of 'growth' is on the agenda (Müller & Siedentop 2004). Alike, urban modelling is also very restricted to growth phenomena and are not considering the shifting of core areas of urban dynamic development (Antrop 2004, Haase et al. 2005). However, the effects of shrinkage will have an enormous influence on the development of cities within the next future: the decline of the population due to low birth rates, massive out-migration and aging of the urban population will lead to a decreasing demand on the residential market. Related economic shrinkage processes due to declining purchasing power and low investment rates in 'urbansheds' will have enormous consequences on the attractiveness for new economic investments as well as for in-migration. Furthermore, and most evident for the urban ecosystems, the consequences of shrinkage on the demand and availability of ecosystem services needed to sustain a high and even increasing status of quality of life for European urban citizens is to be requested.

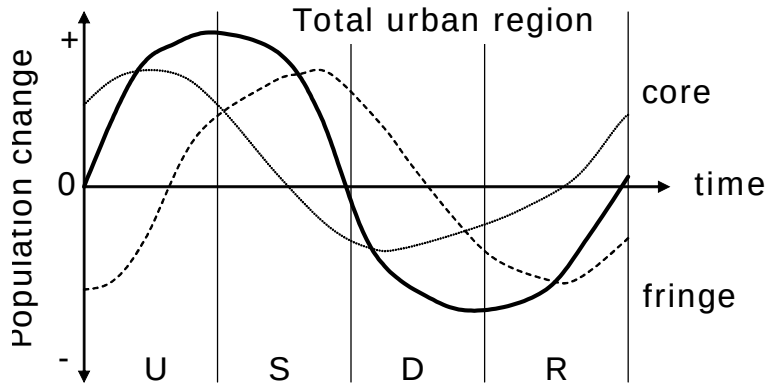

Figure 1: Cyclic model of the stages of urbanization based upon the population change in core and fringe zone of urban agglomerations: U, urbanization; S, suburbanization; D, disurbanization or counterurbanization; R, reurbanization phase (modified after Antrop 2004)

Moreover, urban land use pattern will be influenced and re-shaped through non-growth and shrinkage which might lead to segregation and further spatial differentiation pattern ending in an extreme perforation. This might mean on the one hand areas of high density of residential land use and on the

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other hand urban 'land abandonment' as well as extensive use of natural or ecosystem resources or at least 're-naturation' along an urban-rural gradient? The above raised findings make very clear that the following questions have to be answered by urban, spatial and ecological science:

- What means non-growth and shrinkage in 'urbansheds' and where does it occur?
- What are relevant and robust indicators that enable us to analyse the socio-economic drivers as well as the spatial and environmental implications? And, finally,
- How do we integrate first ideas of mitigating urban shrinkage, demolition of housing estates and allocation of new land-use pattern, into a spatially explicit rule-based model?

Here, the paper delivers a conceptual contribution to the recent discussion.

2 Objectives of the paper

Considering the above raised questions, analysing and predictor variables describing the shrinkage-related land use changes and its effects for the urban ecosystems are most important. According to an existing lack of a 'theory of shrinkage' and missing spatial explicit modelling or even analysing approaches dealing with non-growth, shrinkage and spatial demolition it is a scientific challenge and objectives of this paper

- to extract such predictor variables from a huge catalogue of urban socio-economic and environmental monitoring driven indicators elaborated by many studies for different urban landscapes and scales based on literature, expert and statistics (Nuissl & Rink 2005, Hemphill et al. 2004, Haase et al. 2005),
- to analyse the spatial shape of shrinkage-related land use (change) and, finally,
- to present a conceptual rule-based model for the spatial shape of urban decline and shrinkage.

3 Findings of the recent shrinkage of urban areas

3.1 Demographic change in European 'urbansheds'

Currently, in many European countries we observe a significant shift in urban land use pattern and development due to a rapid and long-time ignored demographic change, which has become more obvious than before within the last few years from 0.2 % growth to < 0.05 % (CEC 1997, Cloet 2003, Lutz 1996, 2001, Figures 2 and 3, Table 1).

In recent studies of population development an average population decrease of 11% within the EU-15 countries until 2050, with extreme values for Italy (25%), Spain, Switzerland and Austria (20 %) is assumed. For the enlarged EU-25, the average estimated decrease is 18% (Kröhnert et al. 2004). This general tendency is highly correlated with continuously decreasing birth rates (currently 1.4 children per woman in Europe, Lutz 2001, Eurostats 2005, cf Figure 3), a steady increase in life expectancies, and significant changes in the age spectra of populations.

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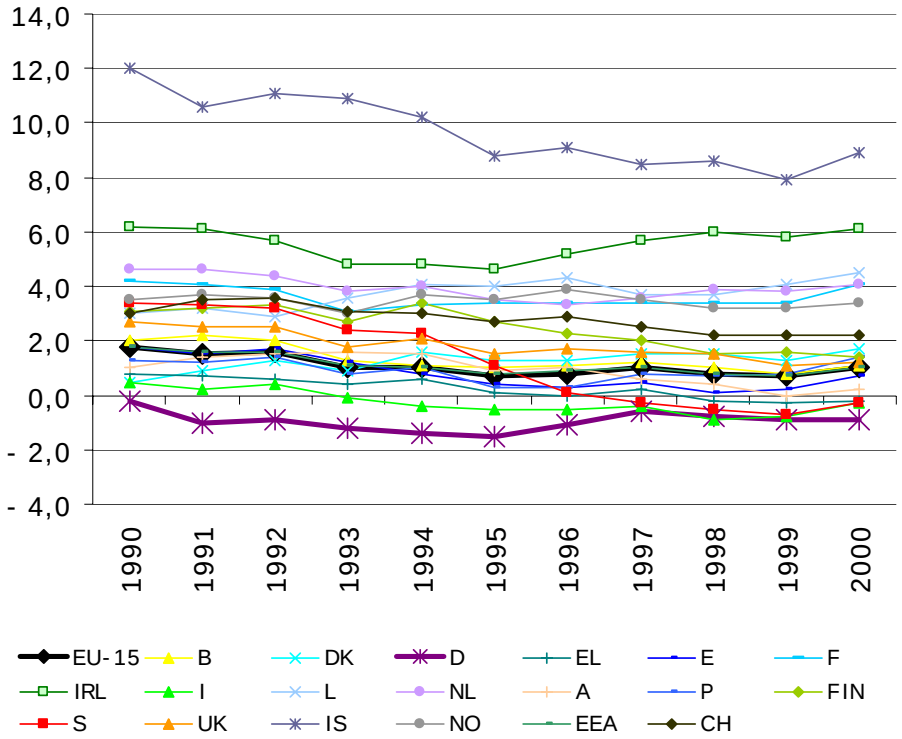

Figure 2: Natural population development per 1000 inhabitants in European cities 1990 – 2000 (data source: own calculations according EUROSTAT statistics)

