Uneven urban dynamics

The role of urban shrinkage and regrowth in Europe

Ph.D. Dissertation

Manuel Wolff

Supervisor: Prof. Dr. Thorsten Wiechmann
Co-supervisor: Prof. Dr. Dagmar Haase

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»The phenomenon of shrinking urban populations

can be perceived as a sign of a new era in the history of some cities,

in which the initial impulse of all-embracing and ever accelerating urbanization

gives way to a more complex, subtle and ambivalent process. «

(UN-Habitat 2008: 42)

Content

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Summary

This dissertation provides a comprehensive picture of urban shrinkage and its relevance within contemporary urbanization processes in Europe. The thesis demonstrates that shrinking cities are neither a one-dimensional phenomenon nor a side-effect of growth but a unique path of urban development. Thereby, the dissertation address a complex topic that intersects urban geography, demography, planning and spatial modelling thus underlying the interdisciplinary character of this work.

Urban shrinkage is an expression of ***uneven development***, particularly visible in the highly urbanized continent of Europe essentially depending on spatial, dynamic, and causal characteristics (Turok and Mykhnenko 2007). Shrinking cities are, first, differently distributed over the continent. Second, their number differ significantly over different time periods. Third, the remarkable expression of urban shrinkage in Europe is rooted in the interplay of various drivers, ranging from economic transformation and suburbanization to changing demographic conditions and political turns.

Several studies have provided an idea of the persistence and spatial extent of urban shrinkage and the ***discussion*** about how to deal with urban shrinkage had just re-emerged with effects of the global economic crisis. Since 2010, causes, effects, and planning strategies for shrinking cities had been increasingly discussed in an international context. However, a comprehensive picture of urban shrinkage as a multidimensional process in a comparative cross-country perspective feeding this debate, is lacking to a large extent.

Concepts and definitions are difficult to apply in empirical research undermining the test of theories. This methodological-conceptual ***research gap*** is, first, related to the variations of spatial scales depending on the phenomena under investigation. Second, hitherto studies basically conclude on larger cities although Europe is dominated by small cities. This is, third, related to the provision and comparability of local socio-economic data. **Against this background, this dissertation will identify the specific role of shrinking cities within the uneven urban development in Europe.** Thereby, theoretical approaches are linked to methodological-conceptual solutions, giving greater credence to the subcomponents of drivers, implications, and spatial variations.

The ***analysis*** provides solutions to major methodological challenges using spatial statistics and GIS modelling to explore the nature and complexity of urban shrinkage in Europe. Three delineations of cities have been developed allowing a harmonized and flexible application in a

cross-country perspective. By linking a unique local population database with other databases three models could have been tested in order to identify variations and specifications of these models related to urban shrinkage. Structured by three research questions, three papers analyse European cities, and two refer to a national and a local case, in order to deepen the results.

1. The assumption, that urban shrinkage represents a broader trend in Europe between 1990 and 2010 can be confirmed. A typology of population trajectories underlines that 49 % of all analysed 7 742 cities in 33 countries can be regarded as one type of shrinking cities. Of these, 14 % show continuous population losses and 23 % episodically losses esp. between 1995 and 2005. Moreover, among the 2 396 temporarily shrinking cities (63 %), 883 cities were affected by recent population losses from 2005 on and 337 ones ceased to shrink. Especially in post-socialist countries a combination of demographic change and fast deindustrialisation drives long-term shrinkage whereas structural economic disadvantages and a constant job-driven outmigration since the 1970s are keeping cities in Northern France or Southern Italy shrinking. In less dense regions of Spain, Western Germany or Austria outmigration of young jobseekers and low attractiveness for families give full rise to the impact of natural decline with fast declining birth rates. Moreover, an increasing mobility of well-educated and trained labour force and the increasing competition between cities accelerates in recent urban shrinkage even in economically advanced regions what indicates that shrinkage is less associated with economic performance due to an increasing gap between productivity and demographics.

2. If shrinking cities are decentralizing or centralizing depends on their spatial distribution. By considering the hinterland, decentralization is driving growing cities towards a hollowing out and aging of the core city especially in Northern France or Poland. In most parts of Europe, urban shrinkage is especially pronounced when the corresponding hinterland declines. By measuring the intensity of the observed core-hinterland processes it is obvious that the general trend of shrinking cities reveal a slowing down of decentralization in favour of ***centralized decline***; in other words: population decline in the cores slowed down and the hinterland lost population faster. The slowing down of core losses is basically due to the immigration of elderly people and a constant weakening of the hinterland accelerating in strong aging.

3. By investigating the complex setting of changes of population and residential area some specifications in terms of density changes in shrinking cities are obvious. Whereas the majority of shrinking cities deconcentrate with land consumption while population declines, almost 9 % of all cities showed a physical adaptation in terms of demolition after 2000. In

Romania or the Baltic States densities are further declining because population loss is faster than the physical infrastructure can be adapted. In contrast, large-scale demolition programs lead to the paradox of increasing densities in shrinking cities particularly in Germany. As the example of Leipzig shows, this physical adaptation helped to stabilize the housing market and led to regrowth along with densification. However, density is increasing without an expanding residential area as refurbished buildings are reused. After 2000 this phenomenon covers 10 % of all, predominantly large, cities such as in Germany, the UK and even in post-socialist European countries. Thereby, a twofold polarisation is evident: Whereas the number of growing densifying cities below 100 000 inhabitants decreased, its number among larger ones substantially increased. Moreover, the differences between growing and shrinking small cities increased as an effect of specific spatial relations and drivers.

By answering these three questions the dissertation provides a comprehensive picture of shrinking cities in Europe ***relevant for planning and policy*** in order to balance the uneven development. By combining socio-demographic, ecological, monitoring and planning aspects the results support a deeper understanding of the multidimensional patterns of urban shrinkage relevant for different levels from local to supranational. In particular, the EU Cohesion Policy may use the results to draw their policy focus from economic related issues to a broader problem-oriented understanding of urban shrinkage (EP 2008). The results serve as basis for further research which extends the database, applies adapted models to other scales or performs different classification methods. The chosen cross-national perspective allows a harmonized comparison of urban trends between countries, reveal the tremendous local variations of uneven development and helps to increase the attention of urban shrinkage within national and supranational debates.

1. Introduction – shrinking cities in urban Europe

This dissertation provides a comprehensive picture of urban shrinkage in Europe since the fall of the iron curtain. By addressing a complex topic that intersects urban geography, demography, planning and spatial modelling, this thesis demonstrates that shrinking cities are neither a one-dimensional phenomenon nor a side-effect of growth but a unique path of urban development.

The phenomenon of shrinking cities has been well discussed in both urban research and planning and has gained increasing international attention since the late 2000s. The European Union realized that local patterns of shrinkage are totally different from national trends that require adapted local solutions to maintain public services, as well as the need to conceptualize urban shrinkage as a multidimensional process (EC 2005; EP 2008; Gerőházi et al. 2011; Martinez and Weyman 2017). However, with the crises in the capitalist regime of the 21st century, the political debate has narrowed shrinkage down to economic failure, thus absenting the debate on urban shrinkage as a multidimensional process from many national debates (Olsen 2013). Consequently, the persistence of shrinkage has been underestimated and the corresponding challenges for planning on different policy levels are addressed by the 'urban growth machine' (Molotch 1976; Logan and Molotch 1987).

However, urban shrinkage is an expression of uneven development for which a comprehensive picture is lacking to a large extent. Against this background, this dissertation sets urban shrinkage within the context of uneven urban development in Europe from a cross-national comparative perspective in order to detect its relevance within the urban system. The results allow a contextualization regarding other current economic and political processes and their spatial effects.

This dissertation links theoretical approaches to methodological-conceptual solutions, giving greater analytical credence to the subcomponents of drivers, implications, and spatial variations. The analysis applies three models, using spatial statistics and GIS modelling to explore the nature and complexity of urban shrinkage in Europe. Structured by three research questions, five papers analyse European cities, a national and a local case study, in order to deepen the results.

The first part provides an introduction to the problem setting of urban shrinkage in Europe, current research gaps, and how this dissertation will fill in these gaps. Part 2 reflects on the debates on shrinking cities and what theories are used as explanations. Structured by three research questions, part 3 describes the research design before part 4 presents five published

or accepted papers as part of this cumulative dissertation. Finally, part 5 summarizes the results and concludes on their contribution to the scientific debate and practical relevance.

1.1 Uneven development and the phenomenon of urban shrinkage

Urbanization – the concentration of people in cities – is one of the grand challenges of the 21st century. However, heterogeneous settlement patterns, driven by a variety of living styles, working conditions and governmental management (Kourtit and Nijkamp 2013), produces ***uneven dynamics*** that manifest in the phenomenon of shrinking cities. Although the global urban population exceeded the rural population for the first time in history in 2007, accompanied by an increasing land consumption (Nuissl et al. 2009), the percentage of shrinking cities remained steady at around 10 % between 1970-1990 and 1990-2014 (UN 2015: 72). Consequently, the 2014 UN-report expects the global urbanization rate to increase from 54 % in 2014 to 66 % in 2050 – a rate which was expected to be higher six years previously (70 % in 2007; UN-Habitat 2008; UN 2015).

Terms used in this dissertation:

Urbanization is widely understood as population growth in cities measured by the urbanization rate (share of population living in cities), whereas urban shrinkage is usually described by population decline. In terms of shrinking cities, this PhD uses the terms ***urban shrinkage*** *to describe processes that are largely associated with* ***population decline,*** *which is the main indicator that manifests in a* ***shrinking city****, as the spatial reference.*

The slower rate of urbanization as a result of the shrinking cities phenomenon is particularly visible in the highly urbanized continent of ***Europe***.[1] Since the 1990s, at latest, urbanization in Europe slowed to a 1 % increase (up to 72 %) compared to 6 % between 1960 and 1990 (EC and UN-Habitat 2016) – a rate that is expected to further slow down to rates far exceeding those of other parts of the world (UN 2015).

Several studies have provided an idea of the persistence and spatial extent of urban shrinkage and underlined that in Europe the number of shrinking cities has increased faster in the last 50 years than the number of growing cities similar to North America (UN 2015). This was basically a consequence of the so-called 'counter-urbanization' between the 1960s and 1980s (Hall and

[1] Generally, the share of shrinking cities is especially high in the developed world, at 40 % between 1990 and 2000 (UN-HABITAT 2008: 40).

Hay 1980; Cheshire and Hay 1989; Cheshire 1995; Beauregard 2003; Rugare and Schwarz 2008). By the year 2000, the number of shrinking cities in Europe exceeded the number of growing ones (Turok and Mykhnenko 2007). The discussion about how to deal with the problem of shrinking cities had just re-emerged when the global financial and economic crisis drew much attention to this phenomenon of urban shrinkage (Beauregard 2009; Hollander et al. 2009; Schatz 2010; Kabisch N. and Haase D. 2011). However, the European Union recently detected that the share of shrinking cities decreased from 40 % during the 1990s in the EU-28 down to 30 % during the 2000s, concluding that 'cities became more popular' (EC 2016: 38), even those which had previously been shrinking (regrowth of cities).

This already points to the variations in local patterns of urban shrinkage which essentially depend on ***spatial, dynamic, and causal characteristics as an expression of uneven development:***

- Spatial: Shrinking cities are differently distributed over the continent. They are mostly located in the new member states (EU-13) where 60 % of cities have lost population, compared to only 20 % in the EU-15 (EC 2016). Based on a bundle of causes which quickly emerged in post-socialist countries, urban shrinkage dominated large parts of the urban system in Eastern Europe (Turok and Mykhnenko 2007). Still, even in these countries, their capitals reach growth rates which are comparable to Western Europe, revealing that besides inter-state differences, intra-country differences and city size[2] also play a major role in spatial terms.
- Dynamic: Turok and Mykhnenko (2007) demonstrated that urban shrinkage and growth differ significantly over different time periods. In their study of 310 European cities in 36 countries whose population exceeded 200 000 inhabitants, they underlined that between 1960 and 2005 only 13 cities experienced long term shrinkage but 40 % of the investigated cities experienced shrinkage occasionally (Turok and Mykhnenko 2007; figure 1). This points to the time-period-sensitivity of urban shrinkage, which also relates to special events such as economic crises or political upheavals.
- Causal: The remarkable expression of the phenomenon of urban shrinkage in Europe is rooted in the interplay of various drivers which is somehow unique for Europe (UN-Habitat 2008; UN-Habitat 2013; UN 2015; Martinez-Fernandez et al. 2016).[3] Recent

[2] Based on Urban Audit, a European database for comparative analysis of EU cities, the European Union detected that almost one third of large cities could be regarded as shrinking between 1996 and 2001, whereas an extended sample covering also medium-sized cities identified about 40 % (EC 2007; EC 2010; EC 2016).

[3] Globally seen, economic transformation and the loss of industry and jobs as well as suburbanization is driving urban shrinkage in the US, with New Orleans as a shrinking city affected by a natural disaster (Hollander 2011; Mallach 2012; Wiechmann and Pallagst 2012) whereas, in Japanese cities, declining birth rates basically lead to continuous population loss (Matanle and Sato 2012). In contrast, urban shrinkage in developing countries is associated with natural catastrophes, epidemics, climate change and wars (Reckien and Martinez-Fernandez 2011).

research distinguishes five major drivers which are characteristic of the developed world in general and Europe in particular, ranging from economic transformation and suburbanization to changing demographic conditions and political turns (Schatz 2010; Reckien and Martinez-Fernandez 2011; Haase A. et al. 2012; Wiechmann and Bontje 2014).

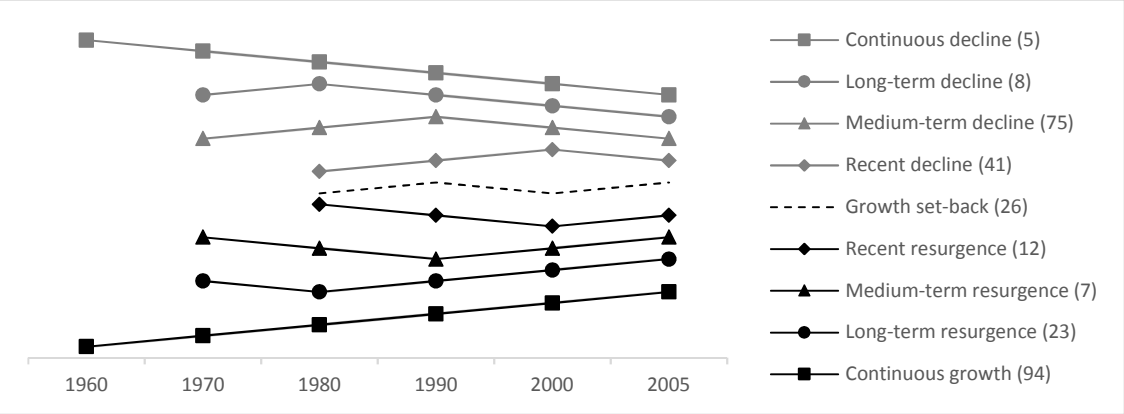


Figure 1: Trajectories of individual cities, 1960–2005 (after Turok and Mykhnenko 2007).

All three characteristics of uneven development lead to different development paths of cities, ranging between growth and shrinkage in time. These paths cluster differently depending on different causes or national correspondences, on which the following paragraph will reflect.

In the frame of ***Economic transformation*****,** urban shrinkage is equated with economic decline triggered by deindustrialization and globalization (Prigge 2005; Rienties 2009; Baron et al. 2010; Reckien and Martinez-Fernandez 2011). Since the fordistic form of mass production and consumption plunged into crisis in the 1970s, deindustrialization has characterised the run-down of old and traditional industries such as mining or shipping. In cities such as in Northern Britain, North-eastern France, the Ruhr and Saar regions in Germany and the Po region in Italy the classical production-line manufacturing jobs play a steadily decreasing role. Cities shrink when they are not able to effectively compensate the declining industrial sector with new tertiary and service-sector industries (Bade and Kunzmann 1991; Rodwin and Sazanami 1991), leading to a downward spiral: unemployment leads to outmigration with decreasing tax revenues, discouraging economic activities and investments, finally leading to increasing unemployment and outmigration (Cheshire and Hay 1989; Baron et al. 2010). This spiral can be reinforced by global economic, social, and political shifts, including changing consumption patterns and technological innovations which enable businesses to become more footloose, together with a constant demand for rationalization and the resulting job-losses (Conti 1997;

Castells 1999; Schelte 1999; Lang 2005). Thus, economic transformation caused former industrial centres to lose their functions and increasingly excluded them from global economic growth with corresponding severe impacts on urban labour markets and selective outmigration leading to a substantial erosion of the workforce available for the city's economy.

Suburbanization[4] describes the increasing accumulation of economic and demographic growth in the cities' hinterland that can drain the economic, fiscal, and demographic resources of the core cities followed by a hollowing out (Couch et al. 2005; Nuissl and Rink 2005; Kabisch S. et al. 2008; Rienties 2009). This process is strongly related to an increasing personal retreat and longing for privacy and individual freedom in countries such as Great Britain, Germany, Italy, and France (Short 1996) or to the rapid privatization of the housing market and a lack of planning such as in post-socialist countries (Kotus 2006). Both reveal that suburbanization and the corresponding shrinkage of cities is not solely an economic effect (Couch et al. 2005). One of the most obvious effects are the increasing rates of land consumption, also known as sprawl (EEA 2006).

Whereas suburbanization and economic transformation are associated with the migration of people, Europe's 'second demographic transition' as part of ***demographic change*** points to the partial decoupling of economic wealth and population growth in Europe (Lesthaeghe and van de Kaa 1986; van de Kaa 1987). This transition which began in the mid-1960s is characterised by declining numbers of married couples, rising divorce rates, an increasing age at marriage and a shift towards more varied household types, including an increasing number of blended families. These factors, in addition to the pill effect, led to dramatically dropping fertility rates far below the population replacement level from the 1970s, thus causing urban shrinkage.

Peripherization describes the one-directional relationship of migration from smaller peripheral cities to larger and prosperous ones (UN 2015), leading to urban shrinkage such as in Scandinavia (e.g. Fertner et al. 2015), Southern Italy, Scotland or Southern Portugal (EP 2008) as well as Central France (Nonny-Davadie 2010). Due to locational disadvantages, the increasing decoupling from transport networks and the continuous cut of central place functions (Cunningham-Sabot and Fol 2007; EC 2007) especially small cities struggle to retain services and to adapt to changing economic conditions (Lang 2005). The parallel spatial concentration of economic, educational and other functions in larger urban agglomerations (EC 2014) finally lead to rapid population decline, aging and a growing number of obsolete buildings in peripheral cities (Knox and Mayer 2009; Borsig et al. 2010).

[4] Some authors use the terms suburbanization and sprawl interchangeably (Couch et al. 2005; Rink et al. 2005). However, this dissertation uses the term suburbanization to describe the increasing population in the suburbs, whereas sprawl is understood as the expansion of the physical space (urban land or built-up area) into the hinterland (Siedentop and Fina 2008).

The ***post-socialist transition*** in Eastern Europe after 1990 triggered a hitherto unknown form of rapid urban shrinkage (EP 2008; Baron et al. 2010) characterised by economic, demographic and political instability (UN 2007; Rienties 2009).[5] The formerly protected non-profitable industries (planned economy) had been exposed to the competitive world market and thus experienced a rapid destabilization of the cities' economies that triggered waves of out-migration as in the Polish Upper Silesian industrial region or the Halle-Leipzig-Bitterfeld region (Central German Chemical Triangle). Social insecurity and uncertainties, a decaying public health care system, physical stress and psychological anxiety have led to a 'demographic shock' with a sharp decrease in fertility parallel to an alarming decrease in life expectancy (Müller and Siedentop 2004; Kabisch S. et al. 2006; Steinführer and Haase A. 2007; EP 2008). Additionally, rapid privatization and a lack of planning regulations have led to an exceptional massive suburbanization and a hollowing-out of many cities (Nuissl and Rink 2005; Kotus 2006; Wiechmann 2008).

This contextualization of urban shrinkage as part of uneven development opens the ***structure of the dissertation*** and forms the basis for problem setting and a reflection on research gaps in chapter 1.2 from which the dissertation's objective is derived in chapter 1.3. As reflected in figure 2, this introduction is followed by a second part which elaborates the European debate on shrinking cities and reflects theories which are used to conceptualize urban shrinkage. This forms the starting point of this analysis which will be further operationalised in chapter 3 along three research questions. Following the research questions and the analytical steps, chapter 5 summarizes the results of five published or accepted papers as part of this cumulative dissertation (full versions in chapter 4) before this chapter concludes on their contribution to the scientific debate and practical relevance.

[5] Moreover, the vacuum of state power has unleashed savage ethno-national conflicts leading to urban shrinkage such as in Ex-Yugoslavia (Rienties 2009).

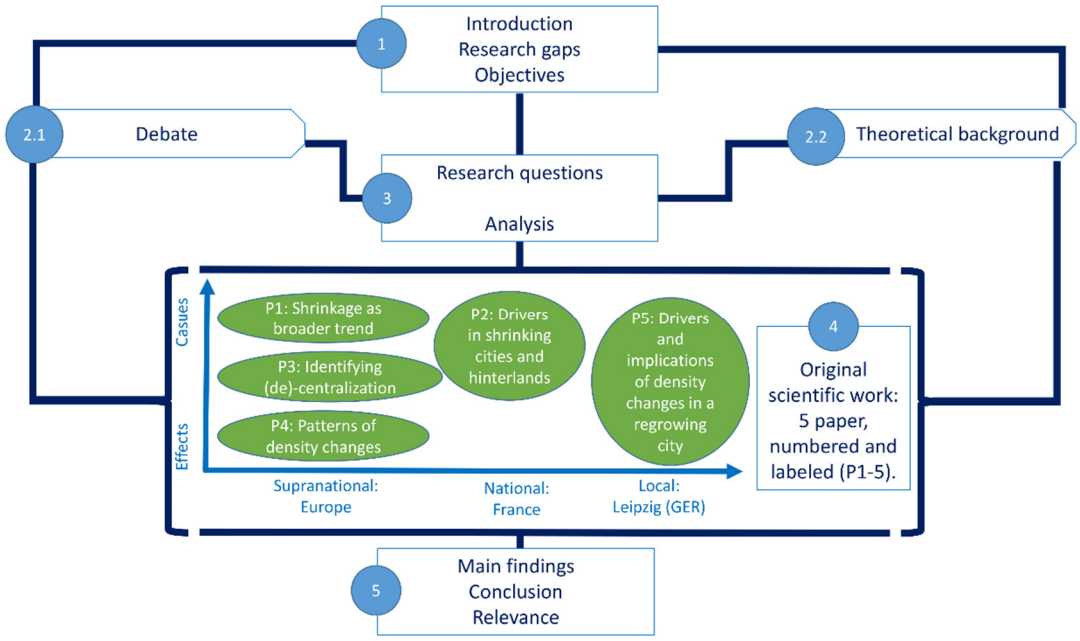


Figure 2: Conceptual structure of the dissertation (numbers indicate the chapters of this dissertation).

1.2 Current research gaps – what's to explain

Since the 2000s, the predominantly national debate on urban shrinkage in science and planning has turned into a debate on the conceptualization of causes, effects and patterns from an international perspective (e.g. Wiechmann 2003; Oswalt and Rieniets 2006; Schilling and Logan 2008; Pallagst et al. 2009; Sousa 2010; Hollander and Nemeth 2011; Martinez-Fernandez et al. 2012b; Haase A. et al. 2013a). However, advancements of this discussion towards a process-oriented and international understanding of urban shrinkage are limited due to a lack of comparative understanding and perspective. The problem thereby is less a theoretical one (we know what a shrinking city is) and rather a methodological-conceptual one between theory and empiriques, as the concepts and definitions of shrinking cities are difficult to apply in empirical research based on quantitative data (Bontje and Musterd 2012). Against this background, theoretical-empirical and conceptual-methodological research challenges arise forming the starting point of this dissertation.

Theoretical-empirical challenge

In light of these empirical problems, there is a deficit between theory and empiricism which basically includes three aspects: multidimensionality as well as spatial and process-related interrelations.

First, much is known about the causes and effects of urban shrinkage but when it comes to empirical evidence, these links show a more complicated picture of urban shrinkage as a ***multi-dimensional*** phenomenon following one or a handful of theories (Haase A. et al. 2013a). Most often, shrinkage is the result of a bundle of causes (Bontje and Musterd 2012) and shows different trends: Some shrinking cities face long-term economic decline while others are economically competitive. Moreover, processes of urban shrinkage which operate outside shrinking cities are only weakly integrated into explanations (Bernt 2015). The multidimensional character of urban shrinkage requires that not just the variety of trends but also the variety of scales on which they operate should be considered (Baron et al. 2010). This has led to the integration of macro trends within definitions or heuristic models (Haase A. et al. 2013a) – but they lack empirical evidence so far. Thus, analysis is needed to show how population loss intertwines with processes on other scales (Bernt 2015)[6] and thus to enrich the explanation both for theory and empirical findings (Bontje and Musterd 2012).

Second, the role of ***spatial interrelations*** for urban shrinkage is important because developments in the city are not independent of their hinterland (Hoekveld 2012; Servillo et al. 2014). Agglomeration effects lead to a reinforced population growth in the hinterland whereas people and jobs can move to the suburbs, leading to suburbanization and finally ending in a shrinking core city (Couch et al. 2005; Nuissl and Rink 2005; Siedentop and Fina 2008). In contrast, formerly shrinking cities have managed to regrow (Lever 1993), leading to a new situation that has already been observed in the US: suburban area decline with problems that used to be exclusively urban problems (deteriorating, vacancies; Bier 2001). There are systematic approaches, based on urban life-cycle models that take this into account. The widely used model of van den Berg (1982) reveals, however, some major drawbacks (Nyström 1992; Antrop 2004; Parr 2012). Thus, a systematic reflection of the spatial interrelations between core and hinterland is essential to broaden the understanding of uneven development trends with associated impacts on the urban labour market, economic development and the housing market in the city and hinterland. It also helps to measure the extent to which suburbanization is driving urban shrinkage in Europe.

Third, there is a weak understanding of ***process-related interrelations*** (Bernt 2015) such as clearly pointing out what physical effects population loss really indicates. The corresponding concentration and deconcentration processes are essential in theoretical terms, as urbanization is understood as a redistribution of both the population and its concentration in cities (Tisdale 1942; Heineberg 2001). A declining population in shrinking cities, for instance,

[6] Since the mid-1990s, a substantial debate on rescaling boundaries at the regional, national, and even global level states that reshaping boundaries depends on social processes and institutional forms (Smith 1995; Brenner 2001; Brenner 2004).

usually goes along with housing vacancies, abandonment and demolition, which is, however, different in each case (Bontje and Musterd 2012). Thus, cities are not just containers of people and jobs but also represent a built-up area whose evolution, however, might not comply with the corresponding population development. The interrelation of both trends results in different density changes within a city, which, in turn, affects the provision of services, the maintenance of infrastructure and environmental implications. Thus, the discussion on growth and shrinkage needs to be connected to changes in settlement patterns (Glaeser 2011) and environmental treatment in cities, which allows a conclusion to be made regarding the accordance with planning ideas (e.g. compact or perforated city, see Lütdke-Daldrup 2001). A systematic approach is needed which links the uneven dynamics of urban growth and shrinkage and their physical implications expressed as deconcentration and concentration of cities and within cities.

Conceptual-methodological challenge

The conceptual-methodological challenge is related to the insufficient coverage of cities in studies to date, as, basically, only larger cities have been analysed (e.g. with more than 100 000 or 200 000; Turok and Mykhnenko 2007; UN 2015) with the rule of thumb that the longer the period surveyed, the larger the cities on average.[7] Thus, an overall picture of shrinking cities might prevent this phenomenon from being side-lined by the dominant debate about the urbanization growth of large cities. However, this is a pure natural problem as the challenge relates to the yin-yang question of scale and data, both of which essentially impact each other especially in cross-national studies.

The ***question of scale*** can be translated into the simple question of what a city is and where it ends (Bontje and Musterd 2012). In figure 3, several delineations are imaginable. Usually, thresholds such as population size are used to separate cities from rural areas as well as reference scales such as administrative boundaries, which, however, can vary in both time and space. In international comparative analysis, two aspects are crucial. First, all countries have individual definitions for cities, such as administrative, functional or morphological ones (and terms), which vary according to the fit to international standards (e.g. UN recommendations); the number, sort and threshold of criteria used (e.g. population, jobs, commuting) as well as their origin and purpose (official, experimental etc.; see Guérois 2003). Second, even among the various international definitions of shrinking cities, the specifications of cities range from administrative to functional and even to parts of a city which are, in addition, defined by

[7] Just recently, two projects have considered very small cities whereas just one has also analysed their trajectories (Servillo et al. 2014; Bretagnolle et al. 2016).

different thresholds. However, the delineation should depend on theoretical considerations. Functional approaches are used to explain population loss in a city relative to its surroundings in order to show decentralization or suburbanization trends or to mirror economic and labour market relations (measured through travel-to-work relations; see Hall and Hay 1980; Cheshire and Hay 1989; Cheshire 1995). In contrast, administrative units are relevant to town and country planning and programming (EP 2008) whereas morphological units display a city in its physical shape, contraction or decontraction, covering land uses and their changes (Siedentop and Fina 2012). Moreover, hybrid approaches are used which, for example, merge administrative units based on building continuity (Turok and Mykhnenko 2007).

The ***question of data*** and their availability has first and foremost limited the sufficient empirical description of the phenomenon of urban shrinkage so far. In particular, the provision and comparability of socio-economic data represent a barrier to sufficiently applying theoretical concepts and, with that, shedding light on the explanatory power of population as a central indicator. As a rule of thumb, data availability decreases the smaller the scale, the more units (cities) are analysed and the more countries are considered. Similar to the question of scale, the question of data again points to theoretical considerations. On the one hand, there is a consensus that population loss displays the main characteristic of urban shrinkage because it is an easily accessible and simple indicator for spatial analysis, standing for a broad range of processes such as household trends, labour market performance and investment decisions (Bradbury et al. 1982; Pumain 2006; Turok and Mykhnenko 2008; Beauregard 2009; Haase A. et al. 2014). On the other hand, shrinkage cannot be mirrored by population loss alone. Nevertheless, other factors are hardly and explicitly articulated but are rather implied as a multidimensional phenomenon with symptoms of a structural crisis (Bernt 2015).

The question of scale and data is already difficult in national analysis but represents a huge challenge when it comes to ***cross-national comparative studies*** which would, however, allow the different characteristics of urban shrinkage and their role within urban systems to be examined. Thus, the knowledge of shrinking cities, at least in Europe, still lacks a comparative view, or – to be more precise – is limited to case studies, large cities, or to a spatial and mostly national snapshot. Although much local data is needed to sufficiently describe urban shrinkage, its quality and especially comparability is, to some extent, highly questionable apart from pure population numbers (question of data). As the quantitative aspects of defining a city differ widely with regard to the applicable threshold as well as scales, a harmonization is required that takes into account the whole range of cities of various sizes (question of scale). Finally, it needs to be questioned not only what a city is but what a shrinking city is (Bontje and Musterd 2012). This is not a banal issue. Figure 3 shows that for the simple indicator

population change, various thresholds are imaginable which describe the extent of losses and thus separate shrinkage from other trends.