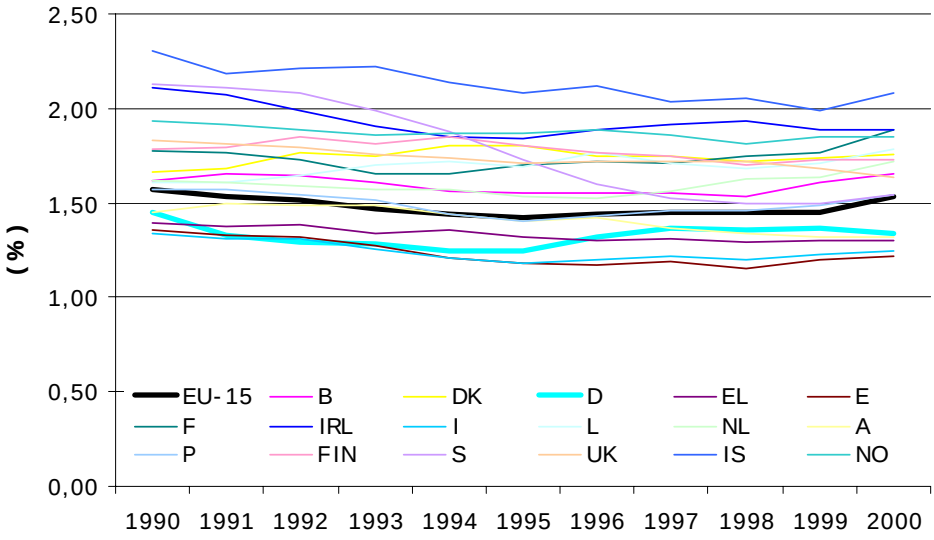

Figure 3: Fertility rate per 1000 inhabitants in European cities 1990 – 2000 (data source: own calculations according EUROSTAT statistics)

Today, we find in European cities the following general demographic trends with spatial relevance: Depending on total number of population, demographic structure and migration potential we have to consider a “decline” of total population due to the generative behaviour of the population based on the indicator ‘birth rate per woman 1.3-1.4) which will develop further negatively, in-migration at the national, regional (rural-suburban-urban) and local (urban) scale as well as an increase of the total

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number of population despite of the decline of the birth rates until 2010 – 2020 (for Germany). After 2012 there have to be considered a negative trend of the total number of population (Lutz 2001).

Moreover, urban systems are faced with aging in terms of decreasing birth rates and an increasing life expectancy leading to a continuous aging of the total population. This trend became already obvious comparing mean values such as the median age (38.0 in 1998; >50.0 in 2050). Furthermore, there have to be considered an increasing heterogeneity of the population due to international (in-)migration and a differentiation of the population (Mäding 2004). Already today there could be observed an increasing number of single households in urban areas (most of all in large cities > 200 000 inhabitants).

3.2 The consequences: rural-urban differentiation and vacancy of residential areas

Regional effects of the demographic change

The above drawn development implicates a major spatial relevance for the land use development and land use pattern in European cities. It leads to high inner-urban discrepancies between growing and shrinking residential parts with a strong gradient from the rural, peri-urban to inner city areas. These areas are characterised by very different population and residential densities, migration potentials and land use intensities reaching from fallow land or large-scale brownfields to extreme dense tenement block housing estates in the direct neighbourhood. It is assumed that this increasing number of persons sharing one flat influence the residential market positively and still reduces the residential vacancy for a limited time frame. In Germany for example, there has to considered still a notable East-West-migration flow due to economic and investment decline and high unemployment rates in Eastern Germany.

To improve the theoretical knowledge on shrinking processes, the allocation of shrinkage and its spatial effects (deconstruction, demolition) at different scales (regional and local scale) need to be investigated. In some of the European cities, former ‘boomtowns’, that decline now, research has been started recently on urban shrinkage. In most cases this research focuses on population decline and a decrease of total population density in the central parts of the city. The studies correspond to vital and economic statistics that are based on overall, individual, and household statistics. They refer to boroughs or urban structures (structural types) such as single family houses, prefab housing estates, historical districts, commercial sites as well as (old) industrial areas (Banzhaf et al. 2005).

The phenomenon of shrinkage in residential areas in European cities has been noticed and already described since the 50/60ies (Couch et al. 2005). A literature review brought up the idea that shrinkage had been tackled most of all as a problem of restructuring of old-industrialised parts, neighbourhoods and boroughs of a city. On the contrary, today, we find most of all an accelerating residential vacancy in housing estates of the inner city and the new built-up areas (Haase et al. 2005, Figures 4 and 5).

Couch et al. (2005) compare Liverpool, Britain, and Leipzig, Germany, as two cities undergoing the profound functional transformation from a former industrial metropolitan agglomeration to a service economy based city. Another study on Ivanovo, Russia, discusses a city in post-socialist economic transition in the aftermath of Perestroika (Sitar & Sverdlov, 2004). Booza et al. (2004) take in their research Detroit, USA, as an example for an American metropolis which turned from growth to a today shrinking city. Dura-Guimera (2003) investigates on the processes of urban de-concentration and simultaneous urban sprawl dynamics including social processes in the ‘Barcelona Metropolitan Area’, Catalonia, Spain.

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Table 1: Population projections for Europe (2010/2020) by different organisations (data source: calculations according to EUROSTAT data 2005)

Country	Eurostat, low estimate		Eurostat, baseline estimate		Eurostat, high estimate		National statistics		United Nations	
	2010	2020	2010	2020	2010	2020	2010	2020	2010	2020
B	10 089	9 898	10 484	10 658	10 824	11 270	10 328	10 338	10 136	10 017
DK	5 215	5 075	5 452	5 526	5 679	5 950	5 496	5 568	5 327	5 283
D	81 722	79 074	84 854	84 670	88 779	91 559	81 036	78 445	82 032	80 996
EL	10 614	10 450	11 079	11 269	11 422	11 900	:	:	10 554	10 141
E	38 981	37 809	40 372	40 307	42 198	43 504	39 800	39 331	39 089	37 627
F	59 614	59 307	61 387	62 831	63 626	66 896	61 721	63 453	60 597	61 500
IRL	3 626	3 652	3 760	3 909	3 939	4 248	3 832	3 947	4 016	4 302
I	55 443	52 753	57 633	56 543	59 820	60 334	57 495	55 939	55 782	52 913
L	442	445	471	501	501	555	459	488	457	464
NL	15 900	15 819	16 659	17 204	17 231	18 319	16 470	16 898	15 973	15 876
A	8 018	7 882	8 326	8 443	8 749	9 231	8 283	8 354	8 348	8 279
P	9 927	9 808	10 293	10 513	10 738	11 265	:	:	9 777	9 515
FIN	5 103	5 008	5 290	5 350	5 519	5 777	5 233	5 222	5 235	5 266
S	8 818	8 792	9 176	9 470	9 609	10 248	9 043	9 222	9 039	9 099
UK	58 569	58 013	60 146	61 038	62 508	65 326	60 352	61 082	59 331	59 845
IS	288	294	297	311	305	326	298	312	304	321
NO	4 476	4 494	4 663	4 851	4 819	5 156	4 656	4 831	4 648	4 777

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Considering recent statistics on population development, in- and out-migration with respect to a specific urban development of Mediterranean cities in Europe Dura-Guimera analyses the decline of population in the central urban area (city centre, core area), an increase in the urban periphery, and the expansion of a dispersed city (summarized in Banzhaf et al. 2005). He specifies the same process which is described as the phenomenon of urban 'perforation' in Germany.