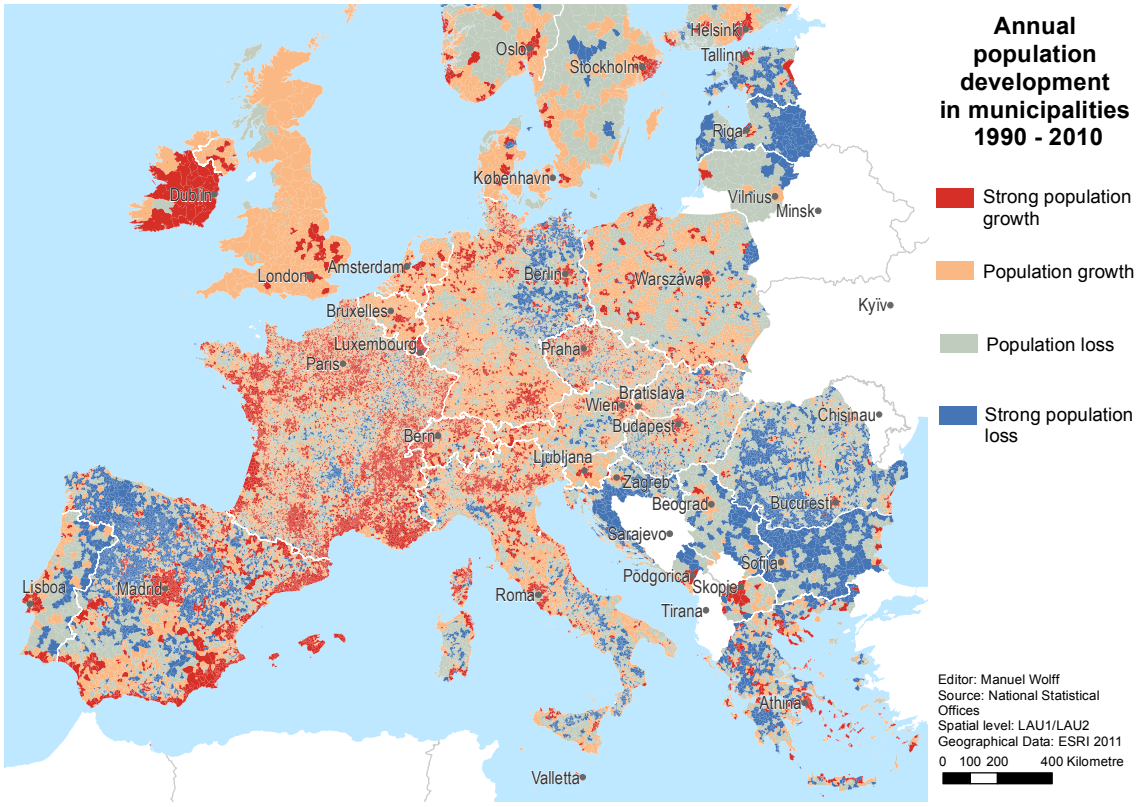


Figure 3: Population development in municipalities in Europe 1990-2010 (a version of this map is part of the thesis' paper 1 and represents the database on local population numbers used in this dissertation).

1.3 Objective of the Dissertation thesis

Shrinking cities are the subject of many theoretical insights and empirical studies. However, the international debate is limited because a) urban scholars know little about the extension and spreading of urban shrinkage from a cross-national comparative perspective, and b) the phenomenon of urban shrinkage is understood differently from country to country.

Against this background, this dissertation will identify the specific role of shrinking cities within the uneven urban development in Europe. The basic assumption is that shrinking cities are neither a one-dimensional phenomenon nor a side-effect of growth but describe a unique path of urban development, forming an own system with different challenges for science, politics and planning. Thereby, the phenomenon of urban shrinkage is conceptually addressed aiming at:

a) bridging the application of theoretical approaches with solutions to methodological-conceptual challenges in order to produce a cross-national perspective on urban shrinkage in Europe, and

b) develop a systematic and process-related understanding in more analytical terms, giving greater credence to the subcomponents of drivers, implications, and spatial variations.

As reflected in figure 4, the dissertation will build on the research gaps and combine aspects of conceptual-methodological (scale, data) as well as theoretical-empirical challenges (cause-effects, core-hinterland and concentration relations) using three research questions, which are explained in more detail in chapter 3. The results of the thesis will support the turn of the debate on urban shrinkage from a national discourse towards a cross-national international process of understanding (Haase A. et al. 2013a) and help to estimate to what extent urban shrinkage is a normal repeating phenomenon within uneven development, forming an individual phase of urbanization (Olsen 2013).

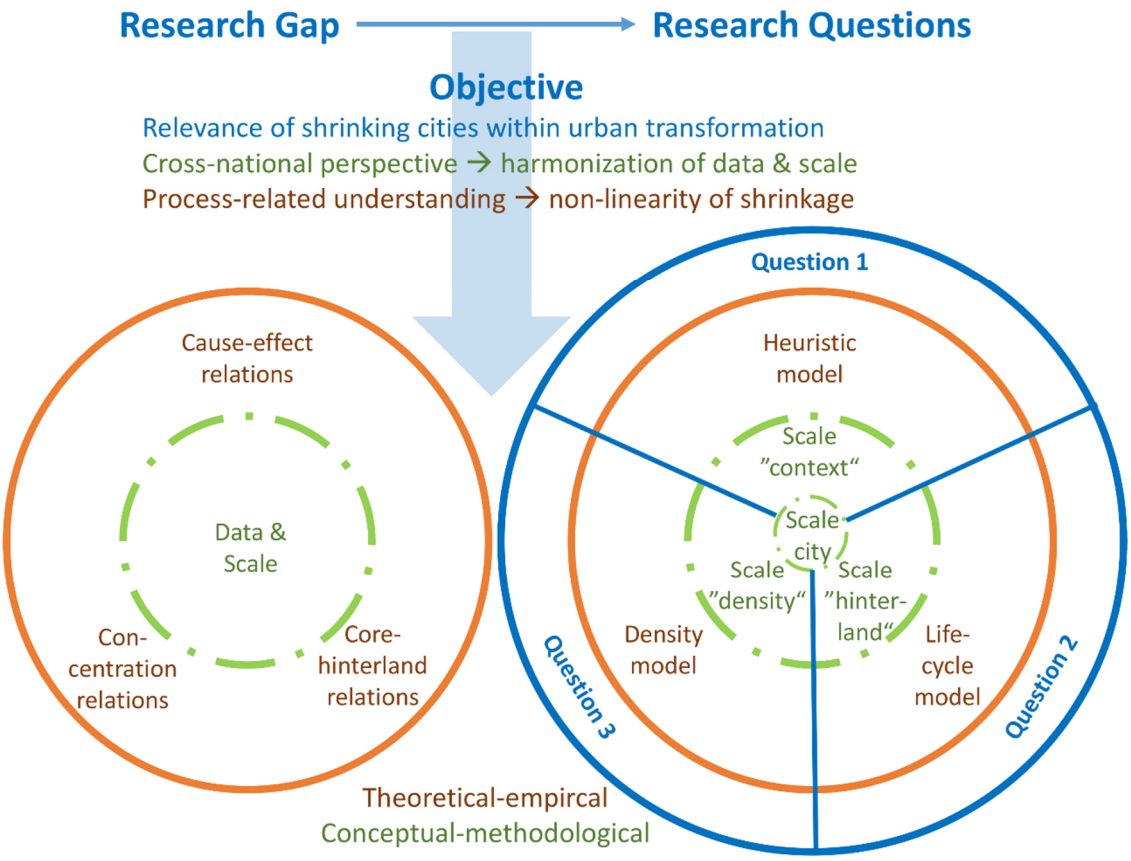


Figure 4: Conceptual link between research gaps, objectives and research questions.

2. Debates on shrinking cities in Europe and theoretical background

2.1 The debates on shrinking cities

The debate on urban shrinkage originated in the Anglo-Saxon school after the Second World War as a critique of the physical and social disadvantages in cities and the expanding mobility of the society observed in the US in the 1960s and 1970s or in Western Europe in the 1980s and 1990s (Mumford 1961; Gutkind 1962; Mumford 1968). The informal tabulation in figure 5, of Google Scholar citations of articles that use the term 'shrinking city' in the title and refer to Europe, highlights the importance of the topic for the research community over time.[8] Thereby, three major strands of debates structure the discussion around shrinking cities.

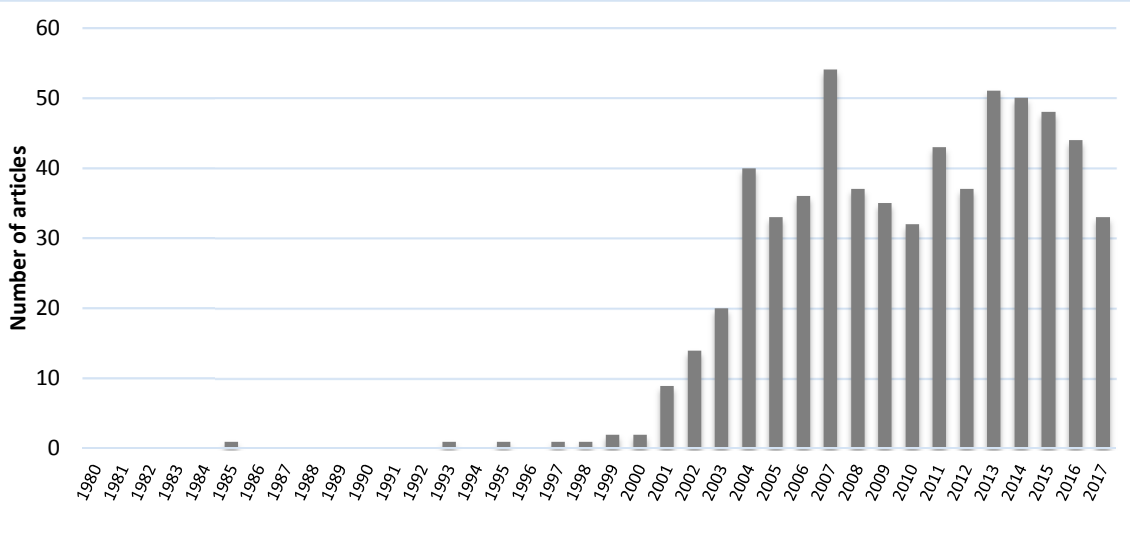


Figure 5: Shrinking City Scholary citation (Source: Google Scholar, tabulation by the author).

Debating factors of urban shrinkage

From the early 1970s, urban shrinkage was strongly linked to the industrial model in Western European countries, with industrialization connected to urbanization and deindustrialization connected to dis-urbanization (Camagni et al. 1986; Short 1996; Meijer 1993; Munck 2005). Although many authors described these ***economic structural changes*** and the collapse of prevailing or traditional industries as triggers for decline, especially during the 1980s different terms were used for urban shrinkage (Berry 1977; Bradbury et al. 1982; Hall and Hay 1980; van den Berg et al. 1982; Hall 1984; Cheshire and Hay 1989; Fielding 1989). The German

[8] The comparably low number of articles before 2000 is a result of the different terms in this phase and the predominance of articles drawing attention to economic restructuring processes or sprawl without explicitly mention shrinking cities. Moreover, the number of articles is underrepresented in the early years as the platform especially detects digital articles. The last update of this figure was performed on 22.01.2018 what explains the slightly lower number of articles in 2017 as not every article published in 2017 was already listed.

sociologists Häußermann and Siebel were the first to use the term 'shrinking cities' (Häußermann and Siebel 1985; Häußermann and Siebel 1987; Häußermann and Siebel 1988) and understood shrinkage to be triggered by the structural change of the 1960s and 1970s which resulted in two observations about shrinking cities in Western Germany: those that shrunk as a result of suburbanization of housing, businesses and industries still embedded in a growing agglomeration; and those shrinking cities that are affected by an erosion of their industrial basis such as coal mining and the steel, textiles and shipbuilding industries, leading to selective outmigration and population loss in the whole agglomeration.

Moreover, the spatial effects of demographic decline from the late 1960s on, when the pill took effect, have been debated (Lesthaeghe and van de Kaa 1986; van de Kaa 1987). It was, again, in Germany where this demographic development entered not just the academic but also the political arena. In 1972, a recommendation by the advisory council on spatial planning categorized regions in West Germany by demographic shrinkage and pointed to negative economic and social consequences (Göb 1977; ARL 1995; Brandstetter et al. 2005). Following these descriptive studies, scholars elaborated causes for this demographic decline, such as the importance of family, housing, employment, education, health, pensions, and economic and ecological development (Mackensen et al. 1984).

Debating effects, strategies and instruments

Whereas in the 1970s the discussion focused on how to effectively tackle the causes of urban shrinkage, such as fostering the economy and preventing outmigration, the debate shifted towards broad planning-dominated and national 'internal' debates (Germany, UK), focusing on effects, strategies and instruments to cope with urban shrinkage. Since the mid-1980s, various effects have been interrelated with shrinkage, such as diminishing municipal finances, leasing-problems, increasing vacancy rates and subsequent financial problems of the housing companies, demanding qualitative improvements to the housing market and the adaptation of the social infrastructure (Ganser 1985; Henckel 1985). A prominent early example of how to deal with shrinkage in practice was the International Building Exhibition (IBA) Emscher Park (1989-1999) which developed ideas for economically restructuring the former industrial Northern Ruhr Region and gained national and international attention (e.g. by actors from England's West Midlands). However, planners and politicians retain the motivation that the restructuring of the economic base will overcome shrinkage (Ganser 1997: 9; Nelle et al. 2017).

From the turn of the millennium, an open political and academic discussion started in most countries for the first time. This was fostered by the unsolved urban crisis phenomenon of

Western Europe and the distinct downward spiral of shrinking cities in Eastern Europe which led to a hitherto unknown constellation of the urban realm by the end of the 1990s (Turok and Mykhnenko 2007) with a rapid economic erosion in Eastern Europe and a vacancy crisis in the housing market in Eastern Germany.[9] Thus, the following paragraphs basically reflect the German debate.

With the report of the vacancy commission in the year 2000, the topic of shrinkage reached a climax in public consciousness in Germany and beyond. This is frequently quoted as the advent of a widespread, interdisciplinary attendance to urban shrinkage in Germany, presumably because it bluntly points to the necessity to manage shrinkage. Based on the observation of very high vacancy rates in Eastern Germany, a large demolition program was introduced in 2002, accompanied by suggesting integrated planning approaches to upgrade inner city areas. The academic contributions of those years focused on impacts on the housing industry and vacancies, urban restructuring programs in disadvantaged quarters or planning strategies and instruments (Lang and Tenz 2003; Nuissl and Rink 2005; Kabisch S. et al. 2006; Oswalt 2006b; Siedentop and Wiechmann 2007; Bernt 2009). They all called for a shift in planning paradigms and a re-thinking of development goals (Weiske und Schmitt 2000; Hannemann et al. 2002; Kil 2004).

Characteristically for this time, first, the term ‘shrinking city’ was established in academic, planning, and political discussion, and researchers and planners used similar patterns of argumentation. They embarked on formulating visions for a qualitative adjustment of shrinking cities and, thus, set up a discussion that went beyond the pure problematization of urban shrinkage, such as ‘the perforated city’ (Die perforierte Stadt) as normative contributions (Lüdtke Daldrup 2001; Oswalt et al. 2002; Lang and Tenz 2003; Lüdtke Daldrup 2003). Second, applied projects such as the International Building Exhibition (IBA) Stadtumbau Saxony Anhalt, which ran from 2002 to 2010, had a particular impact on the practical debate on urban shrinkage in Germany and in the World as it broadened the debate by pursuing concepts in the realm of urban shrinkage and linked responsible staff in municipalities with academics and external consultants. Third, the understanding of urban shrinkage was still highly dependent on the national discourse and context. However, with the crisis in Eastern Europe, scholars focussed on the supposed ‘catch-up modernization’ of market-driven growth in the context of depopulation and deindustrialization (e.g. Großmann et al. 2008) and thus started to call for greater comparative efforts than before.

[9] In the early 1990s, the debate in Germany was, however, overlaid by growth expectations due to the East-West migration within Germany.

Debating international characteristics and spatial structures of urban shrinkage

The third strand describes the international debate on causes, paths, and planning strategies for urban shrinkage. First, the international research project 'shrinking cities', financed by the German cultural foundation (Kulturstiftung des Bundes, 2002-2006), managed to draw attention from a wide range of communities, including architects, planners, artists, scientists and the general public. By using publications and exhibitions, the project highlighted the cultural aspects of urban shrinkage, reflected on ways to deal with urban shrinkage, pointed out international parallels, and thus strongly influenced the international discourse (Oswalt 2006a; Oswalt 2006b). Second, the 'Shrinking Cities International Research Network' (SciRN) installed in 2004 encouraged the discussion among urban and regional scientists and planners from different countries, highlighting lessons learned and strategies to deal with causes and effects in a wide spectrum of worldwide cases (Pallagst et al. 2009; Martinez-Fernandez et al. 2012b; Pallagst et al. 2014; Wiechmann 2015). Third, shrinkage was conceptualized as a site product of the temporal and spatial cycle of the global economy and markets (Harvey 2000; Soja 2000; Sassen 2001; Dickens 2003; Scott and Storper 2003). This became relevant again when the global economic crisis and its effects from 2008 on brought a new wave of mass lay-offs and a collapse of big companies with an increasing number of distressed regions across the globe (Martinez-Fernandez et al. 2012a; Pallagst et al. 2014). The massive offshoring of labour-intensive manufacturing jobs from developed to developing countries, where it is most profitable, explained the shrinkage in Northern America and Western Europe (Birch and Mykhnenko 2009).

Additionally, there were attempts to theoretically elaborate urban shrinkage and embed this process within existing theories (Weiske et al. 2005; Bernt and Rink 2010; Wiechmann and Pallagst 2012; Haase A. et al. 2013a). In particular, two major international research projects fostered the international discourse. The COST-Action 'Cities Regrowing Smaller' (2009-2013), which unified experts from 26 European countries, aimed at fostering knowledge on regeneration strategies in shrinking cities across Europe and highlighted urban shrinkage as a result of globalization pressures (see special issues in International Journal of Urban and Regional Research 2012; Built Environment 2012; European Planning Studies 2015). The outcomes cover a conceptual framework on shrinking cities research, a synthesis report focusing on different types and cases of shrinkage across Europe and a local database for measuring shrinkage in Europe.[10] In parallel, the research project 'Shrink Smart' (2009-2012) which incorporated cities from the UK, Italy, Poland, Czech Republic, Ukraine and Romania

[10] The PhD candidate was a member of this COST Action and established this database which forms the central quantitative data source of this dissertation.

looked at power constellations, the political and cultural context and the effects of regeneration policies in shrinking cities, framed by cultural and polity contexts (Haase A. et al. 2013a; Haase A. et al. 2014; Rink et al. 2014). Both projects essentially intensified the knowledge exchange on causes, paths and planning strategies of urban shrinkage within the 'shrinking cities' community, between countries and between scientists and practitioners and – for the first time – stimulated the European political debate (see Baron et al. 2010; Gerőházi et al. 2011).

Currently, the debate is characterized by three aspects. First, the established topic on urban shrinkage in Europe and the US is bridged to debates on shrinking cities in other parts of the world (see Matanle and Sato 2012; Richardson and Woon 2014; Uemura 2014; Mallach et al. 2017; Hattori et al. 2017). Second, shrinkage is linked to other topics such as public and free space, health issues, or transport and infrastructure adaptation (Haase D. 2014b). Third, since the mid-2000s, a general debate on reurbanization or 'resurgent cities' (Cheshire 2006) has started and a reconcentration of population in (large) cities, set against an overall (regional) shrinkage, has been described for Eastern Germany (Herfert 2002; Herfert 2007), Northern England (Couch et al. 2009; Rink et al. 2012) and beyond (Cheshire 2006; Haase A. et al. 2010).[11] As a stage after shrinkage, studies looked at the underpinnings of reurbanization in terms of demographic, household or housing change (Buzar et al. 2005; Haase A. et al. 2012; Karsten 2014) or the role of inner-city revival in the context of urban renaissance policy or neoliberal urban development (Kujath 1988; Helbrecht 1996; Stead and Hoppenbrouwer 2004; Brühl et al. 2005; Storper and Manville 2006; Colomb 2007).

Interim conclusion – the strong need for an international comparative perspective

Since 2010, the debate on causes, effects, and planning strategies for shrinking cities and their international comparisons has made considerable progress beyond national debates. However, a comprehensive picture of urban shrinkage in a comparative cross-country perspective feeding the international debate as well as the conceptualization of this multidimensional process based on empirical evidence, are lacking to a large extent (Pallagst et al. 2017). Analysing a selection of the 100 most relevant articles on shrinking cities in Europe published between 2000 and 2015, figure 6 shows that 55 mirror the national picture of shrinking cities, be it with a rather descriptive character or with theoretical considerations, with recent work referring to Denmark (Fertner et al. 2015), Germany (Milbert 2015 based on

[11] Reurbanization was already discussed in the 1960s and 1970s by urban planners in Germany as a 'concentration in new forms' (Wortmann 1962) and was introduced as a hypothetical stage of core growth and hinterland decline within urban life cycle models (Berry 1977; Klaassen and Scimeni 1981; van den Berg et al. 1982).

Gatzweiler et al. 2003), Slovakia (Bucek and Bleha 2013), and the Netherlands (Hoekveld 2012). However, in terms of international comparative studies, just three articles provide an empirical picture of urban trends (Turok and Mykhnenko 2007; Mykhnenko and Turok 2008; Kabisch N. and Haase D. 2011).

	Comparative survey	National studies	Case studies	TOTAL
Empirical (descriptive)	3	34	22	**59**
Theoretical (conceptual)	4	21	16	**41**
TOTAL	**7**	**55**	**38**	**100**

Figure 6: Scope of articles about shrinking European cities between 2000 and 2015 (Source: Google Scholar, tabulation by the author).

2.2 Theoretical background on shrinking cities

An impressive range of theories and concepts has been developed, which explain the causes of urban shrinkage. However, they do not form a consistent conversation as they were developed at different times, against different empirical backgrounds and in a variety of local, regional, and national contexts (Haase A. et al. 2013a). Nevertheless, the relevant theories can be classified into three groups which range from economic to spatial to demographic explanations.

Economic explanations…

… from a local perspective:

From a local microeconomic perspective, ***neoclassical product cycle theory*** assumes that shrinkage is an outcome of a limited life span of products. The general sequence of products depends on technological rhythms, innovations and the evolution of capitalism (Schumpeter 1939; Hall 1988). For the initial innovation-driven development job growth, highly qualified employees and venture capital are needed, all of which are most likely to be found in cities (Kondratieff 1984; Friedrichs 1993). Due to changes in demand, production, and marketing conditions, a continuous adjustment of the production processes and optimum production site of a product is required. This leads to a standardization of manufacturing conditions with low labour-intensive but less-qualified industrial jobs (mass-production, Fol and Sabot 2010) and difficulties of adaptation to technological changes (Kaniss 1981). Finally, economic decline emerges when one of the major production factors, such as labour, capital or technical progress, fails to expand and cannot be compensated by the growth of other input factors, or if the endowment of all these factors becomes scarce at the same time (Booth 1987).

Consequently, insufficient investment in strategic sectors and weak entrepreneurship (Lang 2005) lead to a downturn in the industrial wave which cannot be replaced by the rise of a new one, as described by the ***macroeconomic theory of long waves*** (Läpple 1987). The resulting lowering of production and labour costs and the relocation of production sites foster job losses, unemployment, and selective out-migration (Malizia and Feser 1999; Fol and Sabot 2010) – all leading to urban shrinkage.

Contrary to the equilibrium-assumption[12] of these neo-classical theories, a circular and cumulative development reinforces the polarization of (economically) growing and shrinking areas (disequilibrium, Liefner and Schätzl 2012). From a ***post-Keynesian perspective***, this is a result of the redistribution of net investments and corresponding agglomeration deficits with unemployment in shrinking cities (Schmidt 1966). Because socioeconomic variables are strongly interrelated, the change of one variable leads to self-reinforcing feedback loops that impact the intensity of the cumulative process of drivers and causes (Myrdal 1957; Liefner and Schätzl 2012). Unemployment leads to outmigration with decreasing tax revenues, which constrains fiscal resources. This in turn leads to discouraging economic activities (entrepreneurship) and private and public investments, for example social infrastructure or technology development, finally ending in negative commerce and increasing unemployment rates (Friedrichs 1993). Operating on different scales (national, international, regional), these feedback loops of economic factors (demand, income, investments, production) give rise to the distinction between shrinking and growing cities, as shown in regional and urban competition theory (Batey and Friedrich 2000).

… from a global perspective:

From a global perspective, economic networks squeeze the production sector by shortened product life cycles with a constant demand for rationalization, relocation, and job-driven outmigration (Conti 1997; Schelte 1999; Lang 2005). In line with the ***new economic geography***, shrinking cities become increasingly 'unplugged' from these networks due to the mobility and volatility of the workforce, capital and investment flows, which are essential and unprecedented in their speed and scope (Scott and Storper 2003; Martinez-Fernandez et al. 2012a). In particular, the ***territorial divisions of labour*** literature argues that urbanization – and with that shrinkage – depends on the functional and spatial aggregation of particular enterprises, industries and labour, as well as on the organization of global production

[12] A balanced economic development (equilibrium) is assumed as an effect of unlimited factor mobility of market and multiplier effects (Liefner and Schätzl 2012).

processes, networks and strategic decisions of specific industries, i.e. electronics, automobiles, banking etc. (Massey 1984; Scott 1988; Bluestone and Harrison 2000; Soja 2000; Dunford 2003). As these decisions are made by multinational corporations that are predominantly located in command and control centres of the global economy, cities are susceptible to a new form of temporary or permanent population decline and shrinking cities form a spatial manifestation of globalization (Sassen 2001; Gereffi 2005; Martinez-Fernandez et al. 2012a).

Additionally, the movement by capital and investment is essentially determining the ***uneven economic development*** of cities (Smith 1984; Harvey 2006). 'Spatial fixes' – so to say investments into, for example, the physical infrastructure, transportation or communication that are made during a growing phase of capitalist cycles (Harvey 2000) – can devalue what leads to a continuous remaking or 'creative destruction' of urban spaces, beginning a new growth cycle of spatial fixes (Harvey 2006; Martinez-Fernandez et al. 2012a; Haase A. et al. 2014). Thereby, the flexible accumulation of capital, international outsourcing to lower-wage locations and lean production within global networks help to cope with profit crises. Shrinking cities are, thus, a 'normal' characteristic of capitalist neoliberal urbanism as they fail to successfully attract investments into the built environment, plagued by abandonment, obsolete industrial branches and their decreasing attractiveness to people, while economic wealth is accumulated and preserved elsewhere (Soja 2000; Smith 2002; Scott and Storper 2003; Harvey 2006). In particular, the increasing market-dependency of a city's financial sustainability and the speculative circulation of capital in the built environment and the privatization or financialization of risks and debts has led to predatory mortgage lending and its securitization in global financial markets, widespread disinvestment and real-estate devastation, reinforcing the shrinking process worldwide (Martinez-Fernandez et al. 2012a; Salone et al. 2016).

Spatial-temporal explanations

Urban shrinkage as an integral part of urban development was first developed for depopulated neighbourhoods (Hoyt 1939) and in the 1980s applied to cities within the ***life-cycle theory of urban development*** (Hall 1971; Berry 1977; Klaassen and Scimeni 1981). Thereby, urban shrinkage, also referred to as 'counterurbanization' (Champion 2001), is seen as a consequence of deconcentration and the onset of urban expansion at the fringe of cities (Berry 1977; Fielding 1982). Following the pioneering work of Hall and Hay (1980), who pointed to regular phases of population growth and decline, van den Berg et al. (1982) developed a phase model which describes a cyclical sequence of concentration and deconcentration of European

cities relative to their hinterland.[13] They identified four successive phases of urban development which differ in relative and absolute population growth or decline in the core city and hinterland – urbanization, suburbanization, disurbanization, and reurbanization – although the latter is treated as a hypothetical stage. Shrinkage was seen as inevitable following growth, as a direct consequence of the strategies of economic agents aiming to maximize their satisfaction according to neoclassical economic theory (Fol and Sabot 2010). Similar to what Häusermann and Siebel (1987) observed, cities start to shrink in their late suburbanization stage and proceed with continuing decentralization to disurbanization – a stage in which the total population of the Functional Urban Region (FUR, the core and the hinterland) decreases. A key feature of this model was the introduction of a fourth phase – reurbanization – in which the city regains population in absolute or relative terms while the FUR continues to shrink, a stage that has been proven for many European cities (Cheshire 1995; Kabisch N. and Haase D. 2011).

In contrast to the van den Berg et al. (1982) model which has been contradicted by a number of studies (Cheshire and Hay 1989; Cheshire 1995; Champion 2001; Buzar et al. 2005), other explanations follow the ***polarization thesis.*** This thesis basically assumes that the classic distinction between cities and rural areas continues to decrease, and that growth is no longer a result of immigration from rural areas or the hinterland, but rather of the withdrawal of populations from other cities. This produces increasing differences between growing and shrinking cities depending on changing economic and social conditions (Häußermann and Siebel 1988). By describing the differentiated development of cities within a region, Geyer and Kontuly (1993) pointed out that cities experience different waves of migration depending on their size. Among the six consecutive phases of the model, shrinkage occurs after the so-called polarization reversal in which outmigration dominates the largest (primate) city and starts also in medium-sized cities, whereas smaller cities at greater distances from the primate city benefit from immigration. Similar to the van den Berg et al. (1982) model, growth is followed by decentralization and finally population losses. However, this shift away from the core city goes beyond the traditional explanation of suburbanization, referring rather to the spatial expansion of cities producing urban spaces of their own such as 'boomburbs' (Teaford 1996; Lang R.E. and LeFurgy 2007).

[13] In the concepts, the terms agglomeration and metropolitan area are used. However, in order to be consistent in the text, this PhD uses the terms city, hinterland and Functional Urban Region (FUR).

Demographic explanations

The dramatic decline of fertility to levels far below the natural reproduction rate has been observed in Central and Eastern European countries since 1990 (Müller and Siedentop 2004; Steinführer and Haase A. 2007). This phenomenon was already interpreted, in the 1980s, as Europe's Second Demographic Transition[14] by Lesthaeghe and van de Kaa (1986; van de Kaa 1987).

Contextualized by high rates of marriage, low divorce rates, and low levels of age at first marriage, ***the first demographic transition (FDT)*** describes the decline of death rates as a consequence of the improvement in medical and hygienic circumstances as well as economic organization in the 19th and the first half of the 20th century. In the later stage, urbanization and secularization processes with rising living standards and technological innovations influenced reproductive behaviour and led to decreasing birth rates, mainly as an adaptation to declining death rates (Heineberg 2001). The end point of the FDT is supposed to be a balance between deaths and births with an older population and higher life expectancies but still having replacement fertility without a 'demographic' need for sustained immigration.

The ***second demographic transition (SDT)*** sees no such equilibrium as it is marked by continuously decreasing fertility rates far below the population replacement level (Lesthaeghe 1995). The SDT began in the mid-1960s and accelerated during the 1980s with fundamental shifts in societal norms and values. This led to characteristic behavioural effects of the people born in the mid-20th century where the "right to personal fulfilment prevails and where fertility becomes the decisive factor since the child may henceforth be considered as an obstacle to the achievement of other personal objectives" (EP 2008: 10). These behavioural effects are marked by declining numbers of married couples, rising divorce rates, an increasing age at marriage and a shift away from the conventional definition of 'families' as couples with children, to more varied household types including an increasing number of blended families (van de Kaa 1987). In addition to the pill, which took effect from the 1970s, all of these changes have led to dramatically dropping fertility rates. Consequently, the increasing life expectancy has led to a much older population than envisaged by the FDT.

The most commonly anticipated outcomes are a decline in the working-age population, a decrease of household size with increasing instability e.g. single persons or lone mothers (Ogden and Hall 2000; Buzar et al. 2005) and the need for replacement migration which will

[14] This dissertation uses the terms second demographic transition and demographic change interchangeably following the English-speaking literature, whereas in countries such as Germany, the term demographic change is usually used. However, both processes share more or less the same aspects (Buzar et al. 2005: 64).

not, however, be capable of stemming aging, but will only stabilize population sizes and requires effective cultural integration (EC 2005; Hartog 2005; Gerőházi et al. 2011).

Although the SDT has led to a slowing down of population growth, especially in cities (Champion 2001; Steinführer and Haase 2007; Turok and Mykhnenko 2007), several authors see aspects of the SDT ***running opposite to urban shrinkage***. The growing number of smaller single-person and childless dual-income households who are attracted by the economic and cultural offers are seen to contribute to the growth of cities (Ogden and Hall 2000; Buzar et al. 2005; Fol and Sabot 2010).

3. Research design and questions

Against the background of the identified research gaps in combination with the reflection on the debate and theory of shrinking cities, three basic questions structure this dissertation. Each question combines aspects of conceptual-methodological (scale, data) as well as theoretical-empirical challenges (cause-effects, core-hinterland and concentration relations), which are addressed by various analyses using existing models and their adaptation (figure 7), applied at the European, national and local level – a work which was published in five scientific papers.