Whereas during the 80ies and 90ies most of the declining regions were thought to clearly defined as old-industrialized areas today it becomes more and more obvious that inner-urban, sub-urban and rural areas are all affected by non-growth and shrinkage but at very different levels and with very different spatial consequences and implications (Müller & Siedentop 2004). Haase & Steinführer (2005) found recent processes of re-urbanisation of the inner-city areas in Leipzig (Germany), Brno (Czech Republic), Leon (Spain), Ljubljana (Slovenia) and Bologna (Italy) represented by re-urbaniser groups such as patchwork families, single pairs and flat sharers.

There has to be considered a polarisation of demographic development between the Western and Eastern European cities in the 1990ies finding a population growth in many West as opposed to a relatively general decline in the East. In most of the Eastern European countries the societal transition after 1990 initiated a similar population shock. Moreover, we find an interregional and intraregional de-concentration of population and employment in Western Germany to the benefit of rural areas comparatively distant from core cities and relatively mature suburban areas. This trend is to be found in the Netherlands or Great Britain, too. If this development will continue in coming decades central cities in Western and Eastern Europe and most of all peripheral rural areas would be most strongly affected by demographic change. Less affected would be suburban and rural areas as well as the inner suburbs of major cities. For example, regions with a strongly declining population (>1%/a) are still to be found only in Eastern Germany whereas in the Western part are still growing demographically.

Empirical studies suggest that relations between central cities, suburbs, and peripheral rural areas need to be reassessed under conditions of demographic stagnation or decline (Haase & Steinführer 2005, Müller & Siedentop 2004, shrinking cities - www.hatjecantz.de). In the mid-1990s there were few regions that did not fit the overall picture of a West-East European gap in demographic development. They included the suburban growth belts, the shrinking old industrial regions and core cities that had failed to compensate local migration losses through foreign immigration.

Due to strong increases in international and internal migration, such differential developments were, however, "externally" concealed by a rise in the population of the overall area. Only with the decline in immigration from abroad that set in the mid-1990s did demographic decline become openly apparent in parts of Western Europe. Not only old industrialised regions, which have long since been suffering a decline in population, but also rural areas are increasingly affected by demographic shrinkage - a phenomenon last observed in comparable dimensions in the 1970s and early 1980s. After the political transition suburban growth belts were developing in many Eastern European urban regions, but since the beginning of the millennium no more than a few "islands of growth" have remained (e.g. Berlin, Dresden, Warsaw, Prague, Budapest, Müller & Siedentop 2004).

Otherwise areas with strong demographic decline have become more and more extensive. Population growth and decline are becoming spatially more and more contiguous, between regions, within regions, and within cities (Müller & Siedentop 2004). Comparing current trends (1999-2002) with developments between 1993 and 1996 reveals another breach in demographic development: a marked fall in interregional and intraregional deconcentration. In many Eastern European cities

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suburbanisation came to a complete halt at the beginning of the new decade. In some urban regions, migration even reversed towards cities and there are signs that this development is more than a short-term, cyclical interruption of an enduring deconcentration process. For Saxony, the government's regionalised population projection anticipates stability for the core cities Dresden and Leipzig (both around 500 000 inhabitants) but population losses of between 15.0 % and 20.0 % for the surrounding counties. In general, mainly the old industrialised areas, the urban centres and prefab housing estates are affected.

Inner-urban differentiation

Coming to the city-scale the process of 'shrinkage' and decline within a city is characterised by spatial phenomena such as re-construction, de-construction or even demolition, land abandonment and (residential) vacancy and thus one of the most obvious and vibrant changes that affect urban land use pattern in Europe today. Shrinkage is a process of marginalisation in urban areas (cities and regions) where selective grading-up processes of the urban fabric and the infrastructure interfere with de-industrialisation, massive (inner-city and from city to city directed) out-migration, aging of the population and decreasing birth rates (Cloet 2003, Lutz 2001, Haase & Steinführer 2005).

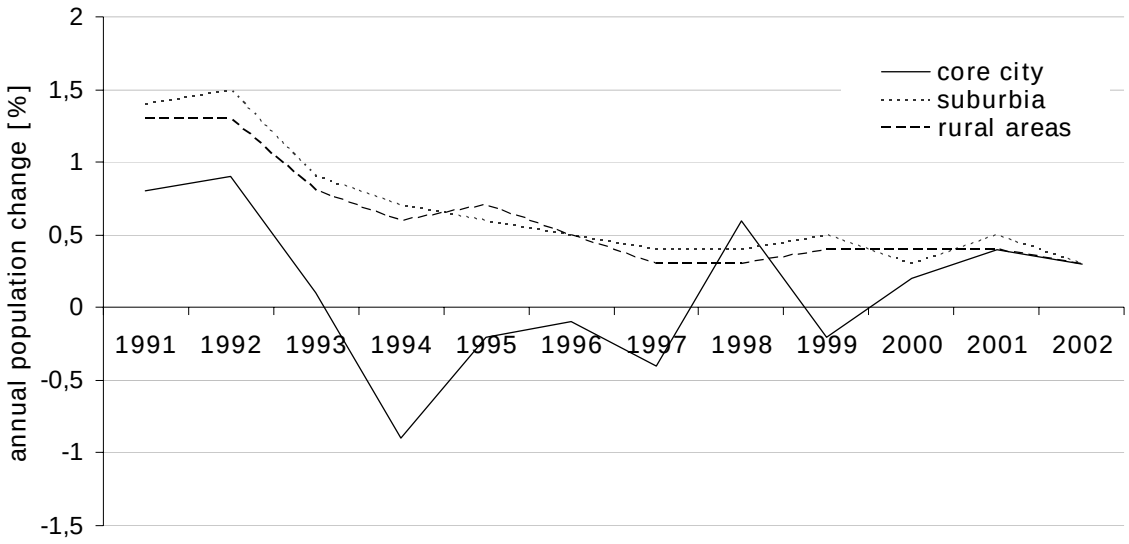

Figure 4: Annual population change since 1990, differentiated along the rural-urban gradient (modified after Müller & Siedentop, 2004)

Internal urban migrations processes still will be targeted towards urban periphery (residential suburbanisation) while, sometimes simultaneously, the inner city areas will become subjects to (partly extreme) abandonment (Figure 4, Heilig 2002). Regarding the process of inner-urban migration there have to considered that this in- and out-migration is related to specific age groups and household types and lead due to recent findings by e.g. Haase & Steinführer (2005) to a further socio-economic social segregation in the urbansheds: younger families and patchwork households are still moving out the inner city area and settle in the peri-urban fringe (Figure 5).

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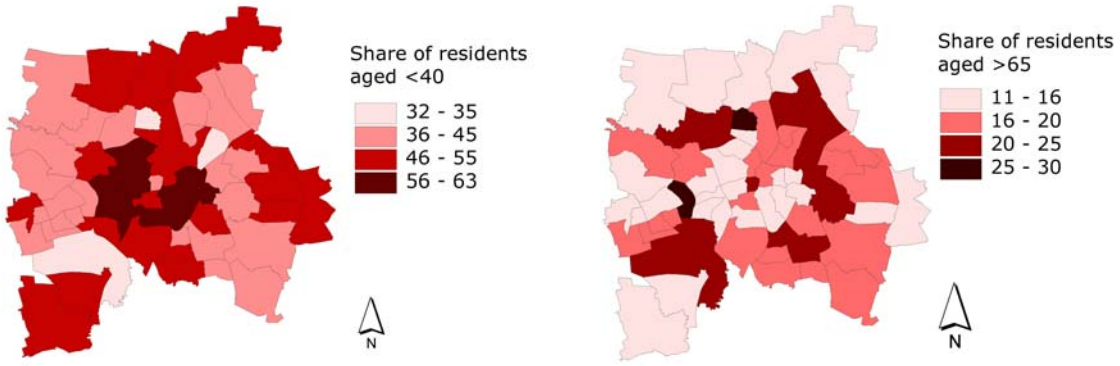

Figure 5: Spatial distribution of the share of age group <40 years in inner and sub-urban areas at the example of Leipzig, Eastern Germany

Aged couples and young singles prefer to stay or even to return into the urban centre. Low income groups show a relatively low residential mobility and remain living in either the urban core or in prefab housing estates at the urban periphery (Figure 4).

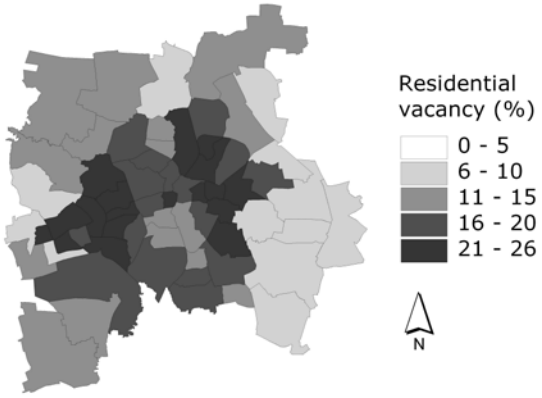

Figure 6: Proportion of residential vacancy at borough scale for Leipzig, 2004

The current situation in e.g. Eastern German cities is rather paradox: on the one hand, we find high dynamics of suburban growth (single and semi-detached house settlements, new 'housing parks') with adjacent partly over-dimensional construction activities (trade and industry) at the urban fringe and, on the other hand, an increasing process of depopulation and related shrinkage, vacancy, perforation followed by demolition in the inner city areas (cf also Table 2, Figures 2 and 3). At the urban periphery where the spatial "distribution" of growth is located urban planning is orientated and still relies on the designation of new building land and new construction. In the inner-city areas we find concepts of reshaping the urban building stock using concepts of designated re-densification areas. To meet the challenge of demographic decline these policy instruments are not longer sufficient. Spatial urban planning concepts and approaches are necessary that focus on stabilisation, revitalisation and qualitative development, re-urbanisation as well as the recycling of open land and building stock. For best practice, Müller & Siedentop (2004) proposed that planning has to be understood as the management of shrinkage processes. Therefore, predictor variables are needed.

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4 Identification of predictor variables explaining shrinkage

4.1 Social variables

In studying the effects of shrinkage, some very complex interactions between demographic, social and economic variables have to be unravelled. This is rendered more difficult by the circumstance that important indicators for economic growth are influenced by both changes in economic performance and by changes in population or employment figures.

The thesis that cities with a shrinking population also suffer deteriorating economic performance implies a high positive correlation between demographic development and economic growth. The literature on macro-economic growth sees as established a high positive correlation between gross domestic product (GDP) growth and population growth. The link is very close that the population growth rates are often taken as a proxy indicator for economic growth. Thus, a demographic decline would accordingly indicate economic stagnation or even a decline in economic performance.

The above discussed shrinkage phenomenon and the related residential vacancy are supposed to be strongly related to economic variables such as low investment rates, high unemployment rates or reduced family income as well as to social features, e.g. total net out-migration especially in the inner-city (Haase et al. 2004, Franz 2004). Different authors focus on the obvious relation between a decreasing economic dynamics and the on-going out-migration as explaining indicators for residential vacancy and shrinkage (Lang & Tenz 2003). Aging has to be added here too.

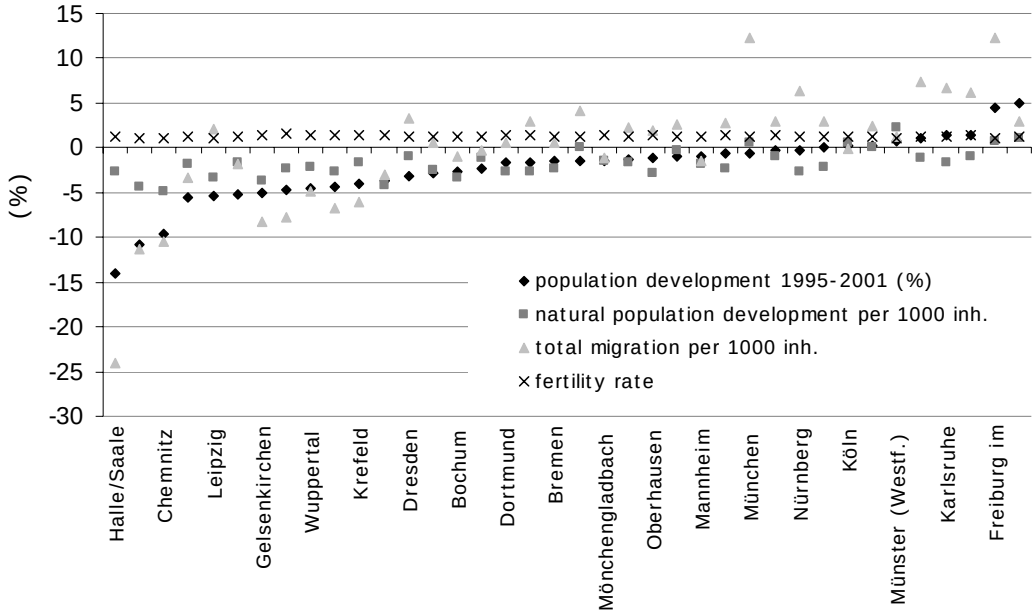

Figure 7: Natural population development, total net-migration and fertility rate in all German cities > 200.000 inhabitants for the time frame 1995-2000 (own calculations)

Figure 7 gives an idea of the regional distribution and the variance of the social variables population growth rate, net-migration and fertility for all German cities with more than 200 000 inhabitants. It is obvious that those cities with high proportion of residential vacancy such as Halle, Chemnitz, Leipzig and the Ruhr area form the group of lowest growth and fertility. Moreover, exerting Figure 8 it

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becomes clear that another cluster of social variables, the distribution of the age spectra is unfavourable in these cities with a high percentage of elderly people compared to a declining youth quota.