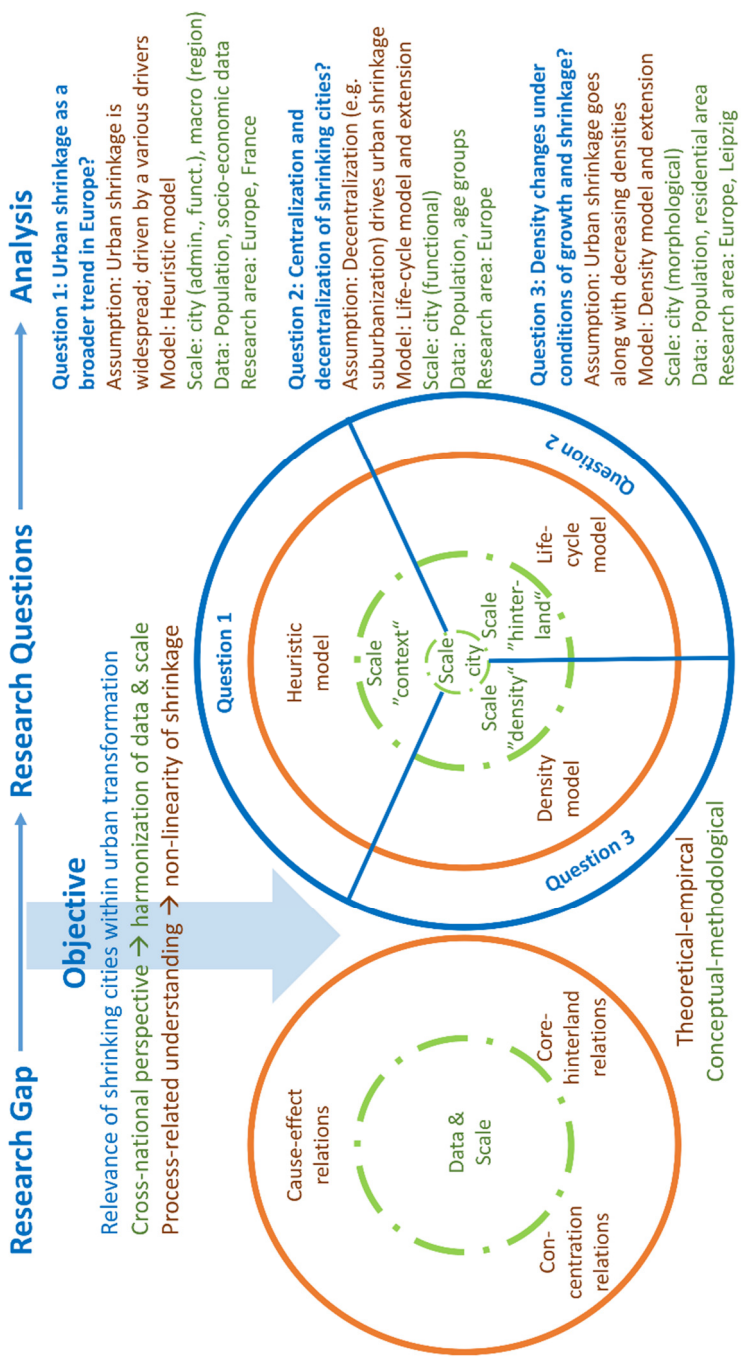


Figure 7: Conceptual link between research gaps, questions and analysis.

Question 1: Urban shrinkage as a broader trend in Europe?

To what extend does urban shrinkage represents a broader trend in Europe and what are basic drivers on macro and local level?

OBJECTIVE

The first research question fills the gap between macro-theoretical conceptualization and empirical observation by identifying types of urban shrinkage in a cross-national comparison. In order to contextualise urban shrinkage within uneven dynamics, the non-linear population development is intersected with socio-economic trends. Thereby, paper 1 asks to what extent urban shrinkage represents a broader trend in Europe, in terms of duration, distribution and the extent to which this is influenced by demographic change and economic restructuring. This is supplemented by paper 2 which identifies underlying factors and processes in French cities. France is chosen as one of Europe's largest economies, with a rather stable demographic performance where, however, urban shrinkage is hardly politically perceived although it represents a broader trend (Julien 2000; Labosse 2010). This contextualization of the results at the European level, both from a spatio-temporal and socio-economic perspective, is valuable in order to understand whether the lack of interest in shrinkage is justified by the fact that this phenomenon is still marginal or if the attention should be drawn to (national) needs for planning reactions.

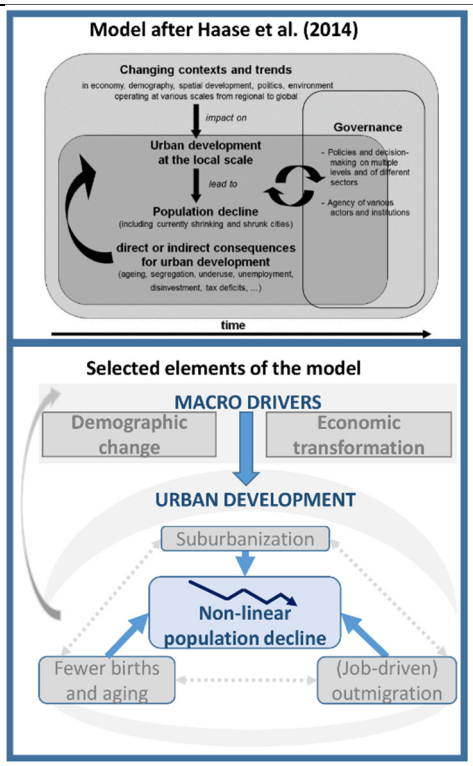
Paper 1: *Wolff, Manuel and Wiechmann, Thorsten (2017): Urban growth and decline: Europe's shrinking cities in a comparative perspective 1990-2010. European Urban and Regional Studies. Vol. 25 (2), pp. 122 – 139.*

Paper 2: *Wolff, Manuel; Fol, Sylvie; Roth, Hélène and Cunningham-Sabot, Emmanuèle (2017): Is planning needed? Shrinking Cities in the French urban system. Town Planning Review. Vol. 88 (1), pp. 131-145.*

MODEL

Following the hypothesis that urban shrinkage in Europe is a complex and multi-dimensional process driven by a bundle of drivers, a ***heuristic model*** (Haase A. et al. 2014) is applied. This model combines various explanatory contextual factors and their local impact on population development. The underlying assumption is that shrinkage is a result of the "place-specific interplay of economic transformation, suburbanization and demographic change" that directly or indirectly impacts on the local settings of a city, for example, the labour market, socio-spatial differentiation, housing, land use, the state of the social and technical infrastructure, etc. (Haase D. 2014b: 1528). By using population as one of the most accepted indicators for spatial analysis, shrinkage is defined by population decrease. The non-linear dynamics of shrinkage allow the interdependencies between macro drivers and population loss to be

concluded (Turok and Mykhnenko 2007; Beauregard 2009). Because cities are not isolated entities but are embedded in regional contexts, this model conceptualizes demographic and economic drivers on a macro scale to explain non-linear local urban trajectories (Grossmann et al. 2013; Haase A. et al. 2013a). The model heuristically connects causes and impacts, based on a variety of theories, which allow its application to different contexts and various explanatory factors to be evaluated



METHODS

Because of shortcomings in the databases currently available for European cites, a ***city*** definition is developed which allows small and large European cities to be studied in a comparable way following existing approaches (Brezzi et al. 2012; Servillo et al. 2014). This approach used various geodata and defined 7 742 cities out of around 90 000 municipalities in 36 European countries which combine a minimum population threshold with a minimum density.

Based on a compromise between ***data*** availability and methodological-theoretical considerations, data are collected from national statistical offices at five-year intervals (1990, 1995, 2000, 2005 and 2010) because it is assumed that changes in a period of five years can be considered as structural changes that can be detected within a minimum period of 20 years (EP 2008; Hoekveld 2012). Based on this, a typology of trajectories was developed and then intersected with regional socio-demographic types. The latter were calculated using seven indicators which are in line with the theoretical assumptions and which had been obtained from EUROSTAT (NUTS2).

For ***France*****,** an official spatial unit was used (354 'Aires Urbaines', defined as travel to work area) as this unit can integrate suburbanization processes. Twenty indicators (19 socio-economic indicators and population) have been used for the period 1975-2007 obtained by the National Statistical Institute of France (INSEE). Because of various changing limits, the data needed to be reconstruct for the most recent spatial reference. The same approach was used for the European local data.

Question 2: Centralization or decentralization of shrinking cities?

Are cities decentralizing or centralizing and are there differences between growing and shrinking cities?

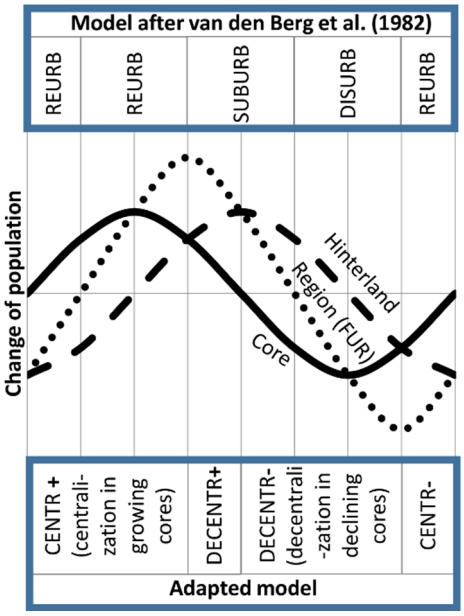
OBJECTIVE

In order to simultaneously capture trends in cities and their hinterlands, the second question seeks to understand whether cities are decentralizing or centralizing and whether there are differences between growing and shrinking cities. Centralization is understood as a stronger population growth of core cities and a situation in which the hinterland is growing slower, while decentralization reflects the opposite, respectively. The rapidly changing population trends since the beginning of the global economic crisis and its effects in Europe since 2008 require that more attention should be paid to changing configurations between cities and processes beyond cities' borders, which is essential for both scholars and urban planners.

Paper 3: *Wolff, Manuel (2017): Understanding the role of centralization processes for cities – evidence from a spatial perspective of urban Europe 1990 – 2010. Vol. 75, pp. 20-29.*

MODEL

To identify patterns of centralization and decentralization in shrinking and growing cities in Europe, the ***life-cycle model of van den Berg et al. (1982)*** is tested for the two decades 1990-2000 and 2000-2010. In this model, four successive stages of urban development are identified that differ in terms of population growth and decline in the core, hinterland, and FUR: urbanization, suburbanization, disurbanization, and reurbanization. These can be further subdivided by taking into account absolute or relative variations. The changes between stages are explained by transportation costs and the spatial socio-demographic, political, or technological trends. Although the model is widely used, only larger cities have been analysed and population change as an indicator hides certain trends, such as shifts in the population structure. Moreover, not all population trajectories follow the consecutive order of the model's stages. Thus, an ***adapted model*** has been applied with the advantage that the four stages fall symmetrically into core population growth and decline, as well as into centralization and decentralization (Hall 1971; Cheshire 1995) which allows the intensity of the trends to be measured and thus explains deviations from life-cycle models.



METHODS

The biased consideration of large cities in previous studies and the lack of a definition of cross-boundary functional urban regions in Europe require an individual ***delineation of a city's hinterland.*** Based on the work in paper 1, the 5 692 cores are defined by merging cities based on a common built-up area, in order to better reflect the morphological character of a city and to increase comparability across Europe (Turok und Mykhnenko 2007; Parr 2012). Following the concept of time-budgets, the hinterland is defined by merging municipalities that can be reached from the core within 45 minutes by car (Guérois et al. 2014; Meijers et al. 2015).

Population ***data*** for 1990, 2000, and 2010 in 36 European countries are used to define shrinking cities by absolute population loss and to construct the stages of the van den Berg et al. (1982) model and the adapted model. For the four stages of the adapted model, the intensity of relative (de)centralization is measured (Cheshire 1995; Parr 2012) and expressed as the difference between the percentage change in hinterland and core. In order to reflect changes in the population structure and to discuss possible future trends, shifts of different age groups are analysed (Parr 2012).

Question 3: Density changes under conditions of growth and shrinkage?

What is the impact of a changing human demand under conditions of growth and shrinkage on density changes?

OBJECTIVE

The third question seeks to detect to what extent dedensification is universal for growing cities and how (de)densification of both shrinking and growing cities contributes to current land consumtion in Europe. Density is a fundamental element of urbanization processes as it displays the spatial structure of a city and helps to understand how much land is in urban use and why it varies across space and time. While the decline of densities or deconcentration has often been used as the very definition of sprawl around growing cities, it can also refer to a hollowing-out core and a growing periphery (Couch et al. 2005). Density changes reflect the changing physical extent of the city and allow to discuss sprawl, infill within existing buildings and changing demands for supply facilities, transport and supply networks, or flats and houses. Against this background, paper 4 performs a contrasting analysis that reflects recent developments in both de- and reconcentration in growing and shrinking cities, while paper 5 detects differences between successional population growth and decline for density changes on a subcity level and their driving forces in the case study of Leipzig.

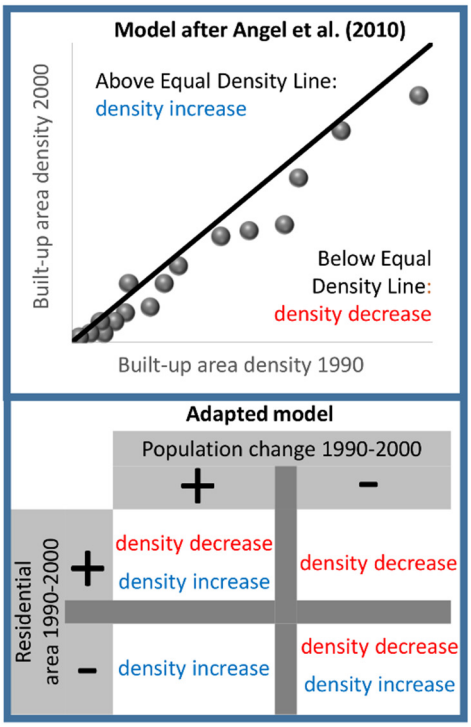
> ***Paper 4:*** *Wolff, Manuel; Haase, Dagmar; Haase, Annegret (2018): Compact or spread? A quantitative spatial model of urban areas in Europe since 1990. Plos-ONE. Vol. 13 (2):*

e0192326.

Paper 5: *Wolff, Manuel; Haase, Annegret; Haase, Dagmar; Kabisch, Nadja (2016): The impact of regrowth on the built environment. Urban Studies. Vol. 54(12), pp. 2683–2700.*

MODEL

A ***density change model*** (Angel et al. 2010) is applied to European cities for the period between 1990 and 2010 in order to compare density change patterns for Europe. At the core of their model, the authors plot the density of a built-up area for one time period against the density of another period. The process-oriented characteristic of the model allows the intensity of (de)concentration processes to be studied and reveals whether a city is developing in a more compact way and with less sprawl than other cities. However, as the model covers large cities, the conclusion is that, basically, urban growth is associated with deconcentration and dedensification as urban land area expands faster than population grows. As this poorly reflects the uneven dynamics of simultaneous population growth and decline in Europe, an ***extended measurement concept*** for density changes was applied to European cities by investigating the relative influence of changes in the population and the residential area in order to draw conclusions about underlying driving forces. In an additional paper, this concept is applied to the sub-local scale for the larger European city of Leipzig in order to better understand supply and demand driven causes of density change at the district level. Leipzig was chosen as it experienced significant growth after a longer phase of shrinkage, a major trend in Europe that allows density change patterns at different development stages and the interrelation of their drivers within demand- or supply-driven conditions to be studied.



METHODS

In line with the analysis by Angel et al. (2010) and due to the shortcomings of existing databases, an approach to ***delineate morphological urban areas*** was developed. The units comprising 5 692 urban morphological areas in 35 European countries are delineated by merging administrative units (Local administrative units at level 2, so called LAU2) defined by paper 1, based on a continuous built-up area using the UMZ-database (Urban Morphological Zone) and the Dictionary of Correspondence LAU2/UMZ. Densities were measured as the ratio of the total urban population and the total residential area. Population numbers were derived

from a database of population figures for municipalities for 1990, 2000 and 2010 and residential area[15] was obtained from the European Environmental Agency for 1990, 2000, and 2012 (continuous and discontinuous urban fabric from Corine Land Cover data).

For ***Leipzig,*** which was analysed for the period between 1985 and 2012, data on the residential area were obtained from a historical land use database for 1985, 1997, and 2003 (Saxon Cadastral Agency) and detailed official land-use data (ATKIS) for 2006 and 2012. By using population data for the 63 districts, densities and their changes were calculated. Furthermore, in order to reflect demand and supply-driven factors (BMVBS and BBSR 2009), net migration, age and household-related indicators were analysed at the district level, together with data on subsidies and jobs at the city level.

[15] In contrast to Angel et al. (2010) the adapted model uses residential density which is calculated by distributing the total population to the area occupied by residential housing in order to reflect the area which is actually used for housing.

4. Original scientific work

4.1 Urban decline in Europe, 1990-2010: shrinking cities in a comparative perspective

Paper 1: *Manuel Wolff, Thorsten Wiechmann*

Urban growth and decline: Europe's shrinking cities in a comparative perspective 1990-2010.

European Urban and Regional Studies, 2017, Vol. 25 (2), pp. 122 – 139,

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Article

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Manuel Wolff
Helmholtz Centre for Environmental Research – UFZ, Germany

Thorsten Wiechmann
TU Dortmund University, Germany

Introduction

At the beginning of the 21st century, the phenomenon of shrinking cities was widely discussed across Europe. Most European countries saw an increasingly ageing population and an internal migration from underdeveloped to more competitive locations. The percentage of cities that experienced population loss, called shrinking cities, has remained stable worldwide at around 10% during 1970–1990 and 1990–2014 (UN, 2015: 72). This trend is largely associated with cities in the developed world, where around 40% were classified as shrinking cities between 1990 and 2000; this is especially pronounced in North America and Europe (UN-HABITAT, 2008: 40). Several studies provide an idea of the persistence and spatial extent of this phenomenon in Europe (e.g. Cheshire, 1995; Cheshire and Hay, 1989; Hall and Hay, 1980; Kabisch and Haase, 2011) and beyond (Oswalt, 2006; Oswalt and Rieniets, 2006). This paper will add to these discussions by revealing that duration and the point in time of urban shrinkage significantly differ depending on contextual factors.

According to the latest State of the European Cities Report, based on the transnational database for European cities Urban Audit, almost one-third of Europe's larger cities lost population between 2001 and 2011 (European Commission and UN-Habitat, 2016). Turok and Mykhnenko (2007) demonstrated that growth and decline differ significantly for most cities over different time periods. They analysed the average growth rates over several time periods between 1960 and 2005 for 310 European cities in 36 countries whose population exceeded 200,000 inhabitants. Only 13 cities in the UK and in Germany experienced long-term shrinkage, and 40% of the investigated cities experienced occasional shrinkage.

Although scholars know much about the causes, effects and planning responses in shrinking cities, the state of knowledge in a cross-national comparative perspective is rather poor, basically because of three facts.

- Firstly, comparative studies on urban shrinkage in Europe usually analyse ***large cities*** with a population greater than 200,000 or 50,000 (European Commission, 2010; Turok and Mykhnenko, 2007) inhabitants. However, Europe is dominated by small- and medium-sized cities with less than 10,000 inhabitants that constitute a remarkable proportion of Europe's population with individual trajectories.
- Secondly, urban trends are hardly evolving in a linear way but rather fluctuate and show changes, such as from growth to shrinkage or vice versa, with different speeds and durations. However, a perspective that considers these ***non-linear dynamics*** of shrinkage in order to explore the interdependencies between causes and effects of shrinkage and the feedback mechanisms that are in operation is lacking (Hoekveld, 2012).

- Thirdly, the non-linearity is accompanied by the need to develop an explanatory heuristic that moves beyond static analyses of population loss and, instead, towards ***more complex*** explanations of context factors and their dynamic influence on urban shrinkage (Grossmann et al., 2013). Such a heuristic conceptualisation of urban shrinkage, which bridges trends on the macro scale, such as demographic change, with population loss in cities, is lacking empirical evidence to date (Haase et al., 2014).

Against this background, this paper fills the gap between macrotheoretical conceptualisation and empirical observation by testing a heuristic model of urban shrinkage developed by Haase et al. (2014). The paper questions to what extent urban shrinkage represents a broader trend in Europe in terms of both duration and distribution, and aims to investigate the influence of economic and demographic drivers on the non-linear evolution of shrinking cities in Europe.

Firstly, a definition of cities is developed that allows the study of both larger and smaller cities and the differences between trajectories with respect to a city's size (total survey). Secondly, the paper draws attention to a dynamic perspective by demonstrating a typology that investigates to what extent the duration and speed of urban shrinkage differ. Thirdly, this typology is linked to the heuristic model in order to identify possible impacts from the macro trends of demographic change and economic restructuring on shrinking cities.

This approach provides the opportunity to broaden the focus on the phenomenon of urban shrinkage and its drivers by discussing the spatial distribution of different trajectories of shrinking cities in Europe during the period from 1990 to 2010 in a comprehensive survey and their intersection with major contextual factors on the macro scale.

From the debate on shrinking cities to the challenges of conceptualisation

Since the turn of the century, and in contrast to the past, a great deal has been written about the causes and impacts of shrinkage, as well as about policies and planning strategies, especially in Germany (Bernt, 2009; Kabisch et al., 2006; Pallagst et al., 2013; Wiechmann and Pallagst, 2012). Although the academic debate on a long-term population decrease and urban transitions had already started in the 1980s, particularly in Germany (Häußermann and Siebel, 1987), the point of departure for a broad debate on urban shrinkage was primarily the East German housing market crisis in the early 1990s. In Europe, the 'demographic shock' of post-socialist countries (Steinführer and Haase, 2007) shifted the focus of the debate on shrinking cities from a one-theme issue to a policy field that incorporates a range of issues. For Europe (Baron et al., 2010; Turok and Mykhnenko, 2007), as well as for North America (Beauregard,

2009; Hollander et al., 2009), recent research highlights shrinking cities as a dominant developmental trend and an emerging focus for research on planning. The discussion about how to deal with the problems of shrinking cities had just re-emerged when the global financial and economic crisis, which was triggered by the bursting of the US housing bubble in 2007, drew much attention to this issue. Thus, urban shrinkage, as such, is not new, although the major causes of shrinkage have changed in post-industrial times. Recent research has distinguished several major drivers of shrinkage (Haase et al., 2014; Reckien and Martinez-Fernandez, 2011; Wiechmann and Bontje, 2014) that are basically rooted in changing demographic and economic conditions, and reinforced by shifting spatial configurations (suburbanisation).

In Central and Eastern Europe, in particular, the political changes led to an exceptionally severe shrinkage phenomenon driven by changing ***demographics***, including outmigration and a sharp decrease in fertility rates since 1990 (Müller and Siedentop, 2004; Steinführer and Haase, 2007). This dramatic decline of fertility rates to levels far below the natural reproduction rate had already been interpreted in the 1980s, during Europe's 'second demographic transition' by Lesthaeghe and Van de Kaa (1986; cf. Van de Kaa, 1987). The transition, which began in the mid-1960s and accelerated during the 1980s, was marked by declining numbers of married couples, rising divorce rates, an increasing age at marriage and dramatically decreasing fertility rates, especially after the contraceptive pill was introduced in the 1970s. In addition, in several European countries, the flight of people and jobs to the suburbs has led to a hollowing out of the core city (Couch et al., 2005; Nuissl and Rink, 2005), which is described within the framework of life-cycle theories of urban development (Berry, 1977; Van den Berg et al., 1982).

The search for jobs is very important for migration decisions, and often leads to changes in the territorial division of labour (Massey, 1984). For a long time a decline was expected to occur only if dominant industries or companies lost their competitive position and market shares, which depend on the actual forms of production and strategic decisions (Haase et al., 2014). Thus, the ***economic*** concentration of enterprises, industries and labour can dissolve when forms of production (e.g. towards tertiarisation) or demand is changing, or in case of crisis effects. The basic assumption was that economic decline leads to selective outmigration and, concomitantly, to population decline. Such structural economic changes have been observed ever since the Fordist form of mass production and mass consumption (Beauregard, 2009) plunged into crisis and could not be replaced by modern services or other industries of the tertiary sector. This has led to spatial disparities and even to the redistribution of capital, thus

serving as an explanation for the dynamics of urbanisation under capitalism and the emerging 'uneven development' (Harvey, 2006).

In general, it is not easy to establish clear cause– effect relationships between demographic or economic drivers and the local impact on population development. However, it is important to combine these factors for the heuristic model developed by Haase et al. (2014). The underlying assumption is that shrinkage is a result of the 'place-specific interplay of economic transformation, suburbanisation and demographic change' that directly or indirectly impacts on the local settings of a city, for example, the labour market, socio-spatial differentiation, housing, patterns of land use, the state of the social and technical infrastructure, etc. (Haase et al., 2014: 1529; see Figure 1). The advantage of this model is the heuristic connection of causes and impacts, based on a variety of theories, which allows it to be applied to different contexts and to evaluate various explanatory factors. However, besides qualitative and narrative studies, an empirical implementation of this model is still lacking.

Thus, following this heuristic, this paper aims to test the model by providing a synthetic, cross-country picture of the varieties of urban shrinkage using demographic and economic trends to explain local urban trajectories. Because cities are not isolated entities but are embedded in regional contexts, a broader scale of observation is required (Grossmann et al., 2013; Turok and Mykhnenko, 2007; Wolff, 2010). The drivers are therefore conceptualised by the development of a region in which a shrinking city is located in order to estimate the influence of the regional context on the local trajectories of cities. Thus, we can hypothesise that urban shrinkage will hold longer for regions that are less economically strong, have a weaker labour market and have a less favourable the demographic situation.

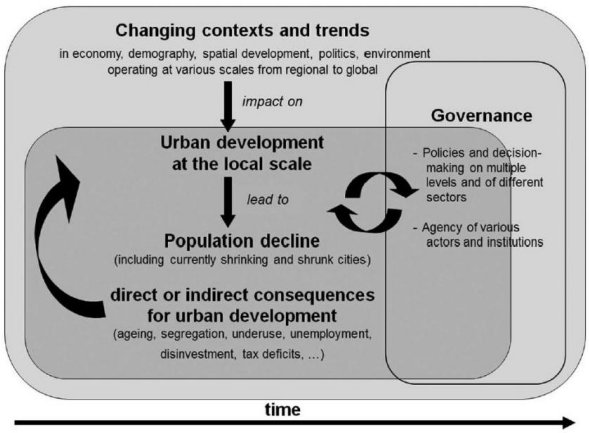


Figure 1: Heuristic model of urban shrinkage (Haase et al., 2014).

Methods and data

The model is operationalised by using population decline as the key indicator for describing shrinking cities (Bradbury et al., 1982; Haase et al., 2014) because it is an easily accessible and simple indicator for spatial analysis and allows several assumptions on households and investments (Beauregard, 2009; Turok and Mykhnenko, 2007). For the collection of local population data, a compromise between data availability and methodological–theoretical considerations has shown that analysing the midterm past after the political changes in 1990 would be most beneficial for the expected results. Since population change shows a non-linear evolution (Beauregard, 2009), the observed period is split into 5-year intervals (1990, 1995, 2000, 2005 and 2010)[1] because it is assumed that changes in a period of more than 5 years can be considered as structural changes (Hoekveld, 2012).

However, population change reflects the multidimensional phenomenon of shrinkage only to a certain extent (Grossmann et al., 2013). Therefore, we add a second-level analysis that focuses on the impacts of changing contexts on shrinking cities. More specifically, we investigate the impact of demographic change and economic restructuring (macro trends)[2] at a regional scale (NUTS 2) on their embedded cities.

In line with other studies, the operationalisation of demographic change uses the natural population balance (birth–death ratio), the total fertility rate (TFR) and the share of elderly (65+) people as indicators, thus providing information about the surplus of deaths, the reproduction level and the ageing process (ESPON, 2010). Economic restructuring is described by gross domestic product (GDP) changes indicating changing production conditions, and by employment and unemployment rates, which indicate work productivity and, furthermore, provide evidence of the impact of economic changes on the society (Hannemann, 2003). Unemployment must be seen in combination with job development because, when people lose their jobs, they can still out-migrate. Therefore, we include migration balance, which indicates employment deficits and reflects residential decisions due to changing lifestyles (Kabisch et al., 2006).

Population data are used to differentiate between trajectories that demonstrate the duration of a city's population loss. In order to draw a conclusion about the impact of macro trends on the trajectories of shrinking cities, the development rate of all seven regional demographic-economic indicators[3] was calculated for 1990–20003 and 2000–2010 and finally clustered (ward algorithm with squared Euclidian distance and elbow criteria). The resulting five regional types were then intersected with the trajectories of the cities.

In each country, different definitions of cities exist and the databases currently available for Europe cover large cities. To define cities, also taking smaller ones into account, we followed existing projects but developed an independent approach (Brezzi et al., 2012; ESPON, 2014).[4] In order to minimise the bias due to size and shape, a combination of a minimum population threshold within the administrative territory and minimum density of their morphological units is applied. The resulting 7742 cities in 36 European countries fully meet three criteria:

- minimum population of 5000 inhabitants in 2010;
- minimum density of 50% of the population living in densely populated parts with more than 1000 inhabitants per km2 in 2006[5]; and
- minimum share of built-up area of 5% in 2006 for municipalities with less than 30,000 inhabitants in 2010.

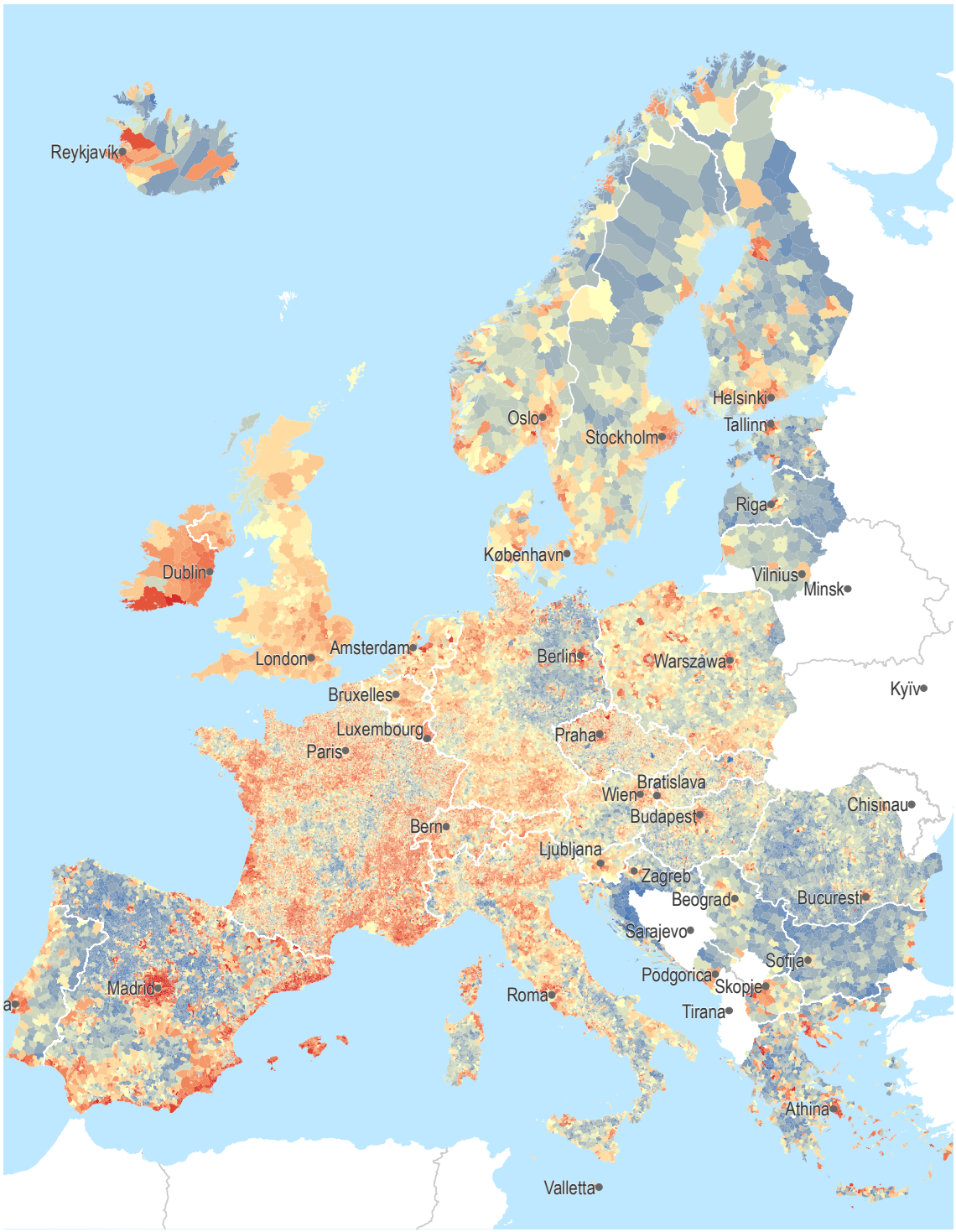
For some countries with limited data availability LAU 1 had to be chosen, which required two indicators in addition those listed above in order to allow comparability:

- the ratio of population of the largest settlement[6] to the total population of all settlements within one municipality exceeds 80%; and
- the ratio of the population of the largest settlement to the total population of its municipality exceeds 50%.