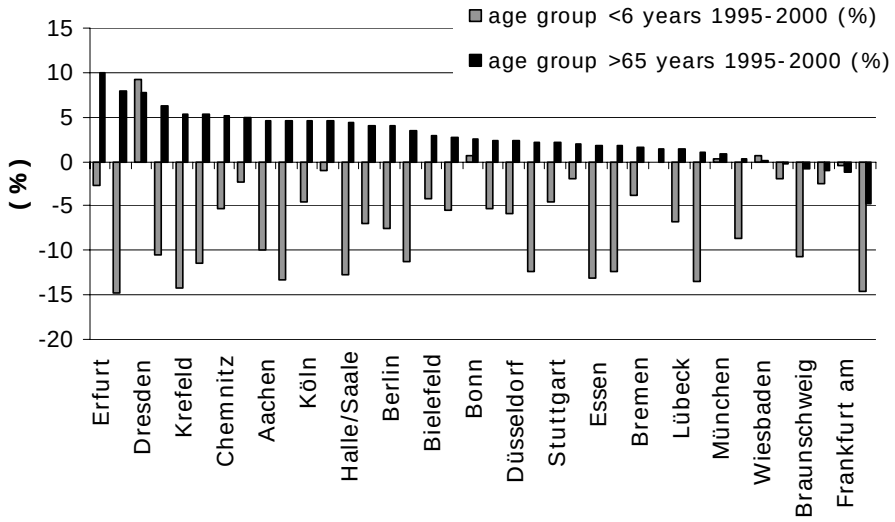

Figure 8: Natural population development, total net-migration and fertility rate in all German cities > 200.000 inhabitants for the time frame 1995-2000 (own calculations)

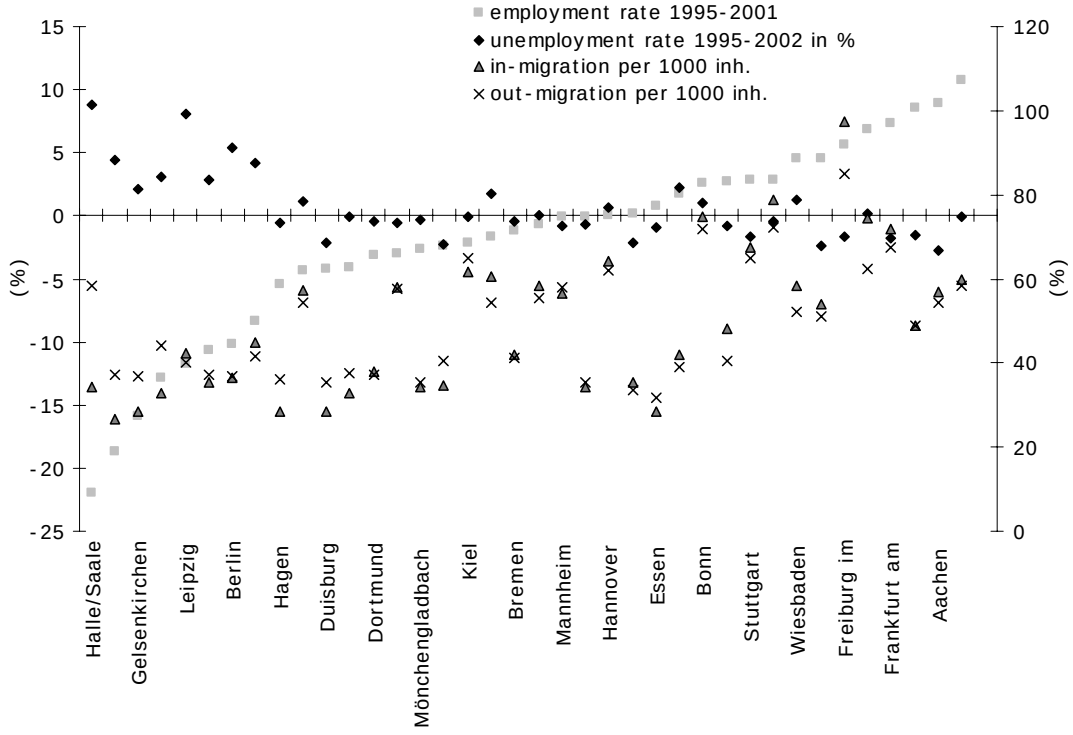

Figure 9: Employment, unemployment, in- and out-migration rate in German cities > 200.000 inhabitants 1995-2000 (own calculations)

Finally, Figure 9 proves that besides the natural population growth rate, the fertility rate and the age spectra distribution there has been proved true also another relation according to migration and employment status analysing the same data set: the Eastern German and Ruhr area cities are characterised by increasing unemployment and resulting out-migration over the last decade.

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For building conceptual models that explain residential shrinkage, vacancy and "plan" demolition the following social predictor variables have been selected after the above shown Germany-wide statistics for the investigation area of Leipzig (cf also Figures 7 and 8):

Table 4: Correlation between vacancy and potential social predictor variables for Leipzig, 1990-2002

Variable	*R^2 to vacancy*	*1990*	*2002*
out-migration	0.7*	15315	19312
foreigners	0.4	8744	31078
% married people	- 0.6	59000	38200
unemployment	0.6*	0.0	18.4
% car owner	- 0.7*	-	-
age group >65	0.8**	78209	92811
age group <15	0.1	78561	53759
social welfare recipients	0.8*	5398	29563

Significance level **= 1%/*=5%

The social predictor variables for residential vacancy and thus urban shrinkage given in Table 4 were selected and discussed with social scientists of the UFZ carrying out social empirical work in Leipzig. Correlations between these variables and residential vacancy and correlations among variables were tested to select the set of variables for the conceptual model. The correlation coefficients in Table 4 give an idea of how good vacancy and shrinkage can be explained by social features. Finally, the variables "out-migration" and "share of population above 65 years" were selected, as they have the strongest correlations with vacancy and are not correlated to each other. Unemployment data as well as data on social welfare recipients are seen as relevant, too. They will be also considered when building the model.

4.2 Economic variables – theoretical findings

It is assumed that the shrinkage phenomenon and the residential vacancy are strongly related to economic variables such as low investment rates, high unemployment rates or reduced family income as well as total net out-migration especially in the inner-city, too (Haase et al. 2004). First, owing to persistently high unemployment, a reduction in the labour supply due to a decline in population is hardly likely to limit growth, since the labour factor will continue to be available at an adequate level even if population figures continue to decrease. Studies on the phenomenon of jobless growth indicate that economic and employment growth need not always show a high positive correlation in the shorter term (Caballero & Hammour 1998). For European states in transition, jobless growth could be particularly important, since various studies on productivity have noted a considerable and enduring productivity gap for enterprises in the region. Many Central Eastern European enterprises are therefore likely to achieve substantial progress in productivity in the years to come. This could lead to gains in growth not necessarily accompanied by higher employment rates (example: BMW enterprise in the north of Leipzig).

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This means that a "making up" of productivity offers potential for growth that could be achieved without a significant impact on the level of employment and thus relatively independently of supply changes on the labour market (cf Table 5).

Table 5: Economic and demographic indicators for different growth and shrinkage constellations

	Decreasing or non-growing population (including employment rate)	Increasing population and employment rate	Functions
GDP growth and increase in productivity	Jobless growth or statistical growth	Normal growth	$G = f(GDP, E) = GDP * E$ with G = growth, GDP = Gross domestic product, E = total number of created jobs
GDP growth and decrease of productivity	Declining economy and declining population	Expansion of job-intensive branches of low productivity	

In interpreting regional economic growth, the standard measures are nominal gross value added per person employed and per capita income. But taking persons employed or population as normalization denominators means that values are influenced by changed employment and population numbers in the region under study as soon as several points in time are examined and compared.

Table 6: Effects of demographic change for demand and supply of economic and spatial goods of an urban area with respect to the core city

Demography	**Economic relevant effects**		**Spatial effects**
	on the supply of jobs	on the demand of products	on the demand on land or space
Negative population saldo between core city and periphery	No effects assuming a stable number of job sin the core city	No effects assuming stable consumer behaviour	limitation of the supply of open land in the urban periphery, urban sprawl
Negative saldo of regional migration	Decreasing number of manpower assuming that the majority of the out-migrating persons aged between 18-65	Consumer behaviour is negative and consume declines due to a decreasing number of households	Increasing supply of not used land (with potential to develop into "quasi" natural areas) in the inner city area as well as in the suburban fringe
Birth/fertility deficit and/or death overspill rate	No effect in the short-term, in the long-term decreasing supply of manpower	Consume decreases due to ▪ decreasing household sizes and ▪ decreasing number of households	Perforation of the residential structures of a city Increase of open spaces within the urban area?