Results: Urban shrinkage in a comparative perspective

National differences of population loss in Europe

Within 20 years, Europe experienced a population increase of 2.5% from 1990 to 2000 and an increase of 3.4% from 2000 to 2010. This trend was accompanied by national differences ranging between fast population growth in the British Isles, Scandinavia, Benelux, France and Spain (>10%), and fast decline in the Baltic States and South-Eastern Europe (<– 10%). As Map 1 shows, post-socialist countries with a political and economic transition have municipalities that are especially prone to prominent population losses, for example, the Baltic States, Eastern Poland, Hungary, Romania, Bulgaria, Serbia and the eastern part of Germany. However, contrary to widely held assumptions, municipalities with population loss are widespread in Europe and can also be found in growing countries, such as in the peripheral regions of Scandinavia, Northern Spain and Southern Italy. In particular, the 'inner-peripheral' population loss—declining municipalities that lie within the heart of the country and are surrounded by growing municipalities—is a dominating spatial pattern in Central France, Southern Italy and scattered parts of Greece and Austria.



Map 1. Population Development in Europe 1990 – 2010.

Urban shrinkage unevenly affects countries

Focusing on cities, Figure 2 shows that more than one-fifth of cities lost more than 0.15% per year; in other words, one out of five cities in Europe has faced population losses over the 20 years since 1990. Thereby, shrinking cities are especially pronounced in the Baltic States, Bulgaria, Romania, the Czech Republic, Serbia and Croatia, with more than half of their cities having experienced population decline. Other Eastern European countries have a share of cities with population losses slightly above the European average (25–50%), for example, Hungary and Poland, whereas the large Western European countries, Germany and France, belong to a group within the range of the European average (15–25%). These numbers reveal important differences between countries because population loss in most Southern European and Scandinavian countries is a major challenge for rural areas and a few cities located in remote areas. In addition, Map 1 shows the decline of larger municipalities, due to suburbanisation within their sphere of influence, in locations such as Porto, Lisbon, Barcelona, Athens, Milan, Venice and Naples, as well as Tallinn, Riga, Lodz, Poznan, Budapest and Bratislava.

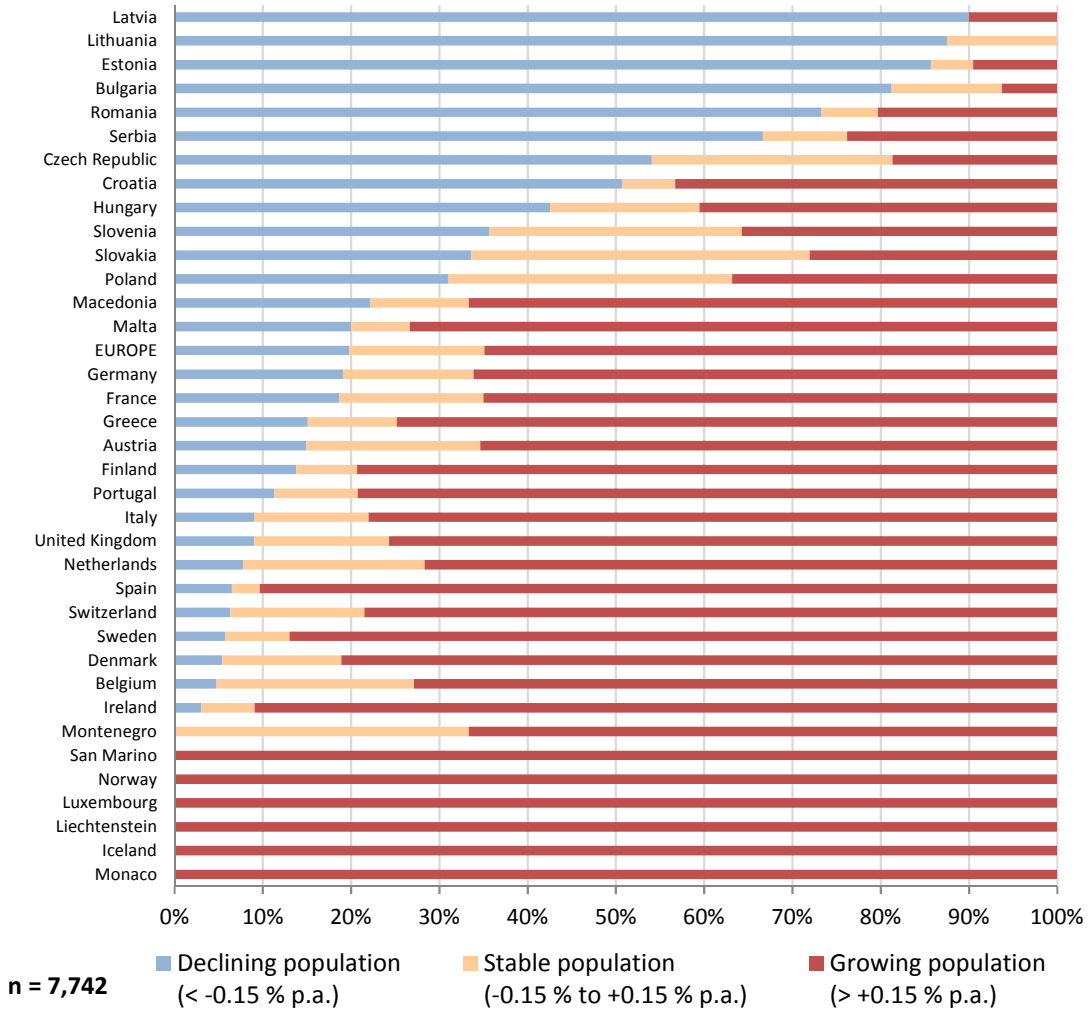


Figure 2. Population development in European cities 1990 – 2010.

Shrinking cities by city size

The spatial patterns described above and, in particular, the inner-periphery effect and suburbanisation, suggest that city size seems to play an important role in urban shrinkage. Table 1 shows a strong, positive relationship between city size and shrinkage: with each size band, the share of shrinking cities grows. The proportion of cities losing population is very low among the smallest cities with less than 10,000 inhabitants (17%) but increases with city size (up to 25% among cities between 200,000 and 300,000 inhabitants). In fact, almost one-third of cities with between 300,000 and 500,000 inhabitants faced population loss in what mirrors the results of previous analyses (European Commission, 2010; Kabisch and Haase, 2011). However, this relationship does not hold for the largest cities (over 500,000 inhabitants) as their agglomeration economies accumulate both economic activities and a skilled workforce (Krugman, 1991).

However, a simple regression model that differentiates between single periods shows that growth rates, especially of these large cities, increased further after 2000, as in Northern and Western Europe. Moreover, several cities in Southern or Eastern Europe have been pushed from former shrinkage to growth after 2005. In contrast, a substantial proportion of small cities had population losses, especially in Western Europe after 2000 and South-Eastern Europe after 2005, with more cities showing a rapid population loss of more than 2% p.a., thus leading to a weakening of the lower hierarchy of the urban systems in these countries.

These short reflections reveal that duration and point in time of urban shrinkage differ significantly. In order to address this complex issue, the paper draws attention to a dynamic perspective and combines this with possible impacts from the macro trends of demographic change and economic restructuring.

Table 1. Cities with population loss, stability, and growth 1990 - 2010 per city size.

Total population in 2010	**All CITIES**		Thereof with population **Loss** (< -0.15 % p.a.)		**Stability** (-0.15 to +0.15 % p.a.)		**Growth** (> +0.15 % p.a.)	
	#	%	#	%	#	%	#	%
5,001 - 10,000	**2390**	**30.9**	407	17.0	319	13.4	1664	69.6
10,001 - 25,000	**2732**	**35.3**	529	19.3	401	14.7	1802	66.0
25,001 - 50,000	**1246**	**16.1**	262	21.1	196	15.7	788	63.2
50,001 - 100,000	**717**	**9.2**	171	23.8	142	19.8	404	56.4
100,001 - 200,000	**370**	**4.8**	88	23.8	61	16.5	221	59.7
200,001 - 300,000	**136**	**1.8**	34	25.0	34	25.0	68	50.0
300,001 - 500,000	**74**	**0.9**	22	29.7	17	23.0	35	47.3
> 500,000	**77**	**1.0**	18	23.4	17	22.1	42	54.5
Total (#)	**7742**	**100**	1531		1187		5024	
Total (%)	**100**		**19.8**		**15.3**		**64.9**	

Trajectories of shrinking cities in Europe

The trajectories follow a definition from the Shrinking Cities International Research Network (SCiRN) and are specified by the COST Action 'Cities Regrowing Smaller', according to which a shrinking city is an urbanised area that has recently faced a population loss of more than 0.15% annually for at least 5 years or in some former period. In order to separate long-term trends from short-term 'events' (Turok and Mykhnenko, 2007), we single out cities that experienced population loss between 1990 and 2010 either permanently or for a minimum of one out of four 5-year periods and derive subtypes, indicating the time period of population loss (Table 2). According to this typology, almost half of Europe's cities have faced some kind of population loss and can be regarded as one of the types of shrinking cities (3784 out of 7742 cities; 49%, Map 2).

Table 2: Trajectories of shrinking cities.

Duration (General types)	**Time (Subtypes)**
continuously shrinking cities population loss of at least 0.15 % p.a. in all four five-year periods	• *continuous shrinkage* population decline 1990-2010
episodically shrinking cities population loss of at least 0.15 % p.a. over the entire period, with a stable or even growing population (> - 0.15 % p.a.) in at least one five-year period	• *periodic shrinkage* population decline 1995-2010 or 2000-2010 • *discontinued shrinkage* population decline 1990-2005, 1990-2000 or 1995-2005
temporarily shrinking cities that have not lost at least 0.15 % of their population p.a. over the entire period, but in at least one five-year period	• *temporary shrinkage in the 1990s* population decline 1990-1995 or 1995-2000 • *temporary shrinkage in the 2000s* population decline 2000-2005 (or together with 1990-1995) • *recent shrinkage* population decline 2005-2010 (or together with 1990-1995 or 1995-2000)

- Continuously shrinking cities

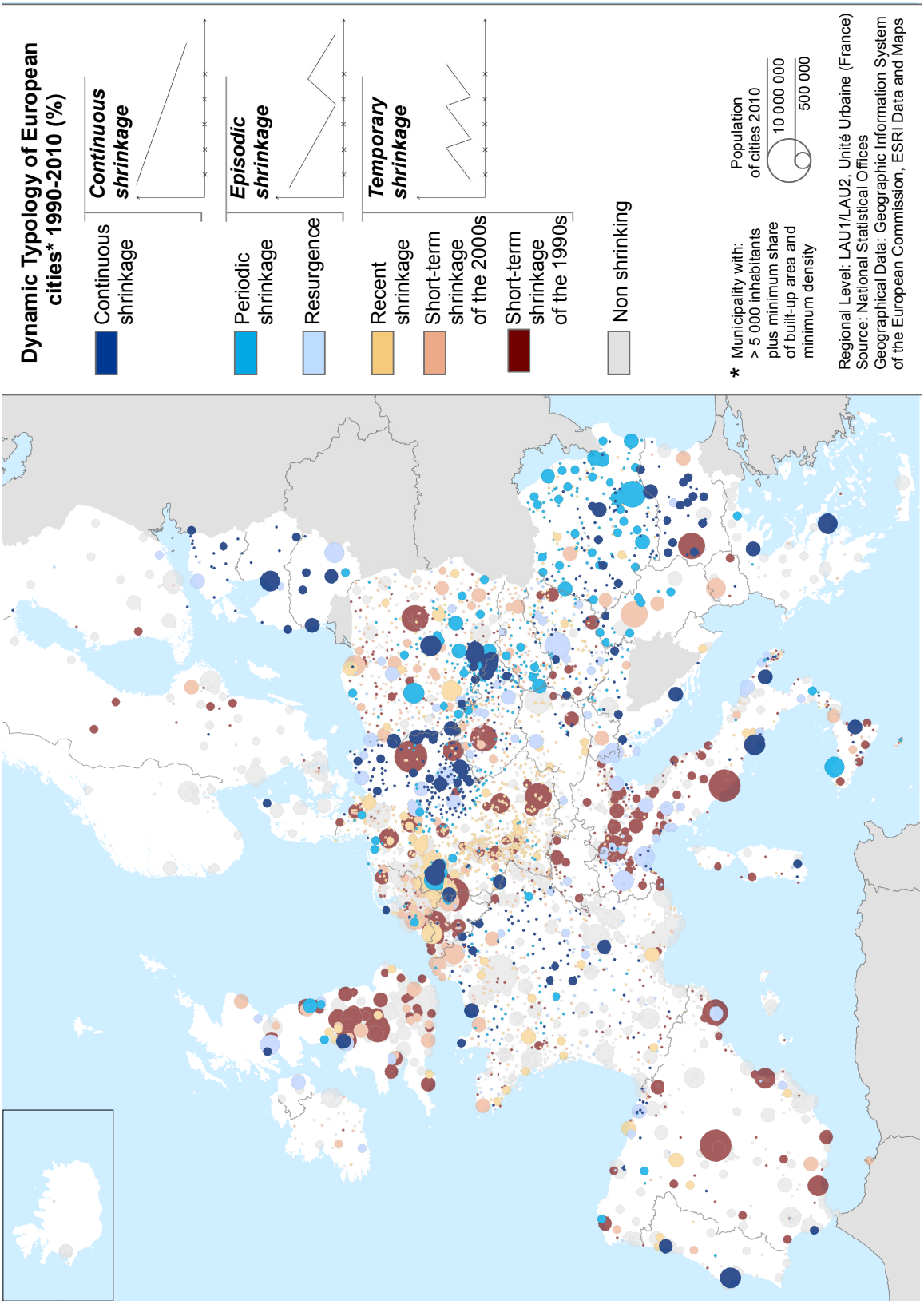
Continuously shrinking cities represent 14% of all shrinking cities (534 out of 3784 cities) and are predominantly located in Western Europe, especially in Eastern Germany, the Ruhr area and the industrial areas of North-Eastern and Central France, but also in Bulgaria, Croatia, Romania, the old Polish-Czech industrial areas and the Baltic States.

- Episodically shrinking cities

This group covers 23% (854 cities), of which the group displaying periodic shrinkage is dominant, that is, those that started losing population in the mid-1990s or after the turn of the century (517 cities). These shrinking cities are concentrated in post-socialist countries: Poland, the Czech Republic, Slovakia, Romania and Serbia, as well as in Western Europe at the former inner-German border, and in Northern and Central France. In contrast, several medium and large cities (>50,000 inhabitants) ceased to shrink after 2005 (337 cities); these are located particularly in Poland, the Czech Republic, Hungary, Eastern Germany and Northern Italy.

- Temporarily shrinking cities

A large share of cities shows temporary shrinkage (2396 cities, 63%). The largest fraction among them lost population during the 1990s, which is very characteristic for Italy and Spain, but also for Sweden, the United Kingdom, Poland, the Czech Republic, Hungary and Western Germany (878 cities). Similar to France and Southern Italy, small cities, particularly in Eastern Europe and capitals such as Warsaw, Prague and Sofia, are affected. However, recent population losses affect 883 cities, especially large cities in Western Germany, smaller cities in Austria and medium-sized cities in France, but also large- and medium-sized cities in Hungary, Romania and Poland.



Map 2: Types of shrinking cities in Europe 1990 – 2010.

Influence of macro trends on the trajectories

Following the heuristic model, European regions show different trends in terms of demographic change and economic restructuring (Figure 3). Whereas some basically post-socialist regions are affected by natural decline and selective outmigration (type 1) in contrast to regions with immigration and a positive natural balance (type 5), weak labour markets lead to job-driven outmigration in North- Western France and Southern Italy (type 2). Natural decline is driving economically strong regions in Germany and Austria (type 3). In contrast, regions in the UK, the Spanish–French Mediterranean and Northern Italy benefit from strong immigration (type 4) with, however, pressure on the labour market because the economy is improving at a slower pace. These trends have different impacts on urban population trends in Europe (percentage values are based on Table 3 in the Appendix).

- Natural decline and outmigration drive long-term shrinkage

Continuously and periodically shrinking cities are predominantly located in regions driven by negative natural growth and outmigration (42% and 62% correspond to type 1, respectively). This is especially pronounced in the post-socialist regions of Romania, Bulgaria, Poland, Croatia6 and Eastern Germany, but also in old industrial regions with a predominance of heavy, extractive and textile industries, especially in Upper Silesia. Unable to adjust to the new market conditions relatively quickly, these basically mono-industrialised cities saw their economy declining even though GDP had risen in these regions, especially after the enlargement of 2004/2007 (Birch and Mykhnenko, 2009). This growth hardly had an effect on the labour market because unemployment rates rose during the 1990s due to the decreasing competitiveness of these regions.[7] The resulting age-selective outmigration reinforced the long-term population loss due to the lack of births and a surplus of deaths (Müller and Siedentop, 2004; Steinführer and Haase, 2007).

- Episodic shrinkage in economically-disadvantaged regions

Old industrial regions that underwent economic restructuring since the deindustrialisation of the 1970s are marked by constant job-driven outmigration (type 2, Baron et al., 2010). Depending on the economic diversity and the degree of specialisation and productivity, this trend pushes continuous shrinkage (12%), for instance in Northern France, Eastern France and Southern Italy, as well as periodic decline (17%), as seen in Central Poland and North-Eastern Romania. These structural disadvantages led to inflexible labour markets (Ferrerol, 2010), marked by increasing unemployment rates and a stagnating GDP. The fluctuation of population loss in these cities can thus be explained by increasingly irregular migration

patterns that are also highlighted by the high share of cities that lost population as a consequence of the economic crisis in the late 2000s that spread all over Europe (21%).

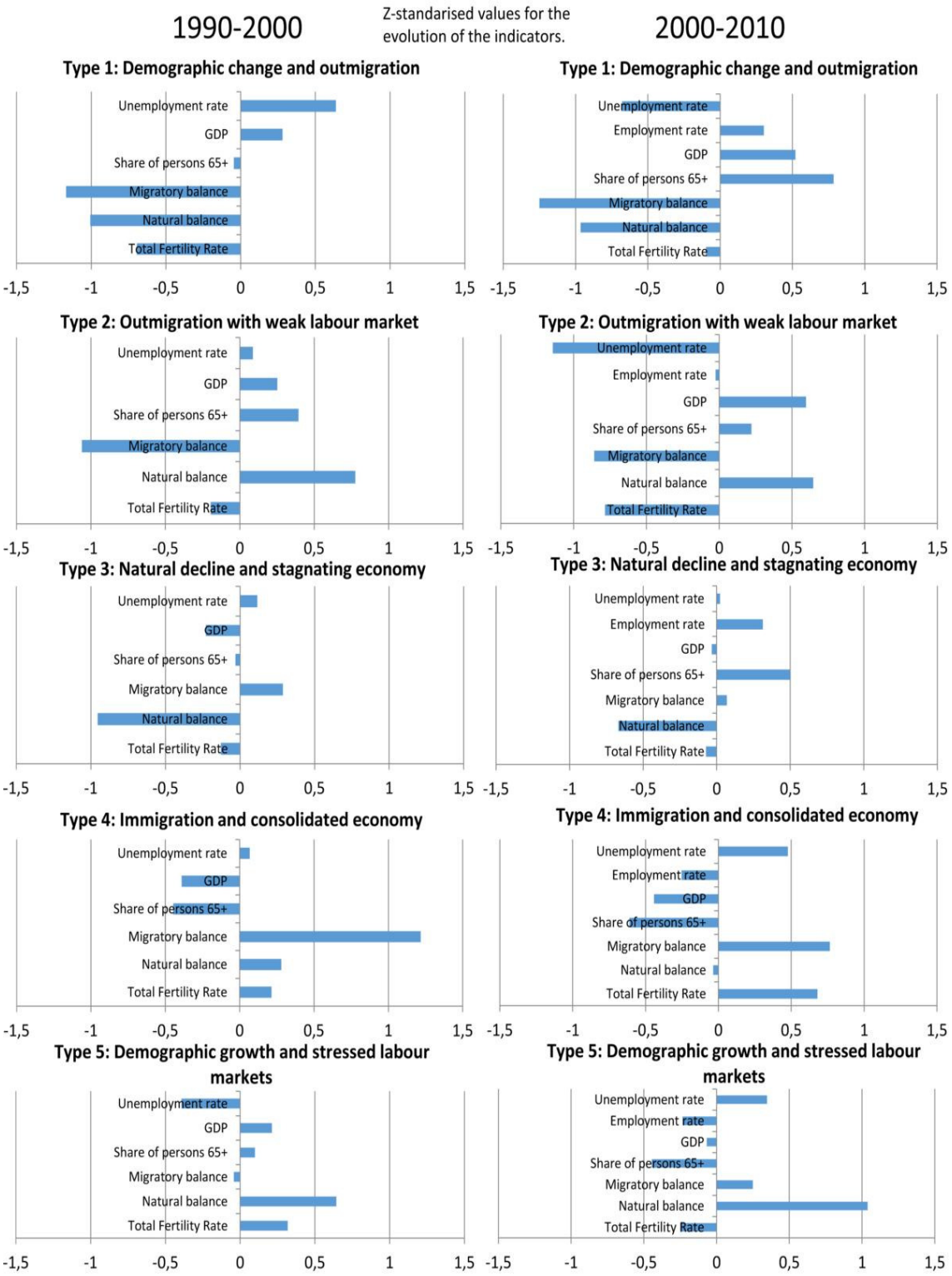


Figure 3: Profiles for each regional type.

- Natural decline as a self-reinforcing avalanche

The impact of natural decline (type 3) as an essential factor for continuous shrinkage (14%) basically occurs in less dense regions such as the Iberian Peninsula, Central France, parts of Austria, Hungary and the Czech Republic. Significantly, this trend is increasingly affecting cities, explaining the high shares of recently shrinking cities: whereas regions with a strong natural decline cover 26% of all periodically shrinking cities with population losses between 1995 and 2010, the share is almost 46% among recent shrinking cities. This trend is characteristic for Western Germany, the Czech Republic, Slovakia and Hungary. Although these regions are economically strong, outmigration of young jobseekers; low attractiveness for families; and absence of immigration due to a loss of functions, for example, supply, administration, health services, etc., give rise to the impact of natural decline in these cities. Besides these local factors, changing lifestyles lead to low and decreasing birth rates, especially after 2000, which indicates a decoupling of population development and economic strength. Rather, the natural decline, in turn, has an effect on the labour market of these regions as productivity only slowly increased, followed by decreasing employment rates. Finally, residential decisions targeting larger cities, accompanied by the stagnation of suburbanisation, for example, in Hungary and Slovakia, and (international) immigration, led to the regrowth of cities (discontinued shrinkage 22%), including Germany, but are at the same time expressing a shift towards urban lifestyles with a strong population concentration, whereas the remaining areas suffer from natural decline.

- Imbalanced labour markets causing temporarily shrinkage

In regions with traditionally high immigration (type 4), cities managed to regrow after 2005 (discontinued shrinkage, 20%), such as in the UK, Spanish-French Mediterranean areas and Northern Italy, mitigating population losses due to suburbanisation and a natural decline in these regions during the 1990s (40%). However, these regions are characterised by the production of low-value and non-competitive industrial products and corresponding low productivity and high unemployment rates, such as in Northern Spain or Southern Italy. Thus, the comparably low share of cities with population loss during 2000 is thereby due to immigration from rural areas and the lack of job opportunities outside the cities (Hoggart, 2005). Consequently, the labour market in these regions is tight because it cannot compensate for the high rates of immigration, leading to decreasing employment and increasing unemployment rates.

- Urban shrinkage due to competition

Short-term population losses in cities can even be recorded in economically advanced regions with positive population development (type 5). Firstly, this phenomenon is due to an

increasing gap between growing productivity and the effects on the labour market with a corresponding increase in unemployment rates. Secondly, residential preferences for urban amenities together with the increasing mobility of a well-educated and trained labour force indicate that shrinkage in densely populated regions close to large centres is less associated with economic performance. Both aspects accelerate an increasing competition between cities and within advanced regions and, as a consequence of the economic crisis during the 2000s, led to temporary shrinkage (Pallagst et al., 2013), which is characteristic for cities in Ireland, Belgium and the Netherlands, and in large parts of France (24%).

Discussion

In almost all European states, some type of shrinking cities with population losses of more than 0.15% can be found after 1990. However, countries are affected differently with variations in city size and duration of population loss. These variations strongly depend on the combination of different drivers, which will now be discussed by reflecting on the used model. Finally, the conclusion points to implications for policy and urban theory.

Reflection on the heuristic model

The model ***confirmed*** that multiple and self-reinforcing negative factors push urban shrinkage towards a structural phenomenon (Martinez-Fernandez et al., 2012). The 534 continuously shrinking cities, in particular, are driven by natural and economic decline, mirrored by fast outmigration and long-term low fertility rates. This is especially characteristic in post-socialist regions based on their less-competitive development within their protected economies before 1990 and especially accelerated, with the exception of the capital regions, during the 2000s, which was reinforced by the 2004/2007 European Union (EU) enlargement with international outmigration.

Moreover, impacts of macro trends are not evolving in a similar way everywhere, leading to ***specifications*** of the model. Firstly, in particular, small- and medium-sized mono-industrialised cities with mining, steel, ports or textile industries have been affected by structural economic downturn ever since the 1970s (Deaton, 2005). As production factors, such as capital or technology, cannot be compensated by the competitive services of the tertiary sector, these cities are especially exposed to changes of demand, production and market conditions; this situation leads to high unemployment and outmigration and thus to long-term, and especially to periodic, shrinkage (Acemoglu, 2009). Secondly, the strong natural decline in several

European regions has an increasing impact on urban shrinkage related to the second demographic transition (Van de Kaa, 1987). Among the 2391 temporarily shrinking cities, a large number of small- and mediumsized cities are affected by recent population losses, especially in South-Eastern and Western Europe. As whole regions and countries are concerned, a shift away from the conventional definition of 'families' as couples with children, to more varied household types, including an increasing number of blended families, is characteristic.

Moreover, two ***variations*** from the model assumption have been identified that are basically due to an increasing decoupling of local population trends from regional economic performance. Neither does economic downturn automatically lead to urban shrinkage, which is observable in Southern Europe, and nor does economic success of a region prevent their cities from shrinking. This is due to the explanation power of the paper's approach, which is limited to the spatial scale chosen, as well as to the selection of seven basic influence factors. However, four points are increasingly important for the discussion on shrinking cities, as follows.

- An increasing mobile workforce leads to increasing *competition between cities* (Batey and Friedrich, 2000) regarding both labour opportunities and urban amenities. From this perspective, not economic decline of one city but, rather, economic growth of adjacent cities leads to shrinkage, which makes it necessary to think about new ways in which drivers interact.
- The *circular redistribution of labour* depends on actual forms of production, functional aggregations of industry in space and strategic decisions (Massey, 1984; Scott, 1988). The question regarding if this weakening manifests in short- or long-term shrinkage depends on the individual preconditions of cities that makes them more resistant to population decline, although they are hit by the same demographic and economic factors. This explains why people move to larger cities where the discrepancy between a qualified demand and an unqualified supply is increasing, although the region's economy is moving downward (Hannemann, 2003). This trend was accelerated by the economic crisis in the late 2000s, where political-economic interventions on a national scale exposed several regional labour markets (Haase et al., 2014).
- In this regard, *city size* seems to play an increasingly more important role, especially in the context of the recent polarisation of the urban landscape in Europe. Predominantly large cities managed to regrow, benefiting from the decline of others (Kabisch and Haase, 2011), whereas, in particular, smaller cities benefit from 'borrowing' agglomeration effects while

avoiding agglomeration costs based on relationships and flows to more distant cities (Camagni and Capello, 2015).

- Natural population drop, ageing and a lack of job-starters for certain industries is of increasing importance compared to short-term migration tendencies, as it discourages economic activities, entrepreneurship, private and public investments, and innovation and technology development, all leading to economic decline (European Commission, 2014; Friedrich, 1987). The impact of natural decline was already visible as soon as immigration was absent, especially after 2005. In the face of the upcoming second demographic wave, this impact is expected to increase even in regions with immigration and economically moderate performance, due to a higher number of job offers, rising living standards and technological innovations that influence reproductive behaviour (Ferry and Vironen, 2010).

Further research

Although this study has not analysed suburbanisation as a driver of shrinkage according to the model, there are indications of the role of the hinterland for the cities' trajectories. In several areas, reurbanisation (Berry, 1977; Van den Berg et al., 1982) can be observed, although their regions still suffer from outmigration and natural decline. This may point to halted suburbanisation with population loss and ageing of former home-owners in the hinterland. In contrast, shrinkage due to suburbanisation does not always coincide with a general decline in the economic activity of the city because people moving to the suburbs keep their jobs in the city. This would also explain why long-term shrinking cities are located in regions that perform well in terms of economy and labour.

In this regard, further research needs to take into account that the cities' trajectories are not autonomous from their hinterland (ESPON, 2014) by questioning whether suburbanisation should be understood more as a spatial consequence driven by economic (welfare) or demographic (family houses) factors rather than as a causative driver. Thus, a second-level analysis would empirically enrich the heuristic model, studying two factors. Firstly, in line with life-cycle models, we need to ask if cities are centralising or decentralising by comparing population growth rates in the cities and their hinterland (Van den Berg et al., 1982). Secondly, as the decline in density has often been used as the very definition of sprawl, a comparison of both the population growth and the growth of built-up areas, expressed as density changes, can provide additional explanations serving the heuristic model (Siedentop and Fina, 2012). Still, both factors need to be contextualised by different national planning schemes and land use regulatory systems.

Conclusion

This study tested a heuristic model of urban shrinkage with a total survey of European cities setting the cities' trajectories between 1990 and 2010 into their regional context. The approach has shed light on the explanatory power of macro drivers on urban shrinkage and, in line with previous studies, serves as an empirical contribution to the debate on urban shrinkage (Haase et al., 2014; Turok and Mykhnenko, 2007). After the fall of the Iron Curtain, 20% of European cities experienced shrinkage, however, with differences between countries and city sizes. Among them, 883 basically small cities faced recent shrinkage in addition to 1051 cities with long-term shrinkage: underlining that urban shrinkage is an emerging issue for scholars and planners.

Urban shrinkage was previously described by conceptual frameworks providing anchor points to major *urban theories*, such as agglomeration effects and uneven development (Harvey, 2006). The demonstrated measurement framework following a heuristic model reveals two dimensions that are deemed to be most significant for theoretical reflections on shrinking cities: the process-specific dimension of different causes and the location of shrinking cities within their regional and national context. To understand the process of shrinkage, the combination of various drivers and impacts on local trajectories needs to be considered, rather than individual factors. The same drivers do not automatically lead to similar population trends. Rather, differences in the dynamics of regional spatial systems point to the strong interrelation of multiple scales causing urban shrinkage. Macro trends, for example, on a regional or even a national level, are always a product of the evolution of the corresponding cities, and vice versa. Thus, typologies have the power to reflect the variations of processes but need to be supplemented by local case studies addressing planning regimes, the role of suburbanisation or the competition between cities. This requires a multi-scale perspective, both theoretically and empirically, to fully elaborate the theories on urban shrinkage.

These theoretical reflections drawn from the empirical findings of the paper also point to *policy implications*. Shrinkage should neither be stigmatised by hopeless spots of unemployment, land degradation and social deterioration, and seeking to reverse this trend at all costs, nor should the emerging open space and affordable housing be praised for solving all problems while being blind to the structural process of shrinkage. Rather, planning needs to understand shrinkage as a normal phenomenon of the developed world determined by regional contexts and local preconditions that requires flexible answers that are sensitive to challenges operating on different scales. Local planning needs to re-think the city as a space for reconstruction or cultural practice by maintaining the infrastructure while facing shrinking

budgets and pressures regarding financial priorities. Multi-scale processes require multi-scale policy responses rather than thinking in economic growth models. Thereby, the proposed typology may support supranational regeneration strategies because it reveals that different strategies are required for long-term versus future-shrinking cities (due low birth rates and economic shifts) and for smaller versus larger cities, as they all follow different logics of shrinkage. Thereby, the EU Cohesion Policy is mostly promising to pay attention to these variations and supporting the implementation of regeneration strategies. These strategies include improving environmental aesthetics, services and infrastructure; encouraging the development of skills, governance partnerships, networking, private and public collaboration; or supporting economic development.