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This could mean that per capita income in an area could increase at an above-average rate in spite of stagnating economic output because the number of inhabitants decreased faster than in other regions. This means only purely statistically determined growth. Another conceivable case is jobless growth, where growing output is not matched by an increase in employment like the case of Leipzig shows in Figure 10 where a relative stable GDP/person is accompanied with an increasing unemployment rate. Both of these cases would mean that growth and demographic or employment development show only weak positive or even negative correlation (Table 5).

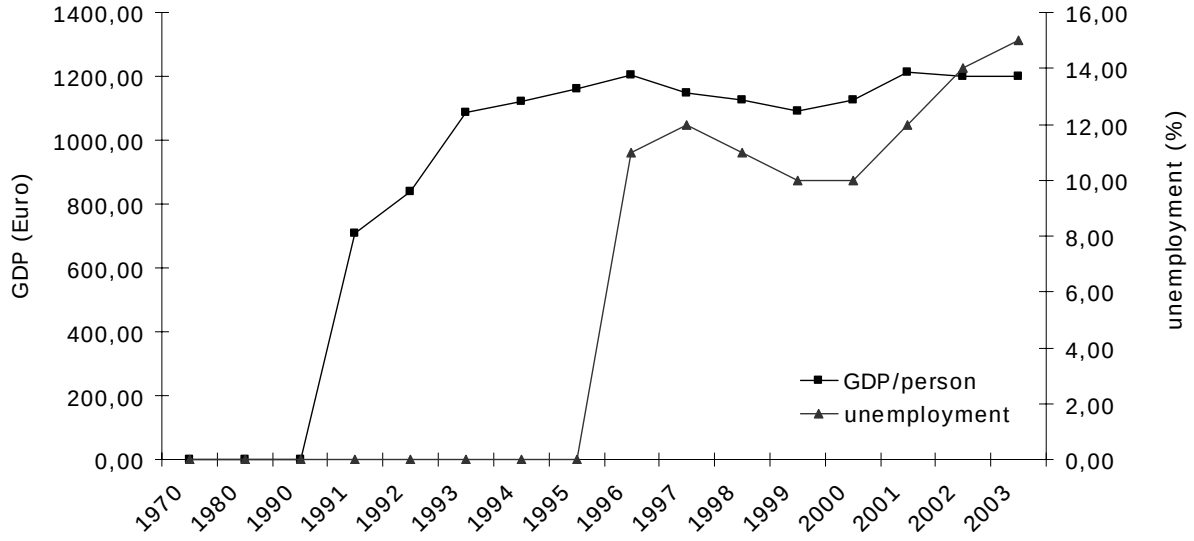

Figure 10: Development of GDP/person and share of unemployment for Leipzig 1970-2003

A negative correlation also results from another conceivable constellation, namely where a region records a rise in population accompanied by below average economic growth since the additional jobs are in low-productivity sectors. This occurs in regions with a high proportion of jobs in tourism (Tables 5 and 6). While changes in economic growth indicators are considered relative to development at the national or macro level, change rates are taken for alterations in population and (un)employment. Considering various constellations which could lead to economic and demographic change in a region correlating in different ways, causal links must now be examined. Since the two factors interact, each will be looked at in turn as an independent variable. In concrete empirical cases the possibility of mutual influence must be taken into account.

If it is true that the extent of regional economic growth influences population numbers in a region, it should be remembered that the population figure reflects natural population movement (births, deaths) and supra-regional migration, i.e., the balance of in-migration and out-migration. As a rule, it is assumed that the growth situation is mainly responsible for the scale of migration. Prosperous regions attract people and households who take advantage of better employment and income opportunities. Vice versa, the number of departing people and households exceeds the number arriving in regions that are stagnating and suffering lower economic performance.

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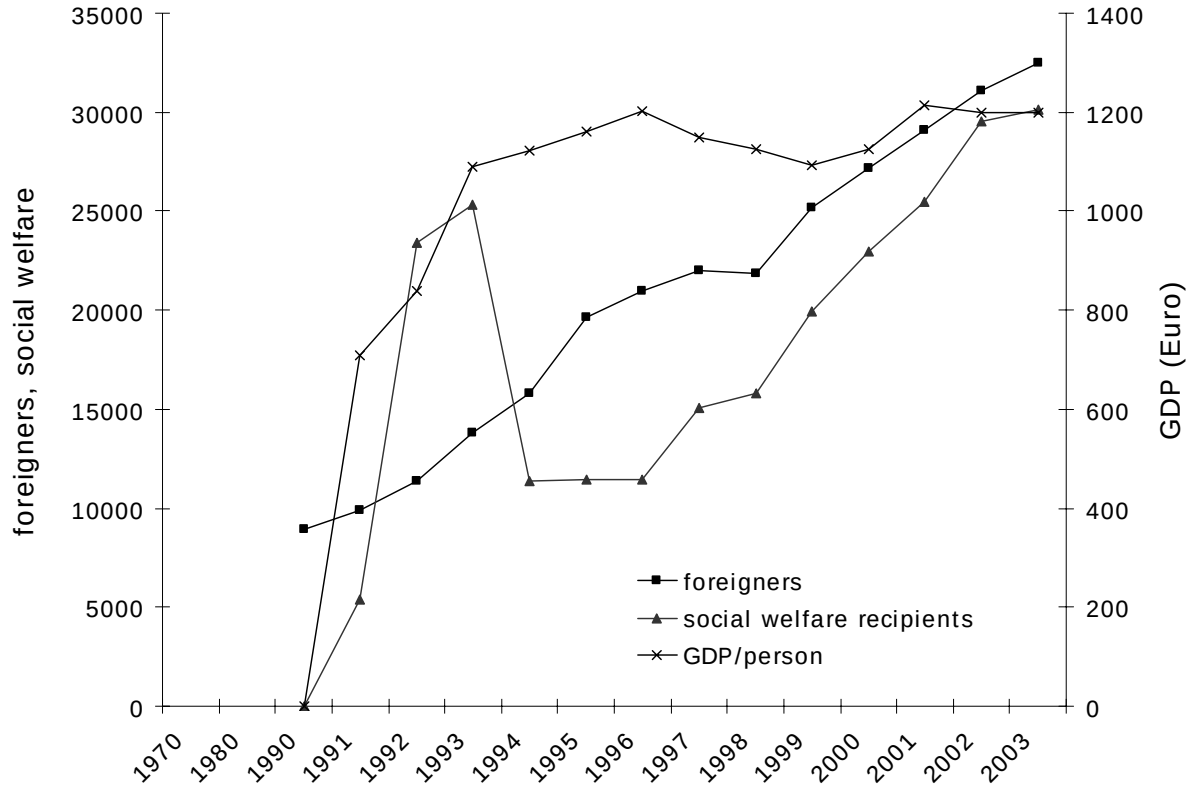

Figure 11: Development of economic variables for Leipzig 1970-2003

In the long-term, economic growth is assumed to influence not only on migration but also on reproductive behaviour. It is further assumed that high (low) demographic growth in a region leads to an optimistic (pessimistic) view of the future with corresponding encouragement (discouragement) of reproduction and in-migration (Figure 11). If natural population movements and the migration balance tend into the same direction, shifts in the migration balance are directly reflected in population figures (Figures 7-9).