Combining the foci on shrinking cities, both the processual and the spatial, allows us to investigate under which conditions shrinkage remains temporary or turns into a structural challenge and points to policy implementations. This seems to be crucial, as many European cities have already lost a segment of their population and the rate is more than likely to increase in the future, representing a major challenge for future urban policies and urban research in Europe.

Notes

1. Data source: national statistical offices. Reference years vary in some cases, ±1 year; in very few cases, ± up to 3 years; for some countries, missing data had to be estimated. Because of boundary changes, frozen boundaries of 2010 or the largest spatial extent of each municipality is used for the calculations of time series.

2. Analysing other model elements, such as governance, would require another research design or spatial scale.

3. GDP 1995–2000, unemployment rate 1989–2000. Data source: EUROSTAT, 2nd Cohesion Report, National Statistical Offices.

4. Local administrative units (LAU 2) are used; a few cases used LAU 1 due to data availability (Bulgaria, Denmark, Greece, United Kingdom, Ireland, Lithuania, Macedonia, Montenegro, Portugal, Serbia); Unité Urbaine was used for France.

5. The GEOSTAT population grid was used with a cluster of all cells with a density above 1000 inhabitants per km2 (for France 300, see ESPON, 2014) within a municipality. For Croatia, Macedonia, Montenegro and Serbia Urban Morphological Zones (European Environment Agency, 2013) and World-Gazetteer, for Switzerland, PELCOM land cover data were used.

6. After population losses during the War of Independence in 1991–1995, Croatia recorded immigration and a positive natural change from 1995 to 1998.

7. Strong outmigration led to decreasing unemployment rates after 2000 (except Romania).

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Annex

Table 3: Cross table of typologies.

	REGIONAL TYPOLOGY OF DEMOGRAPHIC CHANGE AND ECONOMIC RESTRUCTIRING						
In %	**Type 1**	**Type 2**	**Type 3**	**Type 4**	**Type 5**	**Not classified**	**Total**
TYPOLOGY OF TRAJECTORIES	**1990-2000**						
Continuous shrinkage	48.9	17.2	14.4	2.6	6.6	10.3	**100**
Periodic shrinkage	28.6	14.1	25.3	8.7	6.0	17.2	**100**
Discontinued shrinkage	12.2	15.7	36.2	2.4	14.8	18.7	**100**
Temporary shrinkage in the 1990s	5.7	14.2	37.5	9.6	21.8	11.3	**100**
Temporary shrinkage in the 2000s	6.0	15.1	20.0	18.3	17.8	22.7	**100**
Recent shrinkage	6.1	8.6	24.0	43.6	12.1	5.5	**100**
Non-shrinkage	2.2	10.6	25.7	23.0	33.3	5.1	**100**
Total	**8.8**	**12.1**	**26.0**	**20.2**	**23.8**	**9.1**	**100**
	2000-2010						
Continuous shrinkage	61.8	12.0	12.4	4.7	8.2	0.9	**100**
Periodic shrinkage	42.0	16.8	25.9	4.8	8.3	2.1	**100**
Discontinued shrinkage	25.2	16.9	22.3	20.5	14.8	0.3	**100**
Temporary shrinkage in the 1990s	6.6	13.4	21.4	40.2	17.4	0.9	**100**
Temporary shrinkage in the 2000s	15.6	20.8	28.9	10.4	23.5	0.8	**100**
Recent shrinkage	15.4	10.6	46.3	13.1	14.3	.2	**100**
Non-shrinkage	2.9	10.1	18.6	38.5	28.8	1.2	**100**
Total	**13.4**	**12.3**	**23.1**	**28.1**	**22.0**	**1.0**	**100**

4.2 Is planning needed? Shrinking Cities in the French urban system

Paper 2: *Manuel Wolff, Sylvie Fol, Hélène Roth, Emmanuèle Cunningham-Sabot*

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Manuel Wolff, Sylvie Fol, Hélène Roth and Emmanuèle Cunningham-Sabot

Is planning needed? Shrinking cities in the French urban system

Introduction

During the last decade, the process of urban shrinkage has been widely studied in North America and Europe. Shrinking cities, defined as urban areas that have experienced population loss, economic downturn, employment decline and social problems as symptoms of a structural crisis (Martinez-Fernandez et al., 2012), are the result of a multidimensional process that combines multiple factors and has various interrelated manifestations. In Europe, the issue emerged in the early 2000s, along with the effects of the German reunification and the downturn of Eastern European cities. In the mid-2000s, Philip Oswalt et al. (2006) insisted on the international dimension of the process, studying examples from various continents. The Shrinking Cities International Research Network[1] claims that shrinking cities are one of the spatial manifestations of globalisation (Pallagst et al., 2009; Martinez-Fernandez et al., 2012). In the US, urban shrinkage gained particular attention following the foreclosure crisis, which had dramatic consequences in cities where the economic and demographic context was already fragile due to deindustrialisation and the effects of post-Fordist restructuration (Beauregard, 2009; Schatz, 2010).

Urban shrinkage constitutes a major issue in Germany and most Eastern European countries (Steinfuhrer and Haase, 2007; Turok and Mykhnenko, 2007; European Commission, 2007). However, it is not a public issue in France where the growth paradigm is still dominant. France also remains a blind spot regarding shrinking cities research. This neglect is due in large part to a demographic fact. France is among the rare countries in Europe unaffected by demographic change and has a natural growth rate of 0.7 per cent, which is among the highest in Europe. However, urban shrinkage is nevertheless occurring in France as ‘a silent process’ (Cunningham-Sabot and Fol, 2009). Although one third of French urban areas shrank between 1990 and 1999 (Julien, 2000), there has been hardly any political initiative or clear reaction in terms of national policies. At the local level, many small cities are struggling to retain their population and revitalise their economy but their difficulties are not really acknowledged at the national level. Although the situation for French shrinking cities is significantly different from the situation in other parts of Europe (Turok and Mykhnenko, 2007; European Commission, 2007; Baron et al., 2010), some common demographic and economic trends justify their study in a country where the issue of urban shrinkage is neglected.

Therefore, this paper aims to measure the extent of the phenomenon of urban shrinkage in France and to identify underlying factors and processes. It seeks to understand whether the lack of interest toward shrinkage is justified by the fact that this phenomenon is still marginal

or whether its reality should lead to the development of dedicated public policies. After an overview of the literature dealing with shrinking cities in Europe and France, we will present the results of a quantitative study of shrinking cities in France between 1975 and 2007 based on a twofold approach. Finally, we will discuss the relevance of urban shrinkage to planning practice.

Shrinking cities in Europe: a growing phenomenon

After being stigmatised as a topic in planning for a long time, the discourse in Europe has actively taken on shrinking cities since the early 2000s. This is especially true of the sharp decrease in fertility rates, sometimes described as a 'demographic shock' (Steinfuhrer and Haase, 2007), which, combined with dramatic processes of outward migration and suburbanisation in the Eastern part of Europe, has led to the rapid decline of cities (Muller and Siedentop, 2004; Kabisch et al., 2006). Since then, the discussion within urban policy and planning on shrinking cities as a phenomenon and strategies to cope with them has been emerging in most European countries and has been revived with the impacts of the global financial and economic crisis.

For Europe (Turok and Mykhnenko, 2007; Baron et al., 2010; Fol and Cunningham- Sabot, 2010; Wolff and Wiechmann, 2017) as well as for North America (Beauregard, 2009; Hollander et al., 2009; Schatz, 2010), recent research highlights shrinking cities as part of an emerging research agenda in planning. An analysis of 258 European cities between 1996 and 2001 showed that one third of all cities experienced population loss (European Commission, 2007). According to Turok and Mykhnenko (2007), the number of growing cities has decreased steadily since the 1960s. Although the most common profile for cities in Europe is still continuous growth (30 per cent), a significant share of them has been declining on a medium-term basis (24 per cent) or recently (13 per cent). Most shrinking cities are located in Eastern Europe (Turok and Mykhnenko, 2007) whereas Western Europe displays a more diverse pattern in relation to regional contexts. Wolff and Wiechmann (2017) demonstrated in their analysis of population trajectories of 7,035 European cities between 1990 and 2010 that one out of five cities in Europe has faced substantial population losses. Cities with continuous population loss are predominantly located in the Baltic States, Southeastern Europe, Eastern Germany, and the industrial areas of the Ruhr, Southern Poland, and North-eastern or Central France, confirming the conclusions of Baron et al. (2010) that most shrinking cities are located in declining peripheral regions with economic difficulties.

In these economically weak regions out-migration mostly explains population loss. Since industrialisation, decline was expected to occur only if dominant industries or companies lost their competitive position. The basic assumption was that economic decline leads to selective out-migration (e.g. young people) and consequently to demographic shrinkage and ageing. Today some studies point to the dramatic impacts of low fertility rates, already underlined by the 'second demographic transition' theorists (Lesthaege and Van de Kaa, 1986). They describe the effects of an emerging fact: the decoupling of economic wealth and population growth in Europe. In the current post-industrial context, recent research has distinguished five main drivers for urban shrinkage (Schatz, 2010; Reckien and Martinez-Fernandez, 2011; Wiechmann and Bontje, 2014). Among them, demographic change (e.g. falling birth rates), economic transformation and suburbanisation (flight of people and jobs to suburbs) play a central role.

Urban shrinkage in France: little academic interest and few policy responses

In the French literature, urban shrinkage has not been studied as such but rather as part of the dynamics of urban systems (Guerin-Pace, 1993) or related to the decline of industrial cities and regions. Shrinking cities are predominantly located in the regions of Northern France, marked by their industrial past, and today they are affected by the out-migration and ageing of their population (Labosse, 2010). This decline of former industrial cities corresponds not only to the new spatial organisation of economic activity but also to the attraction of the South in terms of quality of life. These effects are particularly marked with regard to small cities, which are economically specialised (Paulus, 2005) and thus unable to reach a size that allows them to offer a wide range of services and industries. In recent decades, small cities in France have been more and more short-circuited and left behind in terms of population, activities and information flows. The increase in transportation speed has generated a contraction of 'time-space' that gives an advantage to large urban centres, while isolating and preventing small cities from development (Bretagnolle et al., 2002). Large cities have consolidated their position, pulling population from small and medium-sized towns (Pumain, 1999), with few opportunities for innovation and diversification (Lugan, 1994).

The various studies mentioned above draw a relatively clear picture of urban shrinkage in France, related to economic specialisation, deindustrialisation and city size. However, the process of urban shrinkage is rarely considered and addressed as such and the interest toward shrinking cities remains very limited in terms of academic interest as well as policy responses (Cunningham-Sabot and Fol, 2009). In the national debate, this issue is not politically visible

and has not managed to get on the national political agenda. Moreover, France is still largely characterised by urban policies that are shaped by a uniform and homogeneous vision of its national territory, blind to local contexts. This contrasts with the situation of many countries where urban decline is a crucial issue on the policy agenda of urban planners (Couch et al., 2011). Measuring the extent of the phenomenon in France is therefore important in order to understand, analyse and try to overcome this lack of policy attention.

Methods

For the analysis of French cities, we use the Aire Urbaine, a 'functional' spatial unit defined as a travel-to-work area. It consists of an inner area (pole) and outer areas (couronnes), which are aggregated from the smallest spatial units in France (communes). Because of various changing limits since 1975, we had to reconstruct the data for all available periods using fixed limits of the extension of all 354 Aires Urbaines in the year 1999.

To demonstrate the role of urban shrinkage in France two approaches are used. In order to allow comparability to other studies, the first approach uses a temporal evolution model and population as one of the most accepted indicators (Beauregard, 2009; Turok and Mykhnenko, 2007), defining shrinkage by an absolute population decrease (an inductive approach). This includes a typology that characterises the periods of decline, performed through a hierarchical clustering (with Ward's method) with standardised population values for each census over the period 1975–2007. The year 1975 was chosen because this year is usually considered as the beginning of the peri-urbanisation process in France, which allows a discussion of shrinkage in light of de-concentration (Paulus, 2005).

Because population changes hide the complexity of urban shrinkage, the second approach follows two dimensions. Socio-economic characteristics are taken into account in order to deduct different types of urban shrinkage (a deductive approach) and to understand the diversity of shrinking processes that are basically driven by demographic change and post-industrial transformation. For the operationalisation of demographic change, we referred to several studies using indicators (listed in Figure 3), which provide information about the surplus of deaths, reproduction level, and ageing process, such as the natural population balance and the distribution of different age groups and women (ESPON, 2010). Additionally, out-migration due to employment deficits has major impacts (Kabisch et al., 2006) and reflects residential decisions due to changing lifestyles. To describe economic decline, we used

changes in the participation and unemployment rate which provide evidence of the impact of economic changes on society. These indicators are calculated for the period from 1975 to 1999[2] for the Aires Urbaines, the poles and couronnes in order to integrate suburbanisation processes, before a cluster analysis distinguishes five types of cities.[3]

Urban shrinkage in France

Urban shrinkage: a process of demographic decline

The shrinking cities phenomenon is rather limited in France considering the number of affected cities and its intensity. Among the 354 French cities, 69 (20 per cent) experienced population loss between 1975 and 2007, representing only 9 per cent of the population of all urban areas (Table 1). Most of these cities are located in Central France and between the North-east and Lyon (Figure 1). Moreover, the intensity of population loss between 1975 and 2007 is rather low. Only eight cities experienced severe population loss with a rate of more than 0.5 per cent p.a., such as Decazeville, Longwy, Le Creusot and Montceau-les-Mines.

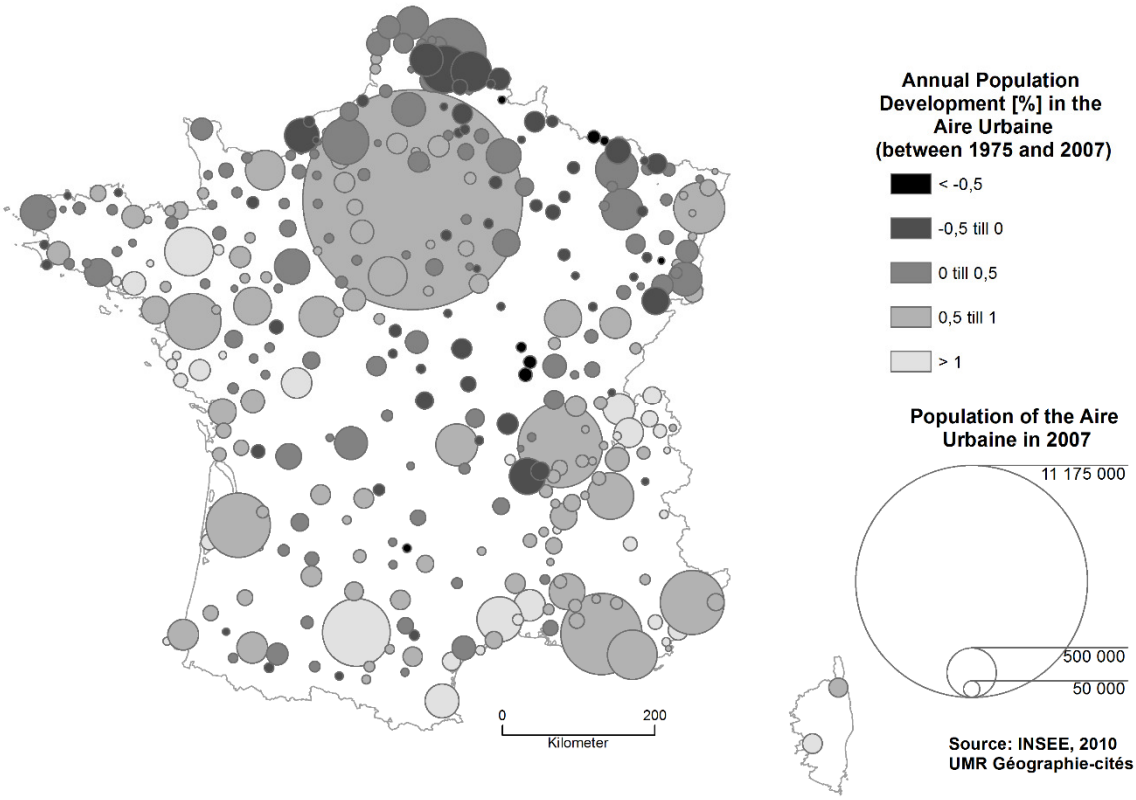

Figure 1: Annual population development of French cities between 1975 and 2007.

Most crucially, urban shrinkage mostly affects small cities: 74 per cent of the 69 shrinking cities have fewer than 50,000 inhabitants, including the most seriously affected cases (<-0.5 per cent p.a.). In contrast, the fairly large cities (100,000 to 300,000 inhabitants in 2007), like Le Havre, Bethune, Montbeliard, Maubeuge and Charleville-Mezieres, show moderate population losses (>-0.25 per cent p.a.). Only five cities with greater than 250,000 inhabitants in 2007 are shrinking, which represents less than 14 per cent of all urban areas within this size-class. Population losses in large cities as Douai-Lens and Valenciennes respectively do not exceed 0.16 per cent and 0.21 per cent p.a. Exceptional among cities over 150,000 inhabitants are Saint-Etienne and Thionville, with strong losses (-0.38 per cent p.a.). In general, the difference between small and large urban areas in terms of population loss is clear: whereas 23 per cent of the population of urban areas with fewer than 50,000 inhabitants live in shrinking cities, only 6 per cent of the population of urban areas over 250,000 inhabitants live in shrinking cities. This result confirms other studies on European cities, which underline the role of city size on shrinking processes (Turok and Mykhnenko, 2007).

Annual population change 1975-2007	**Classes of population size in 2007 (thousand)**								
	< 50	**50 - 100**	**100 - 150**	**150 - 200**	**200 - 250**	**250 - 300**	**300 - 350**	**350 - 400**	**> 400**
	Number of Aires Urbaines								
(< -0.5)	8	0	0	0	0	0	0	0	0
(-0.5 - 0)	43	8	3	2	0	2	1	1	1
(0 – 0.5)	73	20	11	3	0	5	2	0	4
(0.5 - 1)	58	26	12	3	3	0	3	3	10
(> 1)	31	8	2	0	4	1	0	0	3
Total	**213**	**62**	**28**	**8**	**7**	**8**	**6**	**4**	**18**
(< -0.5)	2,3%	0%	0%	0%	0%	0%	0%	0%	0%
(-0.5 - 0)	12,1%	2,3%	0,8%	0,6%	0%	0,6%	0,3%	0,3%	0,3%
(0 – 0.5)	20,6%	5,6%	3,1%	0,8%	0%	1,4%	0,6%	0,0%	1,1%
(0.5 - 1)	16,4%	7,3%	3,4%	0,8%	0,8%	0%	0,8%	0,8%	2,8%
(> 1)	8,8%	2,3%	0,6%	0%	1,1%	0,3%	0%	0%	0,8%
Total	**60,2%**	**17,5%**	**7,9%**	**2,3%**	**2,0%**	**2,3%**	**1,7%**	**1,1%**	**5,1%**
	Population of Aires Urbaines in 2007 (thousand)								
(< -0.5)	219	0	0	0	0	0	0	0	0
(-0.5 - 0)	1.005	627	322	338	0	557	317	399	546
(0 – 0.5)	1.783	1.440	1.346	533	0	1.370	614	0	2.544
(0.5 - 1)	1.484	1.916	1.427	549	704	0	1.000	1.152	20.195
(> 1)	791	594	244	0	930	280	0	0	2.195
Total	**5.282**	**3.281**	**3.339**	**1.420**	**1.634**	**974**	**932**	**1.551**	**25.480**
(< -0.5)	0,5%	0%	0%	0%	0%	0%	0%	0%	0%
(-0.5 - 0)	2,1%	1,3%	0,7%	0,7%	0%	1,2%	0,7%	0,8%	1,2%
(0 – 0.5)	3,8%	3,0%	2,8%	1,1%	0%	2,9%	1,3%	0%	5,4%
(0.5 - 1)	3,1%	4,0%	3,0%	1,2%	1,5%	0%	2,1%	2,4%	42,6%
(> 1)	1,7%	1,3%	0,5%	0%	2,0%	0,6%	0%	0%	4,6%
Total	**11,2%**	**9,6%**	**7,0%**	**3,0%**	**3,5%**	**4,7%**	**4,1%**	**3,2%**	**53,8%**

Table 1: Change in population 1975-2007of urban areas by size.

Urban shrinkage is not limited to a few regions but instead affects various parts of France. In order to distinguish between continuous and fluctuating population loss, a non-linear perspective of trajectories for shrinking cities since 1975 shows that ten cities (3 per cent) have experienced long-term decline over the entire period observed (Figure 2). This type refers to small and medium-sized mono-industrialised cities (Montlucon, Decazeville) or cities with weakening commercial or administrative functions (Autun, Gray). Two other types of trajectories include cities whose population loss was particularly strong in the 1970s and 1980s, also driven by peri-urbanisation processes, but slowed in the 2000s. This concerns a large group of urban areas (12 per cent) in formerly industrialised areas, including large cities like Valenciennes, Douai- Lens, Saint-Etienne, Roanne, or Thionville.

Population loss after growth can be found especially in medium and small cities in Central and North-eastern France (6 per cent). Here, population loss is associated with a decline of shops and services (Epernay, Saint-Dizier, Vitry-le-Francois), industrial functions (Saumur, Flers, Chaumont) or economic restructuring with a reduction of industrial employment (Thiers, Saint-Claude, Maubeuge).

Finally, two types of trajectories can be categorised by their development between 1999 and 2007. Certain long-term declining cities turned into growing cities and thereby testified that population decline is not necessarily irreversible. Such demographic recovery in the 2000s can be found in small towns scattered throughout the country (Verdun, Luneville, Tulle), mostly benefiting from immigration from nearby declining cities and rural areas. In contrast, more than 5 per cent of cities experienced population loss after a period of growth until the 2000s, including both small cities in the centre (Avallon, Migennes) and large ones in the North and North-east of France (Dunkerque, Le Havre).

This non-linear perspective already allows a first distinction between urban shrinkage as a continuous phenomenon or an episodic one, which, of course, highly depends on the interplay between different drivers.

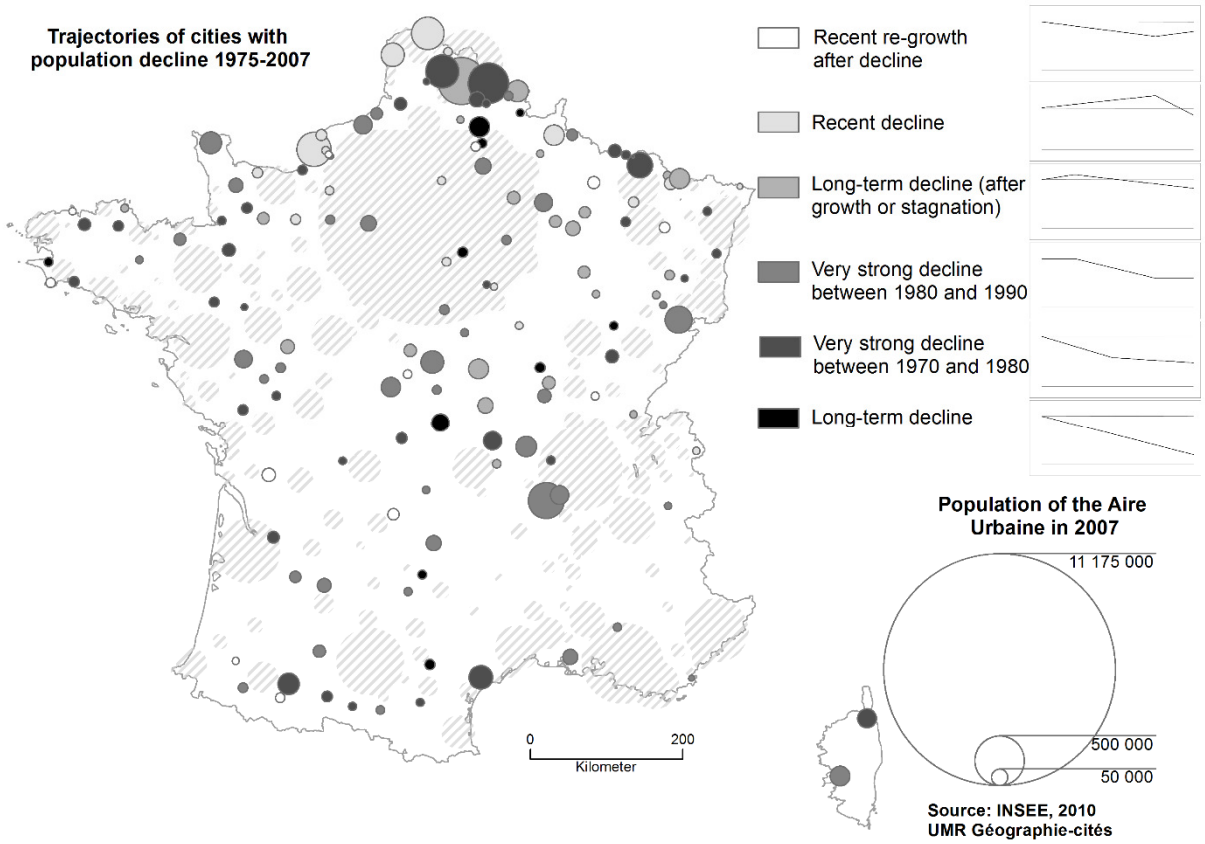

Figure 2: Trajectories of urban areas with periods of population decline 1975-2007.

Urban shrinkage: a relative and multidimensional process

In order to better understand the interactions between demographic trends and socioeconomic processes (Wolff and Wiechmann, 2013) we need to define urban shrinkage as a complex process relating to the dynamics of the whole urban system. An analysis of several socio-economic indicators for the 354 French cities between 1975 and 1999 highlights five socio-economic types, with three of them related to shrinking.

The two first types describe growing cities, which include mostly large and medium-size cities in France. Both types show high immigration rates, but with different demographic evolution. Cities predominantly located in Southern France (Nice, Toulouse, Bordeaux) are affected by low birth rates and a strong ageing process, whereas growing cities in Northern France show a high proportion of young people and a prosperous economic evolution due to their attractiveness for young people for education and jobs (Paris, Rennes, Reims).

In contrast, cities in post-industrial change with high emigration underwent a massive economic restructuring process but hardly managed to attract new industries. The labour market is struggling with very low and decreasing employment as well as high and increasing

unemployment rates in the whole urban area, which especially affects young people. Additionally, a very low proportion of highly qualified employees in the tertiary sector indicates that these cities can hardly compete with advanced economies. This type includes small, medium-sized and large cities (Lille, Rouen, Douai-Lens) located in the North and North-east of France. These cities have reported high and increasing out-migration since 1975, especially from the core cities. However, in spite of the economic situation, young people in particular prefer to stay in the suburban areas and thus contribute to high birth rates with a mitigated ageing process.

The fourth type is characterised by a rapidly decreasing proportion of young people. These are small cities, with a few medium-sized ones like Niort, Blois or Troyes, mainly located close to Paris, Rennes and Lyon. This proximity to large centres might explain the out-migration of young people looking for jobs and education. Thus, the positive natural balance is decreasing constantly, leading to increasing impacts of demographic change in the future. The low proportion of employees in the tertiary sector and high-skilled jobs reveals the lack of attractiveness of these cities within an advanced economy. However, for the remaining population, the labour situation is favourable, with high employment and low unemployment.

The impact of demographic change is especially obvious in declining and ageing cities mainly located in the Central part of France, at the Spanish border and between Rennes and Caen. These cities are characterised by a high proportion of elderly people, low birth rates since 1968 and a negative natural balance. This natural deficit is reinforced by out-migration, especially from the centres, leading to a lack of children and young people. The suburban areas experienced slight immigration, often reinforcing the cores' decline. The labour market is tight and does not provide many opportunities, particularly in the couronnes, where the employment rates are decreasing constantly, leading to high and increasing unemployment rates.

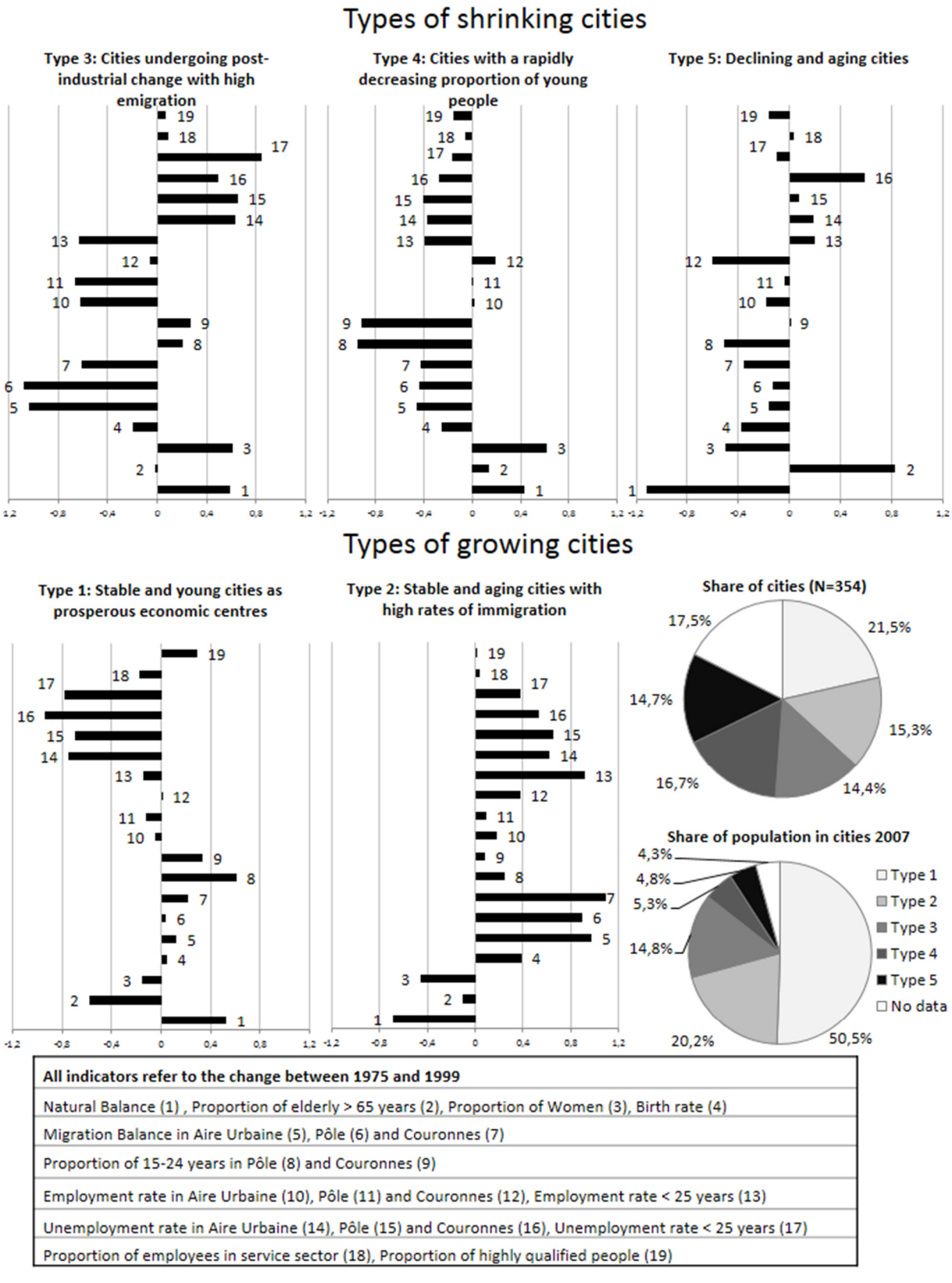

Figure 3: Profiles of the socio-economic types of French cities 1975-1999 (median of the z-standardised values of each indicator).

Discussion – planning needs for shrinking cities in France

The results suggest that urban shrinkage is a rather limited phenomenon in France, with predominantly small cities affected. However, the picture presented here demonstrates that, on the one hand, urban shrinkage is part of long-term dynamics (Paulus and Pumain 2000) and, on the other hand, shrinkage is not limited to small cities but also affects the intermediate levels of the urban hierarchy in France, especially after the 1980s and in the 2000s. Moreover, urban shrinkage is not an isolated phenomenon but rather became a persistent pattern in some regions and even intensified in others with adjacent recently shrinking cities. This spatial diffusion indicates that urban shrinkage is not a short-term trend but might be rooted in the structural problems of cities and regions (Martinez-Fernandez et al., 2012), putting them at 'risk of marginalisation' (Lugan, 1994). This calls for national policies which acknowledge these trends and produce specific and adapted responses (Figure 4).

In France, the attention of policy makers has focused on deindustrialisation and several types of policies have targeted the decline of industrial regions. The French State has helped the implementation of active land policies in regions where the effects of deindustrialisation have been particularly dramatic (brownfields and empty lots) in order to initiate revitalisation projects and large-scale redevelopments. Furthermore, the Agence Nationale de Renovation Urbaine (ANRU), created in 2003, has intervened in urban decline by focusing on the renovation, demolition and reconstruction of a significant part of the housing stock in large social housing estates of the 1960s in the peripheries of big (but rarely shrinking) cities. In 2009, this programme was extended to declining city centres with run-down housing and socio-economic difficulties. This limited awareness of national policies mainly focusing on deindustrialised cities and social housing is somehow in contradiction with the diversity of urban shrinkage in France, an understanding of which is a precondition for designing policy options. The presented typology underlines at least three needs for planning.

The economic erosion in cities of the post-industrial transition is already targeted by national policies. Investing in the centre of small and medium-size cities (culture, retail, public space and infrastructure, housing) is needed to reverse the continuing disaffection of most households for inner cities. This local focus needs to be accompanied by regional economic policies, creating an innovative and competitive economic cluster with stable jobs. National policies need to encourage integrated multilevel governance combining local and regional strategies.

In contrast, ageing cities showing substantial demographic problems are hardly targeted by national policies as they weigh little in economic terms. However, due to a worsening labour market situation, further out-migration is certain. Beside the classical policies targeting the effects of deindustrialisation, there is a strong need not only to adapt these cities to demographic change, such as designing buildings and infrastructure according to the requirements of elderly persons, but also in making investments in infrastructure for the elderly (residential homes) and thus attracting younger people to work in these new services. City planning and municipal budget plans need to be adapted to the impacts of demographic change.

Finally, in cities with a rapidly decreasing proportion of out-migrating young people, large-scale policies are needed. Investments in the education infrastructure and planning for a more diverse labour market may help to overcome the lack of economic diversity and specialisation (Ferrerol, 2010). A wide range of activities and services might incite young people to remain in their cities or at least to return after their education. In parallel, stronger inter-city cooperation (between large universities and smaller facilities of the affected cities, accompanied by a better accessibility) would allow young people to experience some amenities of larger cities without moving there (Alonso, 1973).

We can summarise that, in France, there is a mismatch between processes of demographic change, post-industrial transformations and the perception of urban shrinkage. First, there is an increasing complexity in the processes of urban shrinkage, with a combination of demographic, economic and social factors. This requires shifting the policy focus from economic related issues to a deeper understanding of urban shrinkage. Second, more attention needs to be paid on changing age patterns in order to detect future tendencies and current needs for adaptation. Third, a deeper policy integration is needed both horizontally (urbanrural) and vertically (local-regional-national) in order to provide more opportunities to tackle the various challenges related to urban shrinkage. This would allow a more efficient territorial cohesion policy at larger scales (Baron et al., 2010) thus compensating for the effects of urban competition and metropolisation.

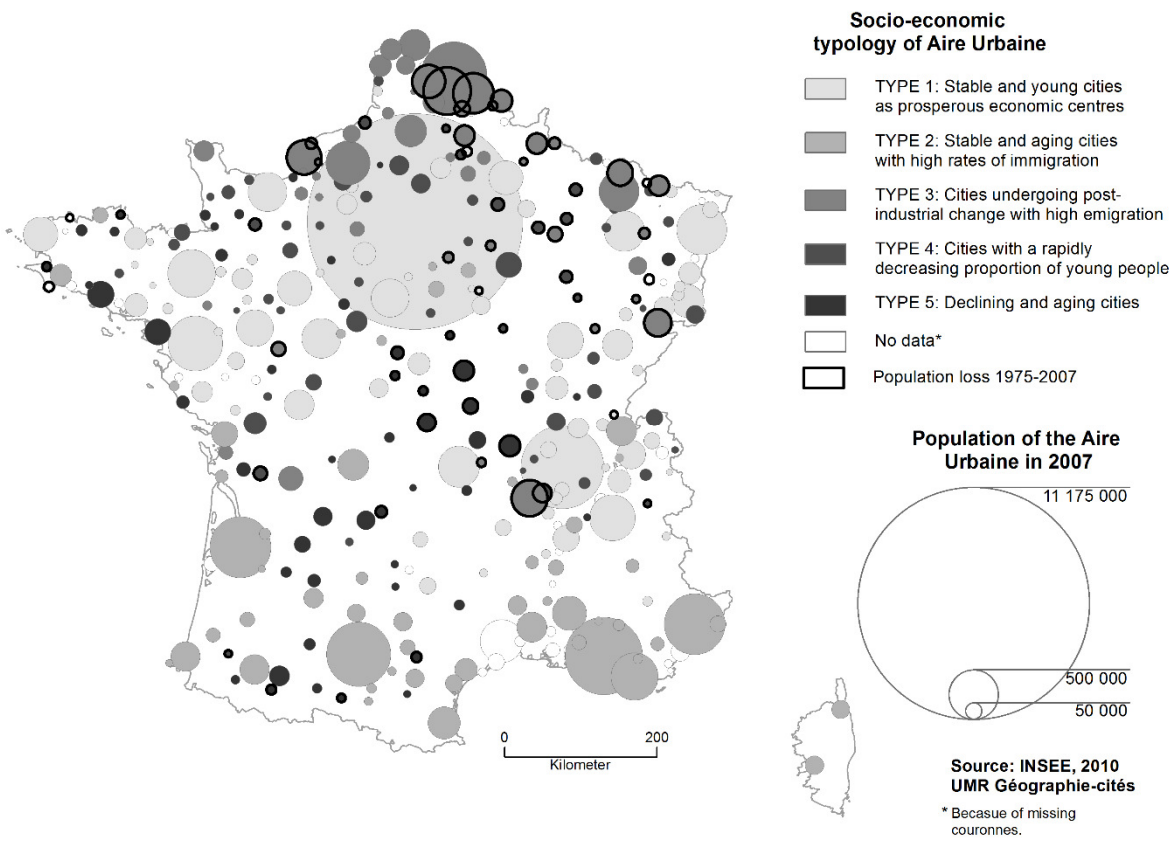

Figure 4: Distribution of different socio-economic types of cities.

Conclusion: role of shrinking cities in France

In many studies (Turok and Mykhnenko, 2007; Baron et al., 2010) France seems not much affected by urban shrinkage compared to other European countries. A closer look shows that shrinkage is now a reality in the French urban landscape, affecting several parts of the country. Although these cities have similarities, the dominant factors of shrinkage, like selective out-migration or declining birth rates and ageing, differ significantly among them, creating specific trends of self-reinforcing downward spirals.

The size effect explains the poor attention given in France by policy makers to the phenomenon of shrinking cities, most of them weighing very little in the nation's economy. Consequently, the decline of small towns is obviously not on the policy agenda at the national level. Policy responses are still mainly focused on reversing economic decline by re-strengthening the economic competitiveness of shrinking cities and going for new economic and demographic growth. This one-sided growth orientation might also be criticised (Häusermann and Siebel, 1987) as not all facets of urban shrinkage are addressed, in contrast

with the political debates in many other countries (Couch et al., 2011). However, a scientific comparison and the characterisation of urban shrinkage trends both from a spatio-temporal and socio-economic perspective can strengthen the decision-making processes and serve as a base to propose new planning and policy strategies.

Notes

1. SCiRN was initiated in 2004 by visiting scholars at the Institute of Urban and Regional Development, University of California, Berkeley. It is an interdisciplinary group of urban planning academics and researchers from five continents, which conducts research on shrinking cities in a global, comparative perspective. The authors of the present paper are all members of the SCiRN. http://www.shrinkingcities.org.

2. Due to changes in the definition of some indicators INSEE (2011b) the typology is limited to the period 1975–1999.

3. For further details see Wolff (2013). Data obtained through INSEE (2011b).

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4.3 Understanding the role of centralization processes for cities – evidence from a spatial perspective of urban Europe 1990 – 2010

Paper 3: *Manuel Wolff*

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Understanding the role of centralization processes for cities – Evidence from a spatial perspective of urban Europe 1990–2010

Manuel Wolff

Helmholtz Centre for Environmental Research – UFZ, Department of Urban and Environmental Sociology, Permoserstr. 15, 04318 Leipzig, Germany

Introduction

In the 21st century, the urban systems in most countries have been subjected to constant change that ranges from shrinkage, through growth, to non-linear trajectories (Turok & Mykhnenko, 2007; Reckien & Martinez-Fernandez, 2011), accompanied by strong interrelationships with the cities' hinterland: Agglomeration effects lead to reinforced population growth in the hinterland, whereas the flight of people and jobs to the suburbs may lead to the decline of other core cities; some cities have even managed to regrow in parallel with population loss, deterioration and housing vacancies in their hinterland (Siedentop & Fina, 2008; Couch, Karecha, Nuissl, & Rink, 2005; Bier, 2001). Thus, cities' population trajectories are not independent but rather is reinforced or runs contrary to the hinterland development (Bento, Franco, & Kaffine, 2006; ESPON, 2014b).

Urban life-cycle models are used to simultaneously capture trends in cities and their hinterlands. By using a systematic differentiation between trends in the core and the hinterland, it is possible to distinguish between stronger population growth in cities' cores and a situation in which the hinterland is growing faster; these two trends are known as centralization and decentralization, respectively (Champion, 2001). Whereas, for Europe, some authors have identified a new centralization or recentralization (Cheshire, 1995; Kabisch & Haase, 2011), others predict that further population increase in cities will slowdown, in favour of decentralization processes (Champion, 2001). Urban shrinkage[1] is thereby treated as an unavoidable consequence of decentralization and as a precondition for recentralization but it has been rarely asked whether shrinkage follows a centralization or decentralization trend.

By successively ordering these stages, van den Berg, Drewett, Klaassen, Rossi, and Vijverberg (1982) developed a cyclic model in which urbanization or centralization is followed by suburbanization, with decentralization tendencies, and, finally, ending in disurbanization, with population loss in cities and their hinterland. Reurbanization, treated by these authors as a fourth hypothetical stage, has been detected in other studies (e.g., Cheshire, 1995; Kabisch & Haase, 2011). Because trends such as urbanization or suburbanization are not treated separately, the model is widely used in order to describe the situations of urban systems. However, it also reveals some drawbacks (for a broader discussion, see Antrop, 2004; Nyström, 1992; Parr, 2012). First, van den Berg et al. (1982) analysed large cities with more than 200,000 inhabitants. Second, the use of population change as an indicator is criticized because it hides certain trends, such as shifts in the population structure. Third, the model captures the changes between stages insufficiently, because population trajectories do not follow the consecutive order of the model's stages.

Against this background, the paper will revisit van den Berg's et al. model and test it against the urban conditions in Europe between 1990 and 2010 by asking whether cities are decentralizing or centralizing and whether there are differences between growing and shrinking cities. In view of the mentioned drawbacks, the paper develops a city delineation covering large and small cities, uses data about age structure, and applies an adapted model by measuring the intensity of the trends. The rapidly changing population trends since the beginning of the global economic crisis and its effects in Europe since 2008 require that more attention be paid to changing configurations between cities and processes beyond cities' borders, which is essential for both scholars and urban planners. Thereby, the papers' objectives are to:

- detect how relevant the life-cycle model is in contemporary urban Europe and what stages are persistent/temporary,
- identify patterns of centralization and decentralization in order to enrich the life-cycle model, and
- discuss emerging policy lessons that can be derived from the results.

Methods

In order to distinguish between cores and hinterlands that form a Functional Urban Regions (FUR), functional approaches are used, which are, however, very heterogeneously defined among European countries (Brezzi, Piacentini, Rosina, & Sanchez-Serra, 2012). Existing databases for Europe also have some shortcomings.[2] Therefore, an alternative approach is developed that aims at defining 'potential' FURs that covers the entire territory and links each municipality in the hinterland to the core within its zone of influence, based on physical accessibility (Hall & Hay, 1980; ESPON, 2014b; Bretagnolle, Paulus, & Pumain, 2002). The core is defined by merging cities, as defined by Wolff and Wiechmann (2017) and is based on a common built-up area, in order to better reflect the morphological character of a city and to increase comparability across Europe (Parr, 2012; Turok & Mykhnenko, 2007). Following the concept of time-budgets spent by commuters as a more stable parameter, compared to commuter flows, the hinterland is defined by merging municipalities that can be reached from the core within 45 min by car (Guérois, Bretagnolle, Mathian, & Pavard, 2014; Meijers, Burger, & Hoogerbrugge, 2015; Thinh & Vogel, 2006). This results in 5692 cores, for which we use the term urban areas interchangeably, and 2733 FURs (Figure 5 in the Appendix).

In accordance with other studies, we use population for 1990, 2000 and 2010 in 36 European countries as a common indicator for urban development (Turok & Mykhnenko, 2007; Haase,

Bernt, Grossmann, Mykhnenko, & Rink, 2013; Hall, 1971), whereas shrinking urban areas are defined by absolute population loss. In order to reflect changes of the population structure and to discuss possible future trends, we further analysed shifts of age groups by calculating elderly, young, and dependency rates (Parr, 2012).

The van den Berg et al. (1982) model is applied by presenting numbers for the two decades 1990–2000 and 2000–2010 for countries and regions together. In order to better mirror changes between stages without assuming a consecutive order, we apply an adapted four stage model that has the advantage that the stages fall symmetrically into core population growth and decline, as well as into centralization and decentralization (Hall, 1971; Cheshire, 1995; Figure 1). Centralization is understood as a population increase that is faster in the core than in the hinterland, or a faster decline in the hinterland than in the core – decentralization reflects the opposite. For the four stages, the intensity of relative (de)centralization is measured (following Cheshire, 1995; Parr, 2012) and expressed as the difference between the percentage change in hinterland and core. The more positive this index, the faster the relative rate of decentralization, irrespective of whether both core and hinterland were gaining, but the hinterland more rapidly, or both are losing, but the hinterland less rapidly. A negative value implies a centralization trend.

Theory: shrinking cities as a stage of urban life-cycle models

To understand urban change, various approaches have been developed, ranging from classical models (e.g., central-place theory) to economic- spatial approaches (e.g., Krugman, 1981). Starting with the work of Vernon (1966), urban development was understood to be closely related to a limited life span of products: from innovation-driven initial development and job growth to decline and obsolescence (Friedrichs, 1993).

This product life-cycle is linked to urban development via the need for an optimal location of production in each stage. For the innovation stage, highly qualified employees and venture capital is needed – both are more likely to be found in urban areas. Changes in demand, production, or market conditions require continuous adjustments of the production processes and a relocation of the products' production site, in order to lower labour and capital costs with a corresponding spread of new technologies and innovation (Friedrichs, 1993). A city shrinks when one of the major production factors (labour, capital, technical progress) fails to expand and cannot be compensated by the growth of other input factors. This leads to a decline of its relative economic position in the larger market, job losses, unemployment, and out-migration (Fol & Cunningham-Sabot, 2010).

In addition, urban economists stress the role of trade-offs between transport costs, urban amenities, and income, which explain spatial centralization and decentralization of agglomeration economies (Cheshire, 1995; Fujita & Thisse, 2002).[3] Centralization and decentralization are understood as stages in urban development, forming a regular sequence from centralization and growth to decentralization and, ultimately, to shrinkage (Hall & Hay, 1980). The robustness of these sequences, demonstrated in several studies, led to the development of urban life-cycle models and theories that explain the different stages of urban development in Europe (e.g., Hall, 1971; Klassen & Scimeni, 1981). Based on this, van den Berg et al. (1982) developed a cyclical urbanization model that has been widely accepted and updated (Cheshire & Hay, 1989; Cheshire, 1995; Champion, 1995; Kabisch & Haase, 2011).

In order to understand the changes between stages of urban development, this model uses transportation costs, similar to economic models, and the spatial behaviour of urban actors (residents, companies, and government). Their mobility, preferences, and aspiration levels are influenced by fundamental economic, social, political, technological, or demographical developments. Four successive stages of urban development are identified that differ in terms of population growth and decline in the core, hinterland, and FUR: urbanization, suburbanization, disurbanization and reurbanization; these can be further subdivided by taking into account absolute or relative variations (eight stages, Figure 1).

Urbanization is characterized by spatial centralization due to massive migration from rural to urban areas as the agricultural society passes into the industrial one observed in Europe until the 1950s. When congestion in the cores increases, decentralization pushes cities to a second stage, with population increase predominantly in the hinterland while the core growth slows down. This suburbanization stage is basically driven by former city inhabitants who search for higher residential quality, together with better transport opportunities; this was characteristic for Western Europe in the 1960s. However, migrants to the suburbs remain oriented to the core in terms of jobs, socioeconomic activities, and services, leading to increasing commuter flows.

Disurbanization describes the stage in which the total population of the FUR decreases as an outcome of the devaluation of the inner-city stock that led to out-migration of businesses and residences. In Western Europe, desurbanization began in the 1970s with migration to rural areas and small and medium-sized cities outside the FUR with lower land prices (also referred to as ‘counterurbanization’; Champion, 2001; Antrop, 2004). This is a direct consequence of the strategies of actors aiming to maximize their satisfaction and, thus, equivalent to the obsolescence stage of the product life cycle (Fol & Cunningham-Sabot, 2010). Moreover, this

population loss is reinforced by the dramatic fall in the birth rate, coupled with increased life expectancy, as part of the demographic transition (van den Berg et al., 1982).

Reurbanization is understood as the stage in which the core regains the attention of investors, companies and people and it is measured by a slowing down of decline and, finally, subsequent growth in the core and a reduced decline in the hinterland. Although van den Berg et al. (1982) understood this stage as an unlikely future process, several authors have identified a slowing down of decentralization processes since the 1980s and a recentralization of population in many Western Europe cities (Cheshire, 1995; Champion, 1995; Kabisch & Haase, 2011). This is connected to rapid structural changes towards a knowledge economy, with human capital as a key factor. Hence, the educated and qualified employees earn high incomes and can place high demands on the quality of life – both likely to be found in urban areas.

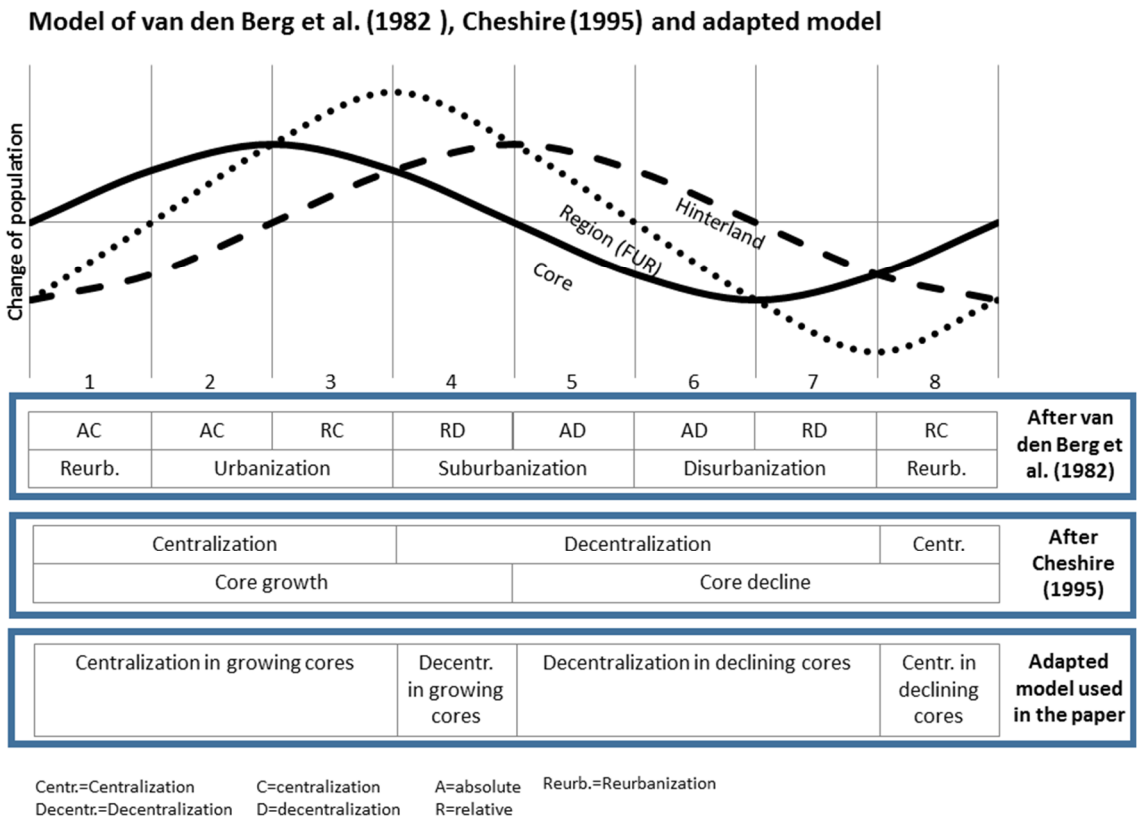


Figure 1: Life-cycle models and adapted four-stage model.

Results

Growth and shrinkage in European cities and their hinterland

Since 1990, population development across Europe has been characterized by an increasingly scattered and polarized spatial pattern. On the one hand, urban shrinkage is a prominent phenomenon in Europe, appearing in more than one-third (35%) of all urban areas in Europe after 2000 (Figure 2). However, the number of affected areas has increased, compared to the previous decade (29% between 1990 and 2000) – especially those with declining hinterlands. On the other hand, although the majority of urban areas follow a growth trend, their number has decreased, particularly among those with hinterland growth (from 60 to 57%). However, for both growing and shrinking urban cores, the growth rates have increased significantly. One might ask to what extent do we see an increasing decoupling from core and hinterland developments – and whether this is stronger for growing than for shrinking urban areas.

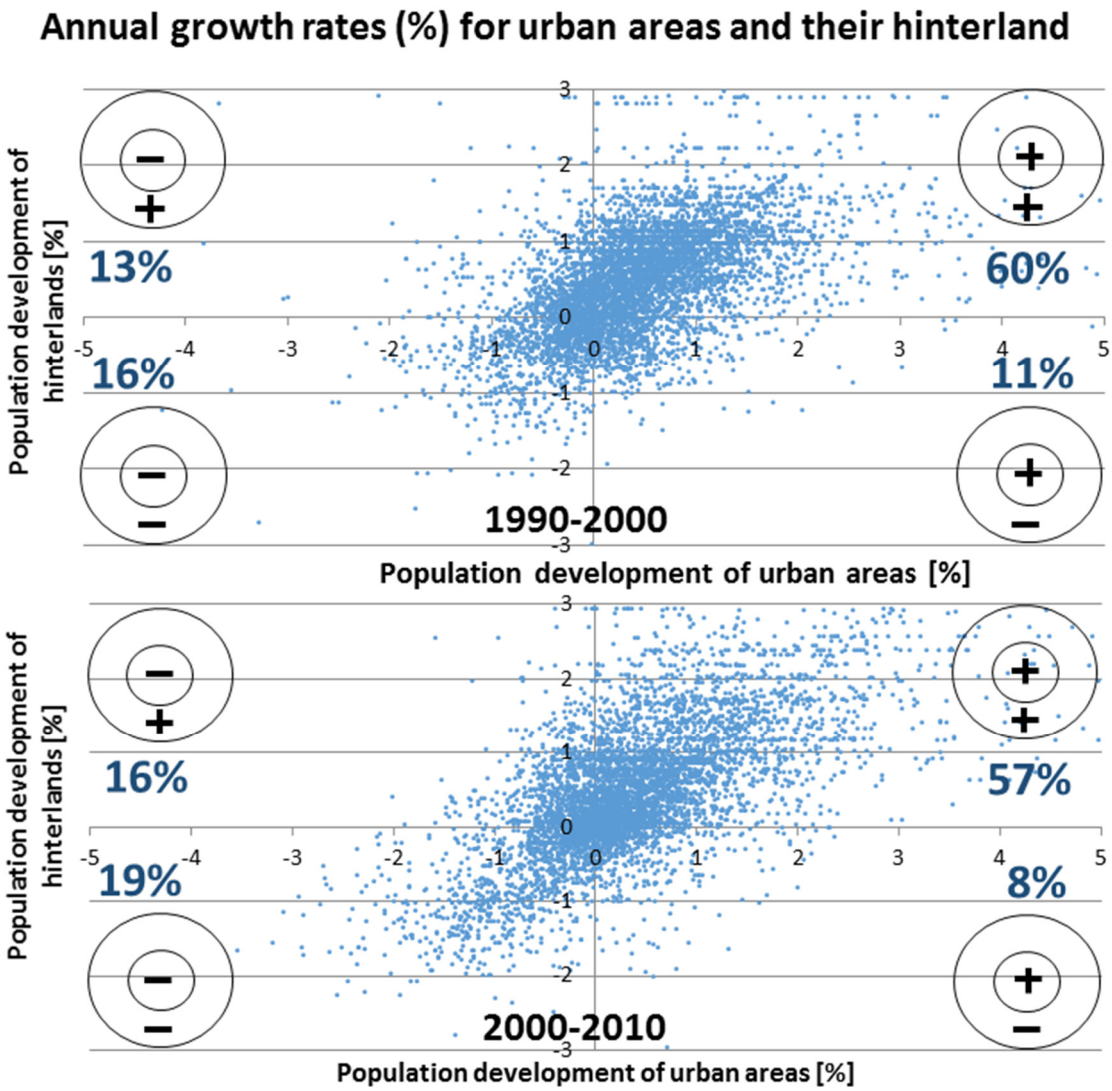


Figure 2: Population growth and decline in European cores and hinterlands 1990-2010.

The application of the van den Berg et al. model emphasizes that population growth of urban areas and hinterlands clearly dominates the urban landscape in Europe, whether with relative decentralization or relative centralization (SUB1 and URB2, respectively, Figure 3). Each stage covers 23% of all urban areas between 2000 and 2010; these are predominantly located in Western, Northern, and Southern Europe. However, in the majority of Western European countries, suburbanization slowed down significantly after 2000, as in Germany, whilst in Italy and Spain, the core growth rates increased, leading to increasing numbers of urban areas in the late urbanization stage. Furthermore, absolute centralization, in terms of growing cores parallel to hinterland decline, is also observed, but it is only valid for approximately 4% of urban areas between 2000 and 2010 (REU2 and URB1). However, this stage is observable in Northern Europe, Greece, and Portugal as well as, to a lesser extent, in regions behind the former Iron Curtain that used to be hotspots of urban shrinkage. In contrast, absolute decentralization, which is expressed as suburbanization with stronger hinterland growth rates and core decline, is especially visible in East-Central Europe, France, and Ireland, where the numbers even increased, due to migration into the hinterland after 2000 (SUB2 in Figure 3). This strong suburbanization tendency in East- Central Europe, pulling urban shrinkage after 2000, represents a major difference to South- and Northeastern (SN-Eastern) countries with predominantly declining hinterlands. In most parts of Europe, and especially in SN-Eastern Europe, urban shrinkage is especially pronounced when the corresponding hinterland is declining, leading to relative decentralization with stronger population loss in the cores, or centralization with more pronounced hinterland losses (DIS2 and REU1). After 2000, the number of urban areas characterized by these stages increased up to 7% after 2000, underlining the fact that urban shrinkage is of increasing relevance. However, the increasing shares after 2000 raises the question whether these stages follow a successive order: Does the increasing share of urban areas in the early reurbanization stage emerge as a result of a slowing down of population loss in the cores, parallel to a faster hinterland decline, or has the population decline of cores intensified, leading to the increasing share of urban areas in the late disurbanization stage?

Unfortunately, van den Berg's 1982 model hardly captures changes between stages because the trajectories do not follow its consecutive order, and also because of the extensive differences between countries. One third of those urban areas that significantly switched to another stage between 1990–2000 and 2000–2010 changed in line with the life-cycle model, one third contrary to it, and one third experienced a faster change that was in line with or contrary to the model (Figure 7 in the Appendix).[4] From this perspective it is obvious that a

clear trend is not obvious, due to complex developmental trends and their substantial deviations from the model's assumptions.

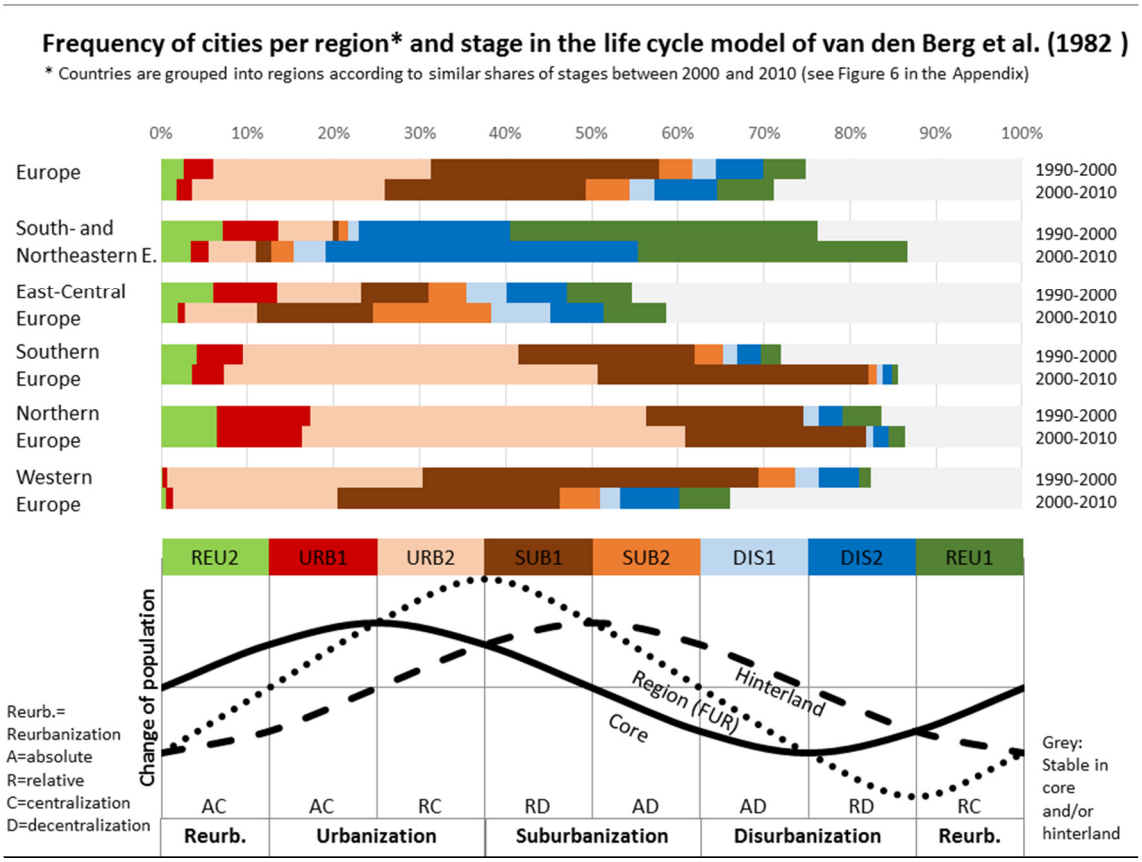


Figure 3: Frequencies of urban areas per stage and region.

Adapting the life-cycle model

The application of a four-stage model and the measurement of the intensity of (de)centralization (Figure 4) and shifts of age groups (Table 1) reveals that three major trends can be detected in contemporary urban Europe: a polarization of growing urban areas between decentralization and centralization, growing cores that moved to shrinkage via decentralization, and a trend towards centralization among shrinking urban areas.

A reinforced ***decentralization of growing urban areas*** after 2000, with 512 cores that went from centralized to decentralized growth, is characteristic for the urban systems of Southern and Western Europe, such as in Northern France and the Benelux (Figure 4). A constant influx of people of working age into the whole FUR drove this process (Table 1), leading to reinforced growth rates in the hinterland. This, in turn led to a suburbanization stage in urban areas, as in Western France or Spain, and it helped formerly shrinking cores to grow again, as in Northern Italy. The most significant increase of decentralization rates was measured in small East-

Central European cores, as in Poland, with very strong growth in the hinterland basically driven by young families. However, the constantly decreasing number of children in the entire FUR indicates the beginning of aging in these regions. Nevertheless, the average core growth rates increased significantly, even though these urban areas followed a decentralizing trend, confirming that populations were concentrating faster in the cores, compared to their hinterland.