From a purely economic point of view, a decreasing number of population in a city has supply and demand-side effects. It reduces the labour supply available in the region as well as the overall demand of private households for consumer goods and environmental services defined as ecosystem services by Costanza et al. 1997 or Farber et al. 2002. It might, however, be the case that population losses in a city have a statistical impact but no economic nor environmental effect. This comes true if migration from cities to suburbs occurs which involves a change in residential location but usually neither a change in job, recreational nor in consumer behaviour. Investigation within narrow administrative boundaries is inadequate in this regard. It needs to include the complete urban region covering the rural−peri-urban−urban gradient including besides the residential suburbanisation also the suburbanisation of industry, trade and services.

All these arguments imply for European cities that different patterns of demographic decline influence growth factors in different ways. A fall in population caused primarily by suburbanisation appears to be less damaging to growth than a decline due mainly to the out-migration of younger carriers of high-quality human capital (Table 6).

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4.3 Spatial variables

Besides socio-demographic and economic variables also spatial variables could be relevant to explain the spatial distribution of residential vacancy in cities (Repetti & Desthieux 2005, Spangenberg et al 2002, Van Herzele & Wiedemann 2003). Most of all distance metrics, density and neighbourhood terms have been selected as interesting variables which are related to the locations where residential (and partially also industrial) vacancy occurs. A summary of relevant metrics is given in Table 7.

Table 7: Selection of distance and neighbourhood metrics which could serve as spatial variables that are related to the attractiveness of urban structures and potential residential vacancy

No	Indicator	Weight	Class Range	Class Description	Impact function	Remarks
1	Urban structure type	3	1 2	classes	3-7	
2	Population density	1	<1000 <3000 <5000 <7000 <9000 >9000	1 2 3 4 5 6	1 4 6 7 4 1	Target: mean population density to ensure quality of life of 2 urban units that are affected by in-migration area with 4000 inh./km² and 4700 inh./km²
3	Sealing rate	2	100 <80 <60 <40 <20 0	5 4 3 2 1 6	1 5 7 5 1 0	single and semi-detached house areas and urban villas with 50% sealing rate
4	Distance to main roads (m)	2	>500 >250 <250	3 2 1	1 6 7	walk distance relevant
5	Distance to primary schools (m)	2	>1000 >500 <500	1 2 3	1 5 7	walk distance relevant
6	Neighbourhood to open/green space (m)	2	<50 >50	1 2	7 1	inquiry: residents width to live near to green areas
7	Total area of green space	1	<1 <3 <5 <10 >10 0	1 2 3 4 5 6	1 3 4 6 7 0	According to an International Criteria Catalogue of the URGE project http://www.urge-project.net
8	Distance to primary city centre and local sub-centres (m)	3	continuous	continuous	1 5 7	Walk and Drive distance relevant
9	Neighbourhood of green space to main road	1	< 1ha > 1ha no	1 2 3	1 5 7	Environmental Atlas of Berlin

According to the expert opinion and planning material for demolition in Leipzig, finally the selected "spatial" variable set includes

- distance to urban or local sub-centres,
- distance to main roads,
- proportion of block-edges not adjacent to open areas and
- urban structure type.

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Data for these variables is available in most of the European cities on different spatial scales (city-level and at the level of the administrative units; URGE project http://www.urge-project.net). For the first prototype of the shrinkage model of Leipzig urban land use data have been chosen including 30 categories was derived from a digitised land use map (Haase & Magnucki 2004) with a spatial resolution of 5 meters. Main roads were derived from a public available administrative data set in vector format.

5 Conceptual model for the process and spatial shape of urban shrinkage

Based on the above discussed variables that are related to urban shrinkage and residential vacancy there had been established a conceptual model that brings the socio-demographic and spatial sphere into a relation (Figure 12). The economic variables are still not included into the concept model because of the still missing statistical significance. Thus, main stock variables that are indicating shrinkage are marked in the model scheme, such as out-migration, age group proportions <15 and >65 years as well as urban structure type which are strongly related to residential vacancy. All the contributing variables are grouped around the explaining ones.

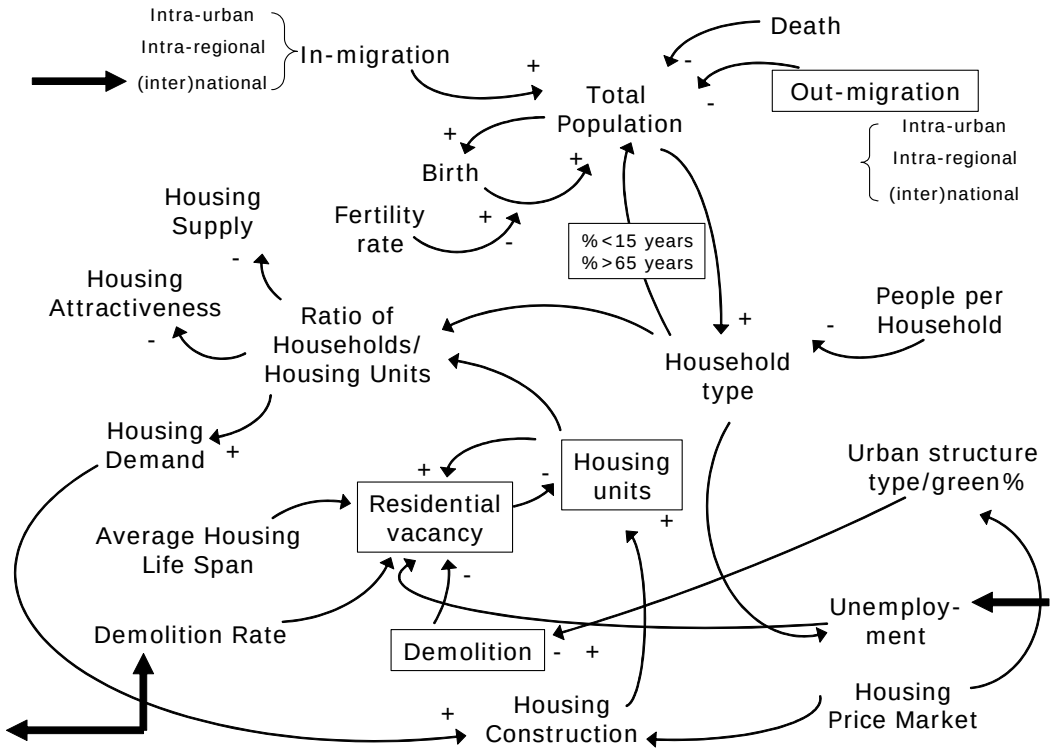

Figure 12: Concept model of related variables of urban shrinkage

The model presented in Figure 12 is presented as conceptual model ('What is the problem?') which has to be incorporated into STELLA or VenSim software for a modelling phase. Besides that, an

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existing spatially explicit rule-based demolition model realised in the SELES modelling environment (Fall 2002, Haase et al. 2005) could be incorporated into the conceptual driver-based shrinkage model that gives an idea where demolition occurs according to out-migration, age spectra distribution and distance metrics (Figure 13).