REGIONS*	FUR				Core				Hinterland			
	1	2	3	4	1	2	3	4	1	2	3	4
Δ Youth Rate												
Europe	-3,3	-2,2	-7,8	-8,5	-3,0	-2,4	-9,5	-9,1	-3,6	-1,9	-6,1	-7,8
East-Central Europe	-13,3	-15,9	-15,2	-14,8	-12,6	-16,5	-17,1	-16,6	-14,0	-15,3	-13,3	-13,1
Northern Europe	-1,4	-1,4	-3,6	-5,1	0,4	-1,1	-3,9	-3,6	-3,2	-1,7	-3,2	-6,7
SN-Eastern Europe**	-7,4	-9,2	-9,3	-6,2	-8,0	-11,5	-13,9	-8,2	-6,8	-6,9	-4,7	-4,2
Southern Europe	-3,9	-2,9	-6,0	-7,3	-3,9	-3,3	-6,5	-7,4	-3,8	-2,6	-5,6	-7,2
Western Europe	-0,4	0,6	-2,5	-7,2	0,1	0,5	-3,1	-6,5	-1,0	0,8	-2,0	-7,9
Δ Elderly Rate												
Europe	7,8	12,0	12,6	10,0	7,8	13,8	14,9	10,7	7,7	10,1	10,2	9,3
East-Central Europe	2,0	1,2	3,1	4,3	3,1	3,7	6,4	6,2	0,8	-1,3	-0,2	2,5
Northern Europe	4,4	2,9	8,9	8,7	4,7	2,2	11,9	8,3	4,0	3,5	5,8	9,0
SN-Eastern Europe**	5,6	5,2	8,6	9,9	4,9	5,5	9,0	9,4	6,3	4,8	8,2	10,5
Southern Europe	5,0	5,0	10,1	10,2	5,0	6,8	12,0	8,8	5,1	3,2	8,2	11,5
Western Europe	13,0	18,1	20,7	12,6	13,0	20,0	23,3	13,8	12,9	16,2	18,0	11,3
Δ Dependency Rate												
Europe	4,5	9,8	4,7	1,6	4,9	11,4	5,4	1,7	4,1	8,2	4,0	1,5
East-Central Europe	-11,3	-14,7	-12,1	-10,5	-9,5	-12,8	-10,6	-10,4	-13,1	-16,6	-13,5	-10,6
Northern Europe	3,0	1,5	5,3	3,6	5,1	1,1	8,0	4,8	0,8	1,9	2,6	2,4
SN-Eastern Europe**	-1,8	-4,0	-0,7	3,7	-3,0	-5,9	-4,9	1,1	-0,5	-2,0	3,4	6,2
Southern Europe	1,2	2,1	4,1	2,9	1,1	3,5	5,5	1,5	1,2	0,7	2,6	4,4
Western Europe	12,5	18,7	18,1	5,3	13,1	20,4	20,2	7,3	11,9	17,0	16,1	3,4

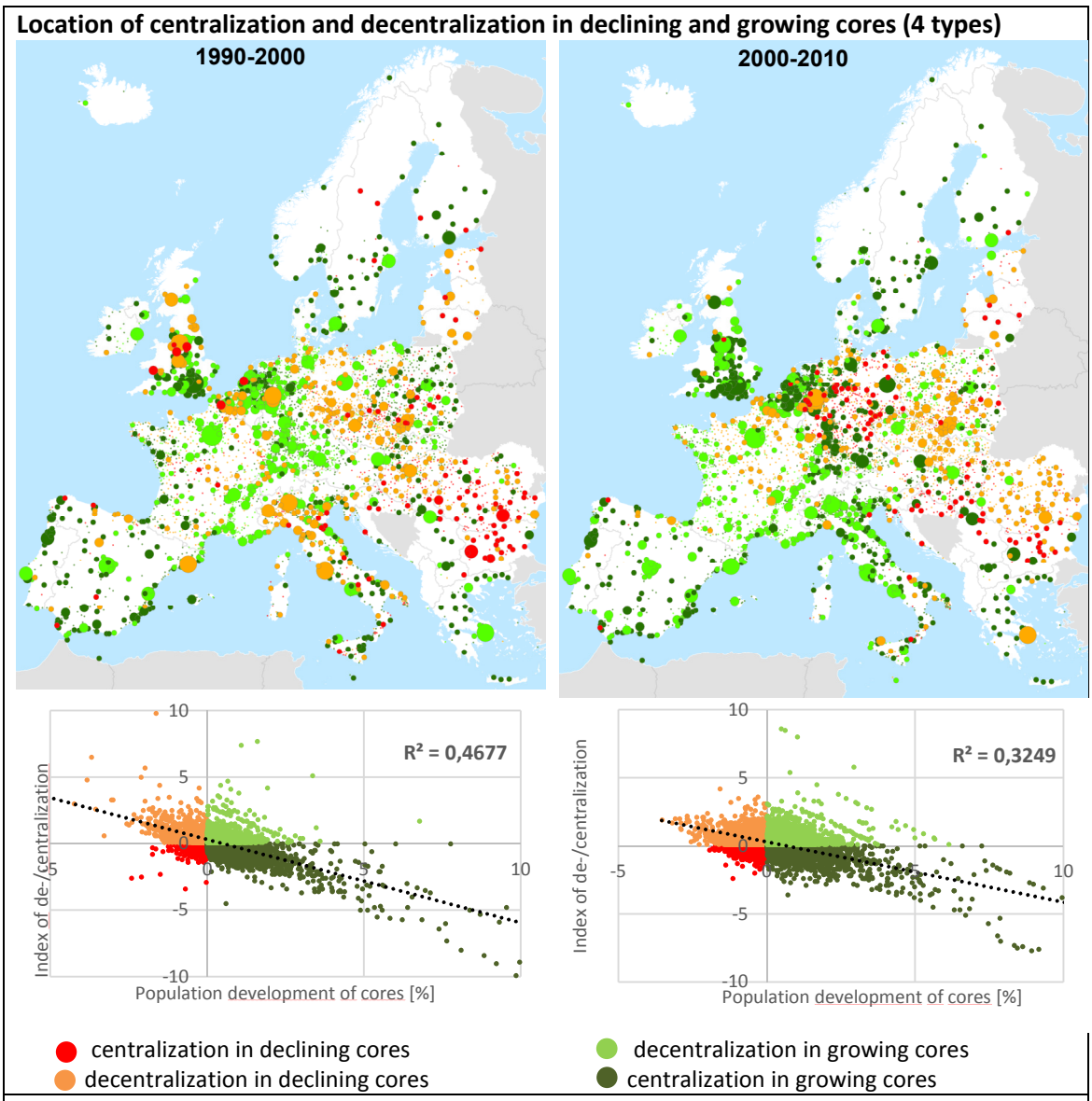
Table 1: Average changes of age indices for 4 stages of the adapted model 2000-2010 (centralization under core growth=1; decentralization under core growth=2; decentralization under core decline=3; centralization under core decline=4). *Countries grouped according to similar shares of stages (Figure 6, **South- and North-Eastern Europe

Figure 4 reflects the intensified ***centralization of growing urban areas*** *i*n large parts of the UK, Germany, Northern and Southern Europe, with 259 cores that changed from decentralized to centralized growth. The intensity of this trend and the shifts of age groups support findings that young families and job starters are immigrating, which leads to mitigated aging (Table 1). Moreover, certain differences between regions are obvious. Whereas the increasingly younger age structure and the increase in the number of children in Western and Northern Europe demonstrate that these groups basically remain in the cores, strong aging and declining birth rates in Southern Europe indicate that these urban areas pull people from rural areas but at the same time, serve as departure points for movement to larger urban areas, or even abroad. For SN-Eastern and East-Central Europe, Figure 4 shows that the strong increase of core growth and centralization rates is basically limited to capital urban areas. Additionally, centralization of small and medium- sized urban areas basically stems from hinterland growth rates, which slowed down, as in Germany or Italy, and even became negative, as in Spain or Greece. In Western Europe, and in particular in Germany, the average core rates slightly decreased after 2000, which basically stems from the increasing number of urban areas that

changed from former shrinkage to new, centralized growth. However, the majority of these urban areas have shown a very rapid development from decentralized decline to centralized growth, driven by families and young people, without passing through a disurbanization stage, as the van den Berg et al. model assumes (Figure 7 in the Appendix).

The general trend of shrinking urban areas shows a ***slowing down of decentralization in favour of centralized decline***. Figure 4 shows that the intensity within decentralized declining cores in almost all regions decreased; in other words: population decline in the cores slowed down and the hinterland lost population faster; this is especially pronounced in Western and East-Central Europe. The slowing down of core losses is basically due to the immigration of elderly people into cores that can still provide social and technical infrastructure (Table 1). This trend pushed 104 urban areas with former stronger losses in the core to centralized decline after 2000 with, however, strong aging, e.g., in Eastern Germany or Hungary. Additionally, marked aging, a lack of births, and rapid out-migration turned formerly growing urbanized, but even more suburbanized urban areas, into a stage of absolute decline in the entire FUR – especially in their hinterlands (centralized decline). This represents the major path of urban areas that moved from growth into decline (210 cores) underlining the rapid evolution of this trend, which is hardly in line with the van den Berg et al. model (Figure 7 in the Appendix).

Even more significant is the ***constant weakening of the hinterland***, with stronger population loss and marked aging, compared to the declining cores. This becomes obvious from a comparison of the average growth rates of centralized declining urban areas in Figure 4: Although the average losses significantly increased, the hinterland still lost population faster than the cores. This indicates that these urban areas survive at the expense of their rural areas and, perhaps, turn to pronounced shrinkage, due to the absence of immigration and to natural decline. An intensified out-migration of young people, in particular, from the cores, a slowing down of immigration from rural areas, and a drop in the number of children pushed this decentralization, with 101 declining cores that went from centralized to decentralized decline after 2000, most significantly in Romania and Bulgaria, with a strong increase of the dependency ratio – the highest among all European regions. This trend is different from suburbanization as a driver of shrinkage, although both show a more favourable development in the hinterland, compared to the core. Suburbanization is of less importance as a factor for urban shrinkage after 2000 and it drives growing cores into decline in some regions, for example in France, Poland, or the Czech Republic. The already strong hinterland growth of predominantly small urban areas pushes them towards decline, or a re-growing hinterland reinforces the core decline, as in France – all leading to a hollowing-out and aging of the cores.



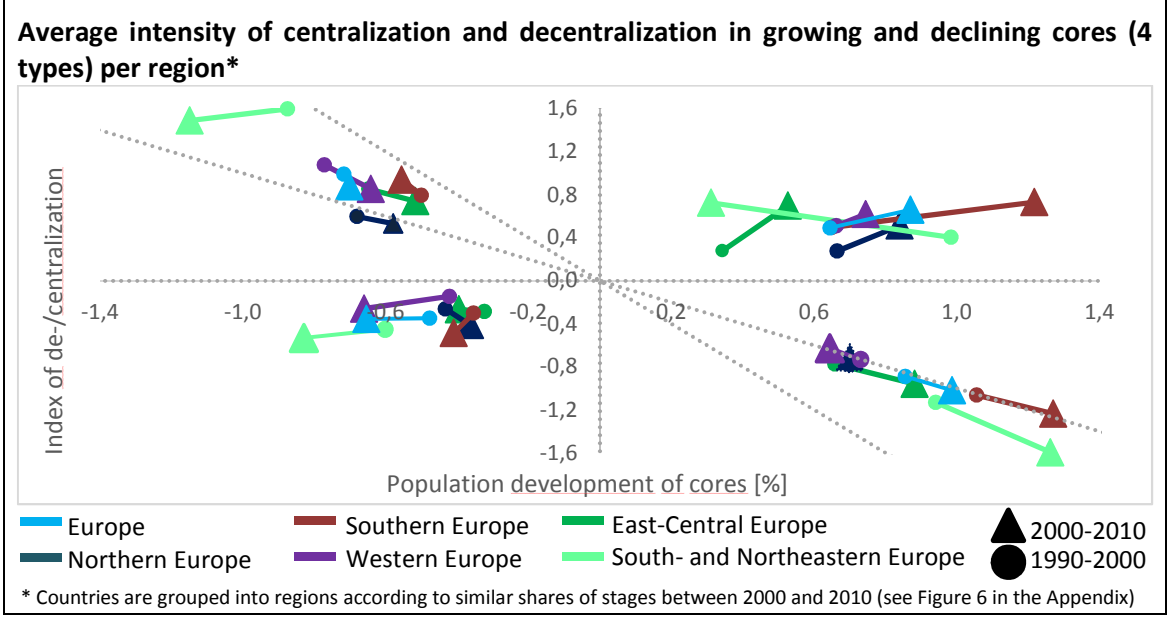


Figure 4: Centralization and decentralization in declining and growing cores – comparison of location and intensity for two decades.

Discussion

The findings presented above characterize the polarization of the urban landscape in Europe after 2000; this ranges between centralization and decentralization among growing cities and centralization tendencies in shrinking ones. This will now be discussed according to the objectives presented above by referring to 1) the paper's main findings and its contribution to the theoretical debate, and 2) to urban policy responses.

1) The large proportion of growing decentralized cities suggests that suburbanization will continue to have an impact on the urban landscape (Conway & Konvitz, 2000). However, because the majority of cities in economically strong regions in Western and Northern Europe rotate between suburbanization and urbanization, the results indicate that the hinterland is urbanizing increasingly (Champion, 2001) rather than following a continuous decentralization trend that ends in population decline, according to the van den Berg et al. model (Cheshire, 1995; Hall & Hay, 1980). Instead, an increasing polycentric pattern is more likely, with continuous urbanization of fast growing cores, which began in the 1980s (Champion, 2001), and variations in the hinterland growth rates. These variations result, first, from mobility decisions that are increasingly influenced by the improvements of infrastructure networks and residential quality in the FUR (Buzar, Ogden, & Hall, 2005; Kabisch & Haase, 2011). Second, the expanding functional connections allow hinterlands and smaller cities to ‘borrow’ some of the agglomeration effects from larger cities, thus leading to increasing competition for knowledge-intensive activities, companies, and, especially, qualified employees between these areas (Camagni & Capello, 2015). Third, the urban orientation of families and young people is also mirrored by a substantial number of basically large cities that moved from shrinkage to growth by benefiting from immigration from their hinterlands.

The increase in urban orientation, accompanied by decentralization tendencies, also occurs at the expense of other cities in peripheral locations but also at the expense of those located closer to the booming cities. Thus, the paper shows that urban shrinkage is a continuing trend and is even speeding up in terms of numbers and growth rates. Thus, the competition between cities plays an increasingly important role as a factor for urban shrinkage and subsequent suburbanization, which used to be dominant in the 1970s in Western Europe and in the 1990s in Eastern Europe (Cheshire, 1995; Kotus, 2006). Although the majority of shrinking cities decentralized, the intensity significantly slowed down in favour of centralized decline with stronger population losses in the hinterland and an unfavourable age structure. However, the speed of these trends and the shifts in age groups make it uncertain that these cities will turn

to growth in keeping with the van den Berg et al. model. First, the strong hinterland decline suggests, instead, a return to decentralized decline, inverse to the model, as soon as the hinterland is 'empty', as is visible in SNEastern Europe. Second, the spatial clustering of declining FURs points to the impact of international migration, leading to increasing numbers of decentralized declining cities in departure countries. Third, out-migration and the absence of immigration give rise to the impact of natural decline, leading to rapid population decline, which is already indicated by the growth rates among centralized declining cities. Thus, it can be concluded that the majority of shrinking cities are locked in a disurbanization stage, with a trend towards centralized decline and a possible turning point that pushes them back to decentralization in the future.

2) The three trends discussed above point to different policy lessons from local to supranational levels. A balanced development between cores and hinterlands is usually seen as a competitive advantage of cities (Hoggart, 2005). As the hinterlands of fast growing cores increasingly urbanize, accompanied by decentralization and suburbanization, local policies of inner-city development are challenged in terms of environmental protection of open space and the provision of affordable housing for current and new residents. This is relevant for centralized growing cities that are continuously urbanizing and especially for those that have seen new growth after a stage of shrinkage (reurbanization), because they have different preconditions, such as high vacancies or brownfields. Additionally, in order to mitigate traffic congestion within the cores, improvements of traffic systems between cities and their hinterland, as part of regional planning, will have to provide new residential quality and profitable conditions for service companies and jobs. However, strong ties between the hinterland and their growing cores are required to avoid decentralization tendencies; these can be influenced by reducing the separation of residences and workplaces or balancing taxes, land, and housing prices in the FUR. This is a major task for decentralized growing cities in Europe. In addition, national decisions and planning regimes need to be adapted according to current trends because they still promote decentralization tendencies (Tosics et al., 2010). Examples are the strong suburbanization trends in France and the Czech Republic or the funding for private housing construction in Germany before 2006. The phasing out of funding, in parallel with investments into cities, led to core regrowth and hinterland decline as in Leipzig or Dresden, which never experienced a disurbanization stage. For other cities with a brief reurbanization period, it needs to be considered whether they will fall back into shrinkage when investments slow down.

Urban shrinkage is persistent in several regions in Europe, but involves different challenges regarding their core-hinterland relationship. Immigration of elderly residents mitigates the

population loss in centralized declining cities, reinforces hinterland decline, and requires the adaptation of the social and technical infrastructure within the cores and the maintenance of the residential and economic attractiveness for the current residents, as the goal of local regeneration. Moreover, the regional redistribution of administrative functions to larger cities needs to be reconsidered because such decisions reinforce shrinkage. Even more challenging is the increasing dependency on external resources and investments that requires answers beyond the local level (Haase et al., 2013). Thus, besides the competition with other agglomerations, decentralized declining cities are increasingly competing with their hinterland in order to attract investments. This pattern of fast declining cores or 'imploding shrinking cities' dominates large parts of Europe, indicating that a massive effort on the national level is required in terms of adapting planning and investment objectives in order to rebalance these uneven trends between core and hinterland decline. While seeking to stimulate growth, regional, national, and supranational policies should not prioritize the hinterland because the cores would face long-lasting hollowing-out, with aging, segregation, and a constant adaptation pressure for the increasingly underused built-up areas. Thus, this pattern contradicts the idea of a compact European city even more than decentralization in growing cities, which requires that supranational policies such as the Cohesion or Social Policy of the European Union need to pay more attention to the current and future patterns of decentralization, especially in shrinking cities.

Conclusion

The van den Berg et al. (1982) model is effective in capturing the current state of urban systems with regard to the dominance of stages. However, the changes between stages are diverse and hardly follow a successive order, without clarity about where the cycle starts and ends (Cheshire, 1995; Buzar et al., 2005; Parr, 2012). By applying a four stage model, which does not assume a consecutive order of stages, the measurement of (de)centralization and shifts of age groups, the paper deals with some drawbacks and provides insights into deviations from the life-cycle model, the speed of changes, and the role of different age groups in terms of mobility, residential choices, and their contribution to natural growth. Nevertheless, the explanatory power of this approach is limited to population redistribution in core and hinterland and does not provide further empirical evidence about elements such as the role of economic factors or the influence of international migration.

The paper describes the increasing polarization of centralizing and decentralizing growing cities and a trend towards centralized decline, all of which require different planning

responses. Besides decentralization tendencies in the heart of Europe, the hinterland is losing importance for both growing shrinking cities but especially for the latter. These trends rarely follow a successive order of urban life-cycle models; instead, they show some self-reinforcing processes, such as aging leading to brief fluctuations between stages, whereas others remain persistent over decades. This requires the extension of life-cycle models, as the paper has demonstrated, as well a redefinition of cities' role for their hinterland in terms of political and planning priorities. In order to understand these processes, these investigations have detected decentralizing and recentralizing tendencies among growing and shrinking cities and they emphasize that cities are not isolated territorial containers but, rather, have interrelationships with their hinterland and require responses that do not stop at the cities' administrative borders.

Notes

1 We use the terms shrinking urban area and shrinking city interchangeably; urban shrinkage refers to the process measured by population decline.

2 The FUA-IGEAT and the Larger Urban Zones (LUZ), as part of the Urban Audit, cover large cities, but cross-country flows of commuters, with which the hinterland is defined, are not available, providing a relatively selective picture (ESPON, 2014a).

3 In regional analysis, the term “(de-)concentration” is used for changes in spatial structures. However, in order to be consistent with urban life-cycle models, which describe changes within FUR, we use the terms “centralization” and “decentralization” (Parr, 2012; Champion, 2001).

4 In total, 1620 urban areas significantly switched to another stage, 1473 remained in their stage, and 2599 showed a stable evolution in either their core or their hinterland.

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Appendix

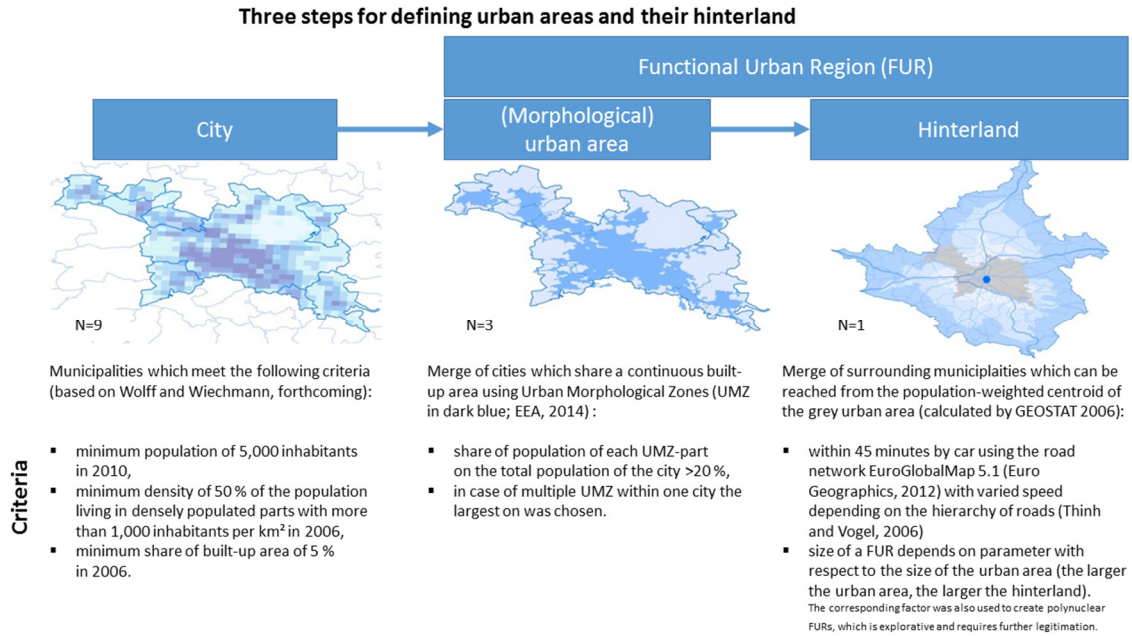

Figure 5: Delineation of FURs (author's own work).

Number of cities per stage 1990-2000 and 2000-2010 according to the life cycle model of van den Berg et al. (1982)

Stage 1990-2000	Stage 2000-2010								
	REU2	URB1	URB2	SUB1	SUB2	DIS1	DIS2	REU1	Total
	Core growth to core growth				Core growth to core decline				
Reurbanization with absolute centralization (REU2)	21	19	16	4	3	3	13	19	98
Urbanization with absolute centralization (URB1)	14	23	34	13	6	3	13	11	117
Urbanization with relative centralization (URB2)	15	29	620	335	28	7	30	36	1,100
Suburbanization with relative decentralization (SUB1)	5	7	318	572	46	15	46	26	1,035
	Core decline to core growth				Core decline to core decline				
Suburbanization with absolute decentralization (SUB2)	4	0	19	64	31	13	21	6	158
Disurbanization with absolute decentralization (DIS1)	2	0	10	25	30	10	24	16	117
Disurbanization with relative decentralization (DIS2)	4	2	11	10	9	22	100	78	236
Reurbanization with relative centralization (REU1)	10	4	11	6	10	16	79	96	232
Total	**75**	**84**	**1,039**	**1,029**	**163**	**89**	**326**	**288**	**3,093**

Adapted four-stage model
- centralization in growing cores
- decentralization in growing cores
- decentralization in declining cores
- centralization under in declining cores

Characterization of stage changes
- contrary to model
- in line with model
- inverse trend
- contrary to model (faster)
- in line with model (faster)

Figure 7: Frequencies of stage changes.

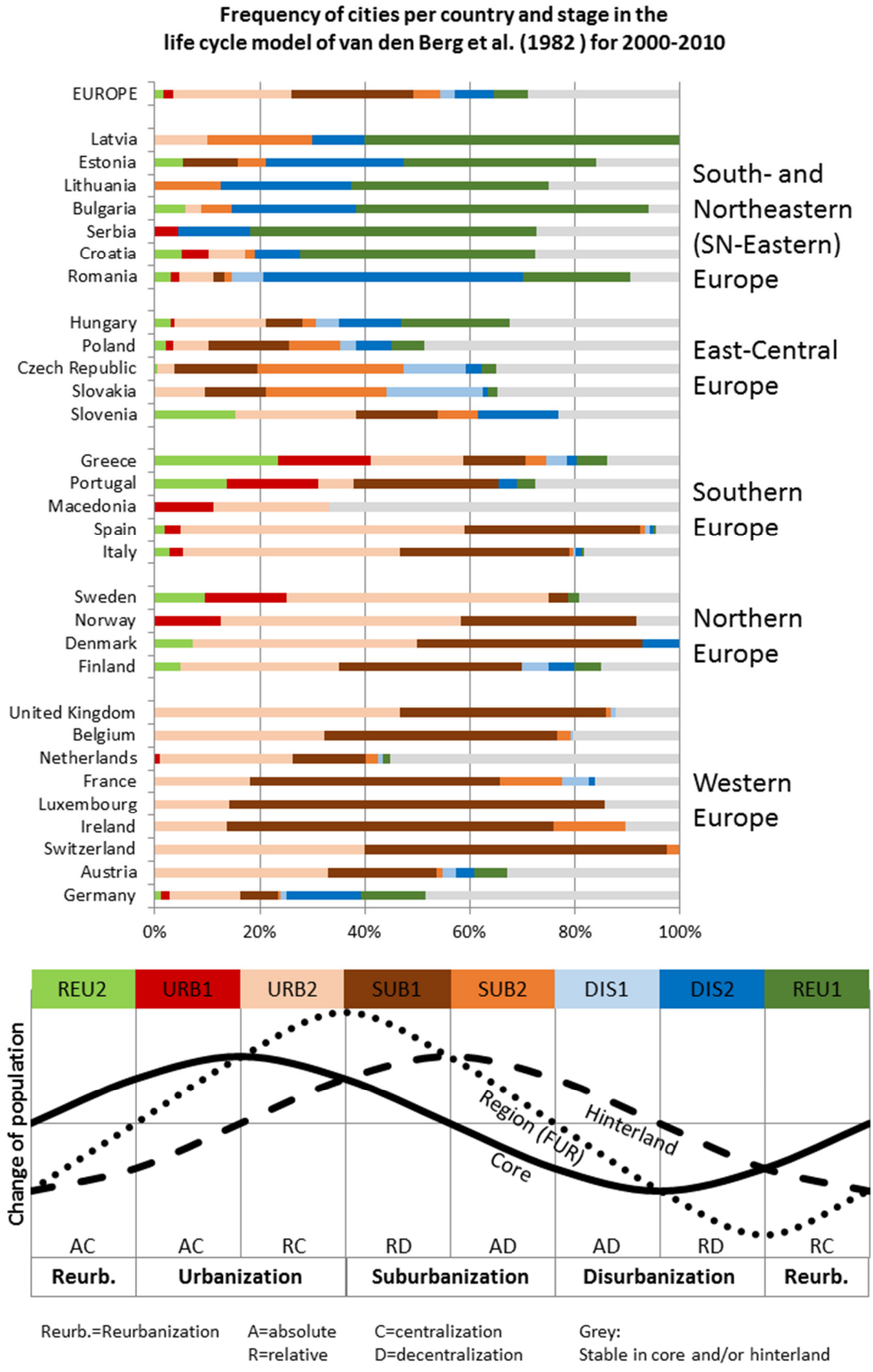

Figure 6: Frequencies of cities per stage and country.

4.4 Compact or spread? A quantitative spatial model of urban areas in Europe since 1990

Paper 4: *Manuel Wolff, Dagmar Haase, Annegret Haase*

Compact or spread? A quantitative spatial model of urban areas in Europe since 1990.

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RESEARCH ARTICLE

Compact or spread? A quantitative spatial model of urban areas in Europe since 1990

Manuel Wolff[1,2]*, Dagmar Haase[1,3], Annegret Haase[2]

1 Department of Geography, Lab for Landscape Ecology, Humboldt Universität zu Berlin, Berlin, Germany, **2** Department of Urban and Environmental Sociology, Helmholtz Centre for Environmental Research – UFZ, Leipzig, Germany, **3** Department of Computational Landscape Ecology, Helmholtz Centre for Environmental Research – UFZ, Leipzig, Germany

Introduction

The concepts and discussions about the direction and dynamics of urbanization, such as growth or shrinkage, have one issue in common: They deal with the relationship between built-up areas in urban areas and the population concentrated in them. Or, in other words: about urban population density. This paper aims to improve the understanding of residential density changes, called density changes in the following, in urban areas by comparing European countries during the very dynamic, recent period between 1990 and 2010.

Ongoing land consumption and sprawl at the edge of European urban areas contradicts the preferred planning normative of the `compact city' [1,2] and, instead, leads to `donut cities' as a consequence of a hollowed-out core and a growing hinterland [3,4]. Studies have shown that sprawl is strongly linked to either increasing per capita land consumption, driven either by income growth of households and of the national GDP [5] or by the availability and price of land [6]. The comparatively low costs of car-based mobility mean that those urban areas that are growing faster and expanding are experiencing an exodus of people and jobs to their hinterland [7,8]. The effects are decreasing densities that are most commonly described as dedensification or `deconcentration'. Contrary to this sprawling development, a new, return flow of small and high-income households targeting (inner) cities is driving a novel (re)growth and (re)densification of the urban area, overcoming patterns such as donuts or urban perforation [9,10,11,12], which, in turn, means new `concentration' within the city borders.

Both deconcentration and (re-)concentration belong to urbanization and the respective population density concentrated in the urban built-up area. These changes of density are an important issue in urban and land-use research [13,14,15] and one major aspect of the global sustainability discussion [16], because it provides evidence on how much land and resources dedicated to this land are taken by urban dwellers, relative to their number. This can be linked to human quality of life and the ecological footprint of this quality of life [17], because urban areas may use more or less primary resources or be more or less efficient in resource use when maintaining a defined threshold of quality of life for their residents [18].

Therefore, assessing residential density changes is essential for evaluating land consumption, the conservation of natural capital and ecosystems, air quality and related health problems in cities, and the corresponding challenges for urban and regional planning [19]. In this respect, residential density is a simple but powerful indicator for urban growth/decline [20], the patterns that these trends reveal for the city, and how they change over time [21,22,23,24,25].

To date, a range of studies has provided valuable insights into the expression of various indices, to describe concentration and deconcentration in European cities; these include

continuity and centrality, clustering and nuclearity, concentration and density [26,27]. Thereby, residential density is regarded as a powerful indicator for urbanization because it reflects the relationship between the supply of built-up area and the demand for it by a certain number of people [28]. Basically, there are three categories of studies that have dealt with residential density. In the first category, density is used to define and delineate territories, e.g., differentiating between urban and rural areas [29], defining specific areas [30], or distinguishing between different degrees of the urban character [31]. The second category, uses residential density to describe and compare urban systems, such as those found in Europe and the US, from a historical [32], spatial [33,34,35], or socio-demographic perspective [36]. In the third category, density is be used to describe processes and phenomena of urban evolution [37]. Deconcentration and dedensification can be parallelized at least to a certain extent with what we know as `urban sprawl' [7], a phenomenon that has been extensively studied in the US [38, 39,40,41,42,43] but also globally [6,14,44,45]. In Europe, in addition to sprawl and in accordance with what happened in the US from the 1960s to 1980s, the well-known concept of the `in-between city' (Zwischenstadt) - something in between `the urban' and `the rural' - has also been discussed [46,47]. Sprawl was studied in Europe basically by focusing on particular regions or even cities [48,49,50,51,52], but recent studies have started to pay more attention to a cross-country comparative perspective that covers a range of cities [5,20,53,54,55,56,57,58].