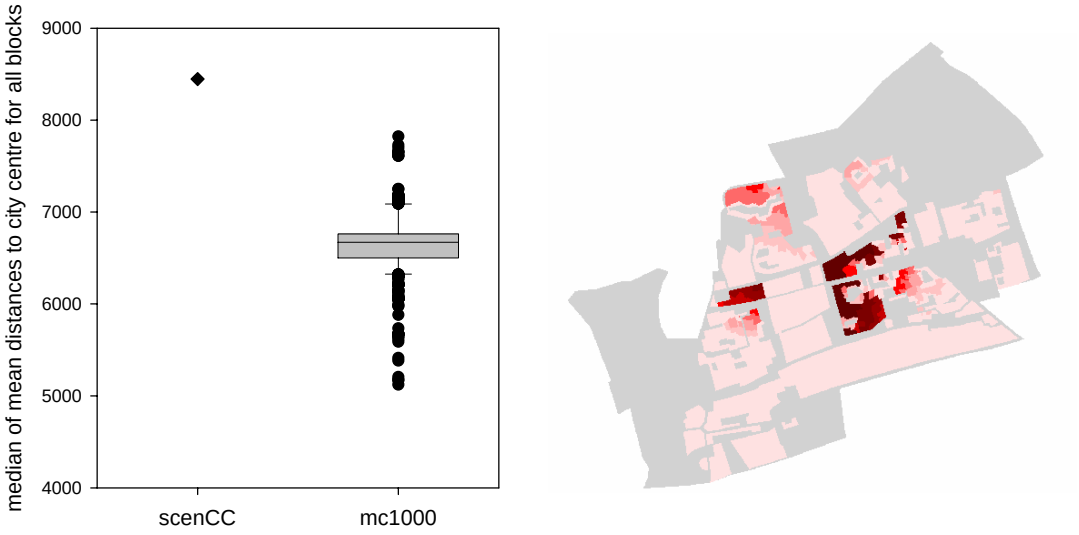

Figure 13: Median of mean distances to the city centre for all simulated blocks of 1000 MC runs compared to the "maintenance of the city centre"-scenario (left) and the spatial realisation in Leipzig-Grünau

Major importance for the model realisation possesses the above discussed variables and their validity. During the modelling phase these data will be utilised for the validation and calibration of the concept model (understanding processes versus calibrating models to reality). Finally, effects of potential policy options could be calculated and visualised in the simulation.

6 Conclusions

The findings of this conceptual paper invite further conclusions. In many European cities, statistically investigated at the example pf the German cities, the prevailing constellation are economic growth coupled with a decline of population, migration and employment. In this case the informative value of the growth indicators need to be assessed with particular caution, since without in-depth studies there is a risk of being misled by statistical artefacts. The study underlines the need for more detailed research. In order to place the findings on a firmer empirical basis, it would be useful to include further smaller towns and cities and, above all, to increase the number of urban regions under study. More differentiated data on the existing household type structure are needed to identify e.g. re-urbaniser groups. In order to test whether a decline of population has a differential impact on sectors that concentrate on regional business and those that do business beyond the region, GDP and gross value added data would have to be differentiated according to the business structure of each city.

Greater scientific light on the links between economic and demographic developments could open new perspectives for local government development policy. Owing to intensive lobbying by the housing industry, the discussion on shrinking cities has been strongly reduced to the issue of eliminating vacant

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housing. But residents are likely to leave even the redeveloped or downsized city if they find no attractive economic opportunities there.

The demand group that expresses a life-cycle need for more living space and which is an essential carrier of home ownership investment will be shrinking in the next years. Although migration studies prove that families with children are not the only actors in suburbanisation, pensioner households, single parents, flat sharers and gainfully employed single-person or childless couple households nevertheless tend to prefer the core city for residence. Thus, in the coming decades, immigration could be the main driver of demographic developments in the inner-urban areas. Core cities and the built-up environs are supposed to receive an increased intake of immigrants from abroad. Moreover, the variable of home ownership should be investigated more detailed among immigrants to clarify whether the new arrivals are to be found in the core-city rental accommodation markets.

But, not discussed in this paper, demographic decline is already endangering the infrastructural viability along the rural-urban gradient. It may affect the thinly populated rural areas, resulting in high mobility costs for the local population as well as suburban in future. With a declining population density, critical thresholds for the viability of technical, transport and social infrastructures and in public facilities are reached much earlier in much less densely settled suburban areas than in larger cities. The result could be longer journeys to visit central facilities and higher charges for technical infrastructure. Elderly households, in particular, could react by returning to the city because day-to-day life is simpler to organise there when mobility is restricted.

Besides the social and economic sphere in shrinking residential areas there have to be considered also spatio-environmental effects. Already today in the new federal countries of Germany we register a considerable under-utilisation of the technical infrastructure for water supply and canalisation (Koziol 2004). For technical infrastructure systems this development has already begun to hamper efficient operation and generate follow-up costs. One of the main determinants of these costs is the urban redevelopment strategy pursued. In the years to come, housing service and maintenance costs are likely to rise in shrinking communities. To avoid or at least limit higher ancillary costs and the consequent worsening of local conditions in the municipalities affected, low-cost urban renewal strategies, i.e., economically sustainable urban redevelopment, need to placed high on the agenda. An examination of how urban redevelopment affects the technical infrastructure provides valuable insights which can be transferred to other aspects of urban renewal.

Urban shrinkage, provoked by demographic change and migratory movements, poses complex problems for housing companies, urban planners, and politicians. But the operators of technical infrastructure systems also face a completely new situation, objectively and subjectively. Declining consumption and smaller service areas are the most striking characteristics. Developments are determined by sinking specific water, heating, and electricity consumption owing to changes in consumer behaviour or technical improvements in equipment or control mechanisms, lower consumption owing to small-scale migratory movements (simultaneous service area deconcentration and expansion), declining consumption owing to extensive migratory movements (out-migration accompanied by service area deconcentration), reduced consumption due to demographic developments (population decline); network reduction through building demolition, declining demand of transport and technical infrastructure by industry and trade according to the economic decline and low investment rates, and, finally, a general reduction of the infrastructure net due to demolition and deconstruction measures (Costanza et al. 1997, Farber 2002, De Groot et al. 2002).

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Demographic decline is also likely in the medium term to ease the situation on core-city housing markets. One of the key determinants of suburbanisation would hence become less important. For population suburbanisation can essentially be understood as an economically determined, spatial avoidance process running from core cities to surrounding areas and thus make it easier for cities to provide an attractive stock of larger dwellings in a pleasant residential environment.

It is certainly not too early to talk of an incipient "urban renaissance or re-urbanisation." Empirical findings suggest that demographic shrinkage will diminish or stop suburbanisation. The degree to which it actually declines depends not only on future demographic and economic developments. A major variable will be whether core cities are able to invent and apply a successful re-urbanisation policy that combines urban proximity advantages with suburban residential quality characteristics. Here, the discussion of the spatial variables of a shrinkage model has to be highlighted.

If the future developments along the rural-urban gradient are characterised by polarisation between core city and surrounding areas or if a greater differentiation in growth and shrinkage is more likely to occur within suburban areas conceptual models as well as a translation into quantitative scenarios are tools that could provide policy support. As shown in this paper statistics as well as exploratory and narrative storylines of the socio-economic conditions in European cities at different spatio-temporal scales are useful to “fill in” such models.

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