Thereby, density was used to study spatial patterns of European cities, using geo-spatial indices and landscape metrics [53,59], in order to identify factors that influence the multidimensional character of sprawl [5] or to explore the relationship between urban sprawl and a set of variables by testing urban economic theories [54]. Similar to a comprehensive study on understanding urban land-use changes in European countries, conducted by Siedentop and Fina [55], Kasanko et al. [20] understand urban density as a measure of land-use intensity. The authors used an indicator framework that led from basic land use indicators to population density measurements and, finally, to a combined analysis of population densities and landuse intensity. There is a long tradition [60] of using density as an indicator in order to measure the compactness and intra-urban population distribution using a population density gradient starting at the city centre and following a negative exponential [61,62], quadric exponential [63] or power function [64]. However, these models mostly aim at testing the fit of the distribution and provide explanations of density changes over space rather than over time (e.g. [65]). Yet other studies have specifically focussed on typologies of urban development in Europe. Based on the prevailing characteristics of land-use changes at the regional level, the LUPA project defines three main types of cities (with slow, rapid, and very rapid growth) that

are, amongst other features, also characterized by a ratio of built-up area to population [66,67]. To our knowledge, a typology developed by the Netherlands Environmental Assessment Agency is the only study that specifically combines density changes with (rapid) population growth/decline, in order to identify and assess urbanisation patterns [68,69].

An impressive picture of density changes for major cities across the globe was drawn by Angel et al. who applied models that explain variations in density [6,7,70]. At the core of their model, the authors plot the density of built-up area for one time period against the density of another period, as shown in Figure 1 [6]. They demonstrated that population growth leads to deconcentration and dedensification in cities across all continents, including Europe, as urban land area expands faster than the population grows [7,17]. Angel et al. [6] emphasized that urban densities generally decreased and will continue to do so in the future. Although this model makes it possible to draw conclusions only about quantitative aspects of density changes, it has, compared to other concepts, three basic advantages:

- Although Angel et al. [7] focused on urban expansion or sprawl, the process-oriented characteristic of the model also allows the study of concentration processes, thus providing the opportunity to test hypotheses about driving forces with tools such as independent t-tests.
- At its core, the model uses changes of built-up area density, which represents ªthe most robust measure of urban expansionº and reveals whether a city is developing in a more compact way and with less sprawl than other cities [70]. Although density changes fall short in describing sprawl in all its dimensions, they still represent a meaningful and illustrative reference for, e.g., policy consultations. Density changes provide a relatively comprehensive characterization of urbanization processes that can be further elaborated and analysed systematically.
- The authors graphically illustrate the density changes with a diagonal line that shows where the density in two periods is exactly equal. This also allows the creation of subsamples with respect to city size, to location in developed and developing world, or to population growth or shrinkage. Furthermore, it easily reflects the amount of density change, thus enabling conclusions about the intensity of the process to be drawn [20,55].

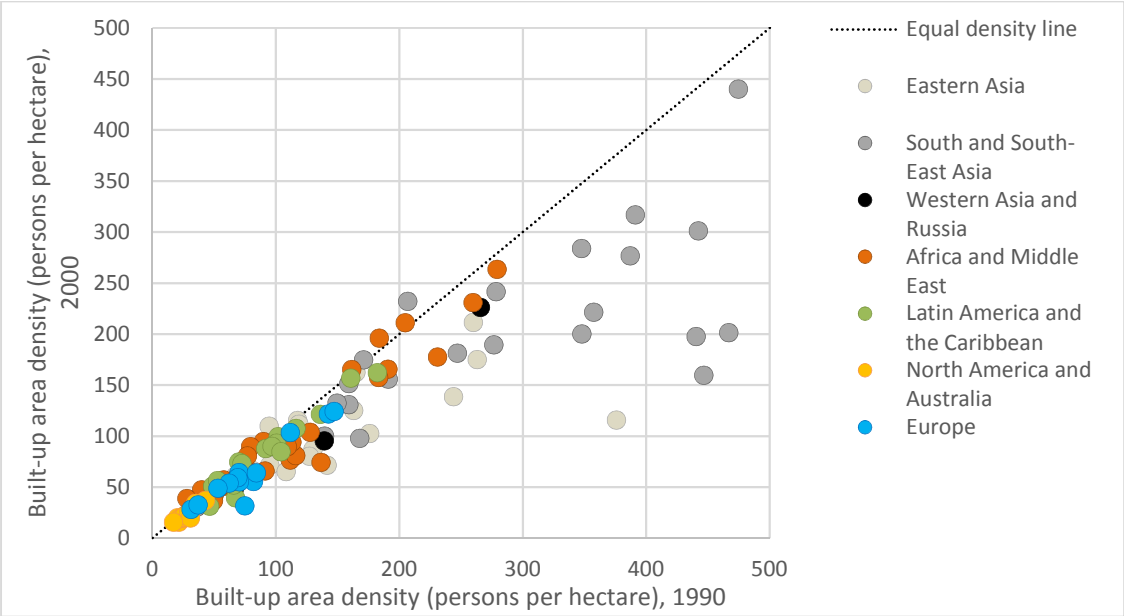

Figure 1: Development of average density in built-up areas, in a global sample of 120 cities, 1990–2000 (Data obtained by [7], figure inspired by [6]).

However, only a few studies use density (change) as a key indicator to characterize urbanization processes [6,9] and, despite the large variety of the studies mentioned above, our knowledge about urban (de)densification is limited for the following reasons:

(a) First, many studies focus on declining density and discuss urban sprawl or scattered urbanization [53,54,55,71]. Thus, they poorly reflect the uneven dynamics of simultaneous population growth and shrinkage in cities. Europe, in particular, is the continent where most shrinking cities can be found [72], including urban land abandonment and land use perforation as a consequence of post-industrial land use changes and demographic ageing [10,73,74]. Besides shrinkage, a considerable number of cities in Europe have experienced recent reconcentration processes [11,12]. Thus, different density pathways have to be expected [9,20].

(b) Second, there is still a gap between observation and theory. Although theoretical considerations are predominantly based on economic models of urban spatial structure [75,76,77,78,79] a theory that explains density changes of urban areas is not fully developed [7]. Several authors emphasize that the basic drivers, such as physical, demographic, economic, technological, and political factors, only explain density changes to a certain extent [6,17,41]. In particular, the role of population growth as an explanatory factor is not clear [17,54]. Thus, further investigation of the relative contribution of density change (mean population and residential area) is required in order to fully understand the specific conditions under which European cities are developing [7,54].

(c) Third, the explanatory power of the studies discussed above is restricted to large cities, thus providing a rather selective picture of the urban hierarchy [17] and underestimating the importance of small and medium-sized urban areas. This is, on the one hand, due to limited data availability, especially for small-scale and comparable population data covering different points in time [5,80]. On the other hand, all concepts of urbanization are somehow confronted with a heterogeneous set of definitions of what, across Europe, an urban area is [80]. However, a large segment of the urban population in Europe lives in small or medium-sized urban areas, which play an important role in terms of economy, service and infrastructure provision, or the well-being not only of their own inhabitants but also of the rural populations surrounding them [81]. Thus, also considering small cities is important for analysing the balanced spatial development and cohesion of the European territory, and also in terms of their different expressions of density changes [5,7,74].

Against this background, this paper presents an analysis of recent urbanization in Europe, with a focus on both deconcentration and concentration with respect to population growth or decline, taking into account small and large urban areas. Due to its advantages, we use the density change model developed by Angel as the starting point of our analysis. This will then be extended by drawing attention to differences between growing and shrinking urban areas in Europe that have experienced physical de- and (re)concentration during the very dynamic period between 1990 and 2010 [53,55,74]. Europe has been chosen because it displays urban growth and shrinkage that is combined with the world's strongest demographic aging tendencies. These processes justify the relevance of our current analysis that were, however, hardly reflected in the model of Angel et al. [6,7]. This allows us to evaluate the relative contribution of the factors contributing to density change and to discuss the approach of Angel et al. An extended discussion of density change under conditions of growth and is also crucial for supporting policy makers who decide on infrastructure adaptation or modes of governance. Set against this background, the paper does not aim to explain sprawl but rather to improve the understanding of changing residential density that depends on growth and shrinkage by answering the following questions:

- Are residential densities in urban areas across Europe generally declining, as the model of Angel et al. [6] suggests?
- To what extent do we find differences in density change between growing and shrinking cities, as well as between small and large ones? And,
- Which driving factors might explain the observed trends?

Materials and Methods

Residential density, as a measure of land-use intensity, is not an easily interpretable concept [42]. For measuring densities the paper uses the term `urban areas' in line with other authors [20], in order to reflect a conurbanisation covering several municipalities, on the one hand, and to avoid confusion about the different terms used in different countries, e.g., cities, towns, agglomerations etc., on the other. We built on the model of Angel [6,7] to calculate density changes in urban areas but extended it in two ways to address the prevailing shortcomings of other concepts. First, we developed an approach for delineating urban areas and, second, we extended the measurement concept in order to reflect on the relative contribution of the components of density changes. The paper uses `residential density', calculated by total population per residential area. This has clear advantages compared to the concept of net-density [82,83], allows comparisons to other studies [20], allows to detect reuse [84] and focuses on the area for residential housing a city requires for inhabit their residential population whereas taking into account further land uses such as industrial areas would to some extend blurs the conclusions on the relation between residents and their available housing.

In order to delineate cities, Angel et al. [6] focused on (morphological) urban areas, which are used when studying land-use patterns and for analysing the planning of infrastructure systems. This morphological approach increases the comparability between municipalities which vary in size and shape by merging administrative units, based on a continuous built-up area and summing up the population number of the merged administrative units [6,7,55]. In Europe, essentially two cross-country databases are available: the Morphological Urban Areas (MUA), which was created in 2007 and updated in 2011 by IGEAT, and the Urban Morphological Zones (UMZ), created by the European Environmental Agency in 2002. The MUAs are defined for the reference year 2001 basically by selecting the most densely populated municipalities (LAU2) with more than 650 inhabitants per km2 and with a minimum population exceeding 20,000 inhabitants [85]. The database comprises 1988 units in 29 countries (EU27, Norway and Switzerland). The UMZs are composed of continuously built-up areas which is derived from Corine Land Cover [86,87], containing "urban fabric" (continuous or discontinuous), "industrial commercial units", "green urban areas", certain forest spaces, and port areas; airports, sports and leisure facilities, and road and rail networks (for more details about the construction rules, see [87,88]). This results in approximately 4300 units with a minimum population of 10,000 inhabitants covering 29 countries (EU28 and Liechtenstein). However, both databases are of limited use. The population data provided for MUAs show some gaps and some results for the smallest units should be interpreted with caution. Whereas MUAs focus on large cities and

tend to over- or underestimate the actual cover of built-up area (see Figure 6 in annex), UMZ units lack time series of population data and are not applied to administrative units. However, this aspect is necessary in order to compare the units with Angel's approach and also because policies at the administrative level may also influence the evolution of cities [66].

Thus, we ***developed an approach for delineating urban areas*** that covers small to large urban areas. Thereby, we used the strengths of the UMZ database and combined it with an approach developed by Wolff and Wiechmann [89], which defined municipalities (LAU2) as cities according to OECD-EC guidelines using a minimum population, density and share of built-up area [31,90]. Figure 2 shows that morphological units are delineated by merging the defined cities with their adjacent non-urban municipalities, based on the rules developed for the Dictionary of Correspondence LAU2/UMZ [88,91]. This approach results in 5,692 (morphological) urban areas in 35 European countries. Table 3 in the annex provides some basic indicators for these countries. A comparison of the median values of population size and surface of residential area (urban fabric) reveals that the units are comparable among European countries (Figure 7 in annex). However, it has to be noted that the low densities in the Scandinavian countries, Bulgaria, and Serbia are basically due to the relatively large units. A selective picture of large urban cities is only obvious for the United Kingdom and Lithuania and needs to be considered when interpreting the results. However, as the number of urban areas is low, the overall picture of the results is not distorted.

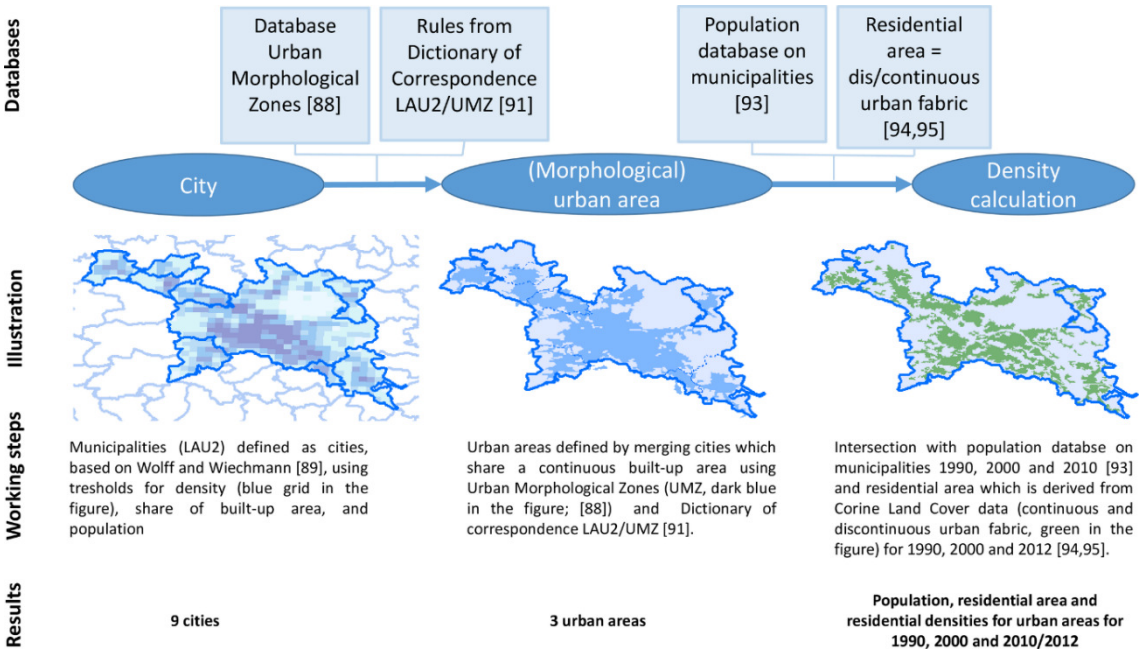

Figure 2: Workflow of the approach.

Densities were measured as the ratio of the total urban population and the total residential area [37,41,42,43,92]. Angel et al. [6,7] used the total built-up area but in line with Kasanko [20] we used the residential area in order to better mirror population concentrated in their residential areas. In contrast to net or urban density, the values of residential densities are usually larger as the same population size is referred to a smaller reference area (residential instead of total built-up area, see also [7] p. 39). In order to exclude fluctuations, a change in the resident population and built-up area exceeding 1% was registered. Population numbers were derived from a database of population Figures for municipalities for 1990, 2000 and 2010 [93] that had been linked to the urban areas (Figure 2). Residential area was obtained from Corine Land Cover data for 1990, 2000 and 2012: we used continuous and discontinuous urban fabric as the residential land uses [94,95]. In line with other studies [20,54,55,59], Corine was chosen because it is, currently, the most recent source providing residential landuse data also for very small areas, whereas UMZs provide data for the entire urban built-up area, also including industrial areas, and only for units of more than 10,000 inhabitants. It should be noted, however, that urban areas smaller than 25 hectares especially in rural areas are not covered and thus urban area is under-represented compared to the official statistics [67,96,97].

Due to the unambiguous relationship between growth of population and residential area [17,80], we applied an ***extended measurement concept*** for density changes, by investigating the relative influence of changes in the population and the residential area, in order to draw conclusions about the underlying driving forces (Figure 3, for details see [9]; similar considerations also in [20]). Changes in residential area reflect the changing physical extent of the urban area and allow the discussion of phenomena such as sprawl, whereas population allows one to set these cities into the context of the debate on growing and shrinking urban areas.

As Figure 3 shows, both a change in population and/or residential areas can result in changes in density. For declining population numbers in urban areas, densities most probably decrease, leading to an oversupply and underuse of urban land and the associated demolition of buildings [98]. However, if the rate of the demolished area exceeds the rate of population loss, due to, e.g., the demolition of large prefabricated buildings, densities can also increase (compact shrinkage). Furthermore, some studies even show an extension of residential areas (e.g., newly built houses) although population numbers have fallen, leading to a paradox situation with increasing densities in other words: sprawl under conditions of shrinkage [4,80].

Increasing densities are usually associated with compact population growth, infill, and new residential areas, which may encourage savings in operational costs for public services, such as schools and water/wastewater utilities [50]. In particular, a constant physical expansion of a city, with newly built housing, can even lead to decreasing densities, which is a common characteristic of many cities worldwide, leading to sprawl-like growth [7,98]. The consequences are longer commuting distances and less access to public transport, resulting in a greater use of private cars [99,100]. In contrast, in urban areas experiencing new growth, in particular, densities can increase without an expansion of the built-up area [101,102], even in the context of ongoing demolition of some decayed buildings, due to reuse and renovation of the existing housing stock that was previously vacant and is now absorbing the increasing demand.

In accordance with other studies, we used population as a common indicator for urban dynamics, in order to define shrinking urban areas by a population loss of more than 0.15% p. a. (and vice versa for growing cities) [74,103,104], and to distinguishing between large and small urban areas, using a threshold of 100,000 inhabitants, in order to allow comparisons with studies by Angel and others [6,7,81]. Thereby, we applied t-tests that investigated differences between growing and shrinking as well as large and small urban areas in terms of their density changes.

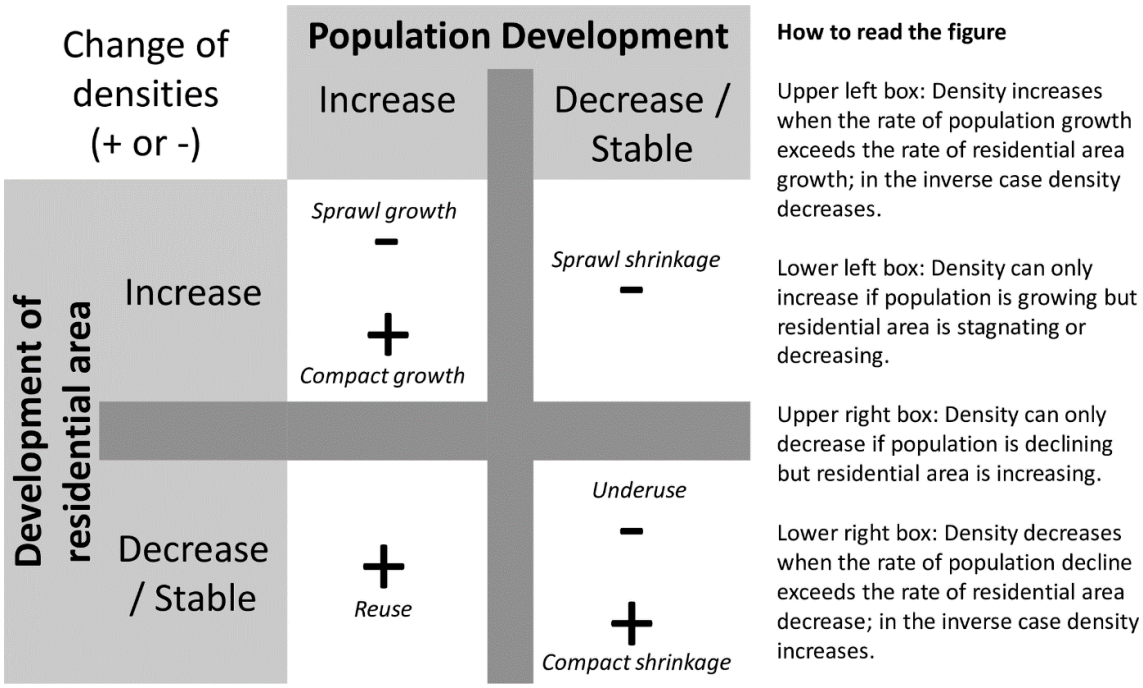

Figure 3: Operationalisation of population density changes under different outcomes of urban population development and built-up areas [9].

Results: Density changes in Europe

Comparing changes in population, built-up areas, and density

In line with other studies, urban growth is prevalent in Europe; approximately 70% of all urban areas experienced population growth between 1990 and 2010 (Table 4 in annex; [73]). Although one third of all urban areas (29%) experienced population loss over the same period, we only observed a significant reduction in residential area for just 9% of all urban areas. Moreover, although the residential area of 76% of all urban areas increased, density decreased in almost 40% of urban areas, therefore reflecting deconcentration. Thus, we need to focus on the extent to which deconcentration and dedensification are universal for growing urban areas. We applied the model of Angel et al. [6,7,70] for the periods 1990±2000 and 2000±2010 and differentiated between growth and shrinkage, as well as between small and medium-sized (<100,000 inhabitants) and large (>100,000 inhabitants) urban areas, because Angel analysed larger ones.

In the decade from 1990 to 2000, growing urban areas experienced the most rapid density changes (Figure 4), especially in very dense urban areas (>100 inhabitants/hectare). In line with Angel et al. [6,7], we found sprawl and dedensification among growing European cities. During this period, however, two other processes emerged: On the one hand, all shrinking urban areas contributed to this dedensification process. On the other, a substantial number of growing cities also exhibited increasing densities with, however, very low rates of density change (Table 1).

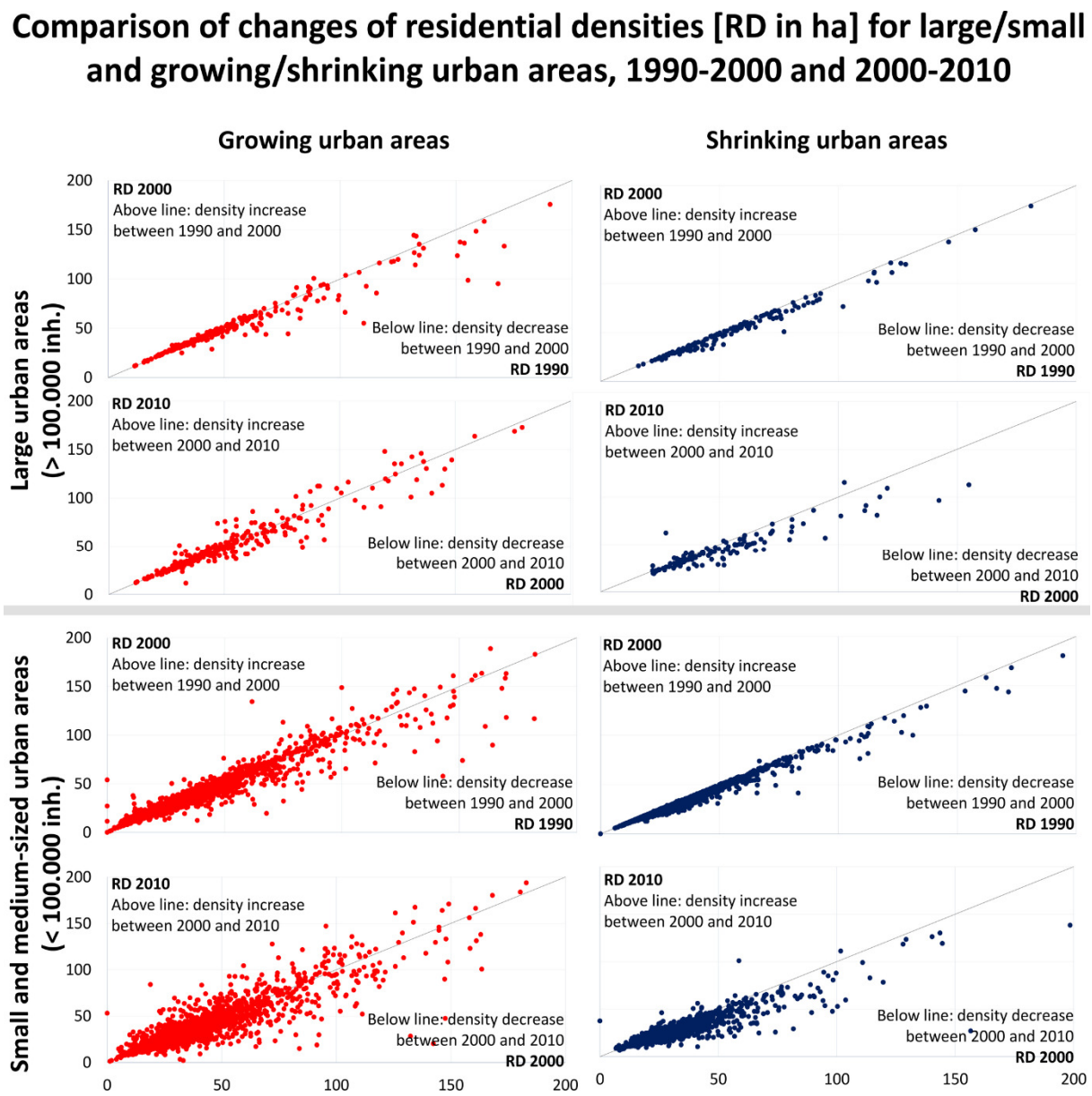

Figure 4: Density changes 1990-2010 for large and small urban areas.

After the year 2000, we observe three parallel and accelerating trends: dedensification in growing as well as shrinking urban areas, and densification in growing urban areas.

The trend of decreasing densities was reinforced because the number of ***growing and dedensifying urban areas***, as well as their density change rates, significantly increased (numbers increased by 66%; change rates by -33% points; Table 1) in both small and medium-sized as well as large urban areas. This is in line with other studies, which underline that urban sprawl is most likely to continue, resulting in less compactness [6,19,20]. Although population rates are generally increasing more slowly in larger than in smaller dedensifying growing urban areas [20], there is very little difference between small and large or between dense and less

dense urban areas, in terms of density change rates, which contradicts the findings of Angel et al. [7] to a certain extent.

Apart from these findings fast, ***shrinking urban areas*** contribute to this dedensification process in both periods with rates exceeding those of growing urban areas. This can be observed especially among less dense urban areas (<100 inhabitants per hectare), but the denser a shrinking urban area is, the more likely it is to follow a decreasing density change (Figure 4). This dedensification process in shrinking urban areas shows similar values, on average, to growing ones, although they experience a gain in the population at a faster rate than shrinking urban areas experience a fall in the population (Table 1). Although the number of shrinking cities increased (from 29 to 36% between the two periods; see Table 4 in annex), the number of dedensifying shrinking urban areas decreased after 2000, because of a new phenomenon. A substantial number of urban areas experienced a very rapid increase in densities, despite the fact that population numbers were still falling significantly overall. As a consequence, we observed a trend towards more compactness in the context of shrinkage in both large as well as small and medium-sized urban areas.

The third trend mirrors a concentration, or the ***densification of growing urban areas***, which was already observed before 2000. However, the average change in density rates of these urban areas increased significantly between 2000 and 2010 and even exceeded those of dedensifying growing urban areas (Table 1). Moreover, after 2000, a significantly increasing polarization between large and small urban areas is obvious. Whereas the number of growing, densifying urban areas with less than 100,000 inhabitants decreased, their number in more populated areas substantially increased. The f-test revealed that differences in density change rates between growing and declining large urban areas decreased and even reached a non-significant level, which actually points to a reinforced densification process (Table 1). We can say, with 95 percent confidence (significance _ 0.05), that, on average, density changes differ by 9.58% between growing and shrinking urban areas between 2000 and 2010. In contrast, the differences between growing and shrinking small urban areas increased significantly as the result of simultaneous population growth and decline and associated densification and dedensification processes in these small and medium-sized urban areas. This is in line with previous studies that demonstrated a redensification of several European cities [20].

Table 1: Frequencies, average changes for four types of density changes and f-tests for differences between growing and shrinking urban areas.

	All Urban areas		Large urban areas		Small and medium-sized urban areas	
	1990-2000	**2000-2010**	**1990-2000**	**2000-2010**	**1990-2000**	**2000-2010**
Absolute frequencies (Frequencies can vary because a threshold of +/- 0.15 % was applied for changes both in densities and population.)						
growth/dedensification	1,028	1,766	124	149	904	1,617
growth/densification	2,704	1,642	120	137	2,584	1,505
shrinkage/dedensification	1,568	1,162	156	74	1,412	1,088
shrinkage/densification	6	767	0	58	6	709
Average values of density changes [%]						
growth/dedensification	-8.6	-41.1	-8.4	-37.9	-8.6	-39.8
growth/densification	8.1	113.5	3.5	92.7	8.3	107.8
shrinkage/dedensification	-6.8	-40.6	-7.0	-40.3	-6.8	-38.5
shrinkage/densification	3.7	78.2		75.6	3.7	68.7
F-Test for differences of density changes between growing and shrinking urban areas						
F-Value	**0.12**	**6.5**	**5.69**	**2.42**	**0.05**	**9.58**
Significance	0.73	0.01	0.02	0.12	0.82	0.00

Typology of density change

Whereas the previous chapter bridges the results of Angel et al. [6,7,70] with an in-depth continental sample and identifies three basic density change trends, this chapter investigates how successional shrinkage and (re)growth have an impact on density change. Therefore, we apply the extended measurement concept and shed light on the underlying dynamics of density changes by focusing on the contribution of changes in the population and in residential areas.

Dedensification and deconcentration are basically driven by the disproportionate development of physical expansion and population development that involve two phenomena: ***extended urban sprawl and sprawl without growth***. First, the phenomenon of urban sprawl or deconcentration, which was already described by Angel et al. [6], counts for more than one third of urban areas; their corresponding share increased from 34% prior to the year 2000 up to 37% between the years 2000 and 2010. Table 2 reveals that, in an increasing number of European urban areas, including small and medium-sized as well as larger ones, residential areas increased faster, in relative terms, than population numbers (leading to sprawl). The share increased markedly in those countries with existing extensive urban sprawl, such as Portugal, Greece and France, or remained high in the Netherlands, Spain or Italy. Second, the disproportion between an expanding built-up area but declining population numbers led to the paradox of shrinking urban areas contributing to the dedensification process (sprawl

shrinkage), which was not covered in Angel's model [6,7]. The data presented in Table 2 show that every fifth urban area follows this sprawl without growth and that the percentage even increased (from 22% to 27%), especially among small and medium-sized urban areas, and fell among larger ones. The percentage of these urban areas with `sprawl-without-growth' dominates in post-socialist countries, e.g., the Baltic States, Poland, the Czech Republic, and increased not only in Serbia, Slovakia, and Croatia but also in Germany. In Western Europe, however, the percentage of urban areas of this type was high before the year 2000, e.g., in Italy and France.

Table 2: Frequencies of urban areas with density changes (+/- in heuristic) in different constellations of changes to the population and residential areas.

	Frequencies *(relative)*		Frequencies *(absolute)*		Heuristic of density changes			
							Population development	
							Increase	*Decrease/Stable*
1990 to 2000	34.3%	22.3%	1,047	680	**Development of residential area**	*Increase*	**+** Sprawl growth	**-** Sprawl shrinkage
	40.5%		1,237				**-** Compact growth	
	2.0%	0.2%	60	7		*Decrease /Stable*	**+** Reuse	**-** Underuse
		0.7%		22				**+** Compact Shrinkage
2000 to 2010	37.2%	27.0%	1,919	1,395	**Development of residential area**	*Increase*	**+** Sprawl growth	**-** Sprawl shrinkage
	17.7%		916				**-** Compact growth	
	9.2%	4.5%	476	231		*Decrease /Stable*	**+** Reuse	**-** Underuse
		4.4%		225				**+** Compact Shrinkage

Whereas, between 1990 and 2000, the residential area was hardly reduced in any urban area but, instead, expanded (Table 4 in annex), in more than 4% of all urban areas we observed a `physical adaptation' in terms of decay and ***demolition of buildings, leading to decreasing densities*** (underuse, 4.5%). The decline in densities caused by these demolition activities is another trend that is not covered by the model of Angel et al. [6,7,70] but it shows that population loss occurs faster than the adaptation of the physical infrastructure. This trend is observed in Bulgaria and Romania but also in peripheral regions of the Baltic States, Austria, or Slovakia. Furthermore, in terms of large-scale demolition programs, such as in (Eastern) Germany, the rate of demolition can even exceed the rate of population loss, leading to the paradox of increasing densities in shrinking urban areas, especially in those urban areas that had already lost a substantial number of residents before demolition started [9]. This type of `right-sizing' or compact shrinkage accounts for 4.4% of all urban areas and is also associated with the reduction of residential areas for infrastructure, commercial, or residential purposes through conversion to other forms of land use such as parks [105], which - in absolute

numbers - is particularly visible in Germany. High shares can also be found in Bulgaria and Romania, as well as in Serbia and Slovakia.

Apart from this, ***densification processes*** are a characteristic of growing cities. A large number of urban areas reflect rising residential densities due to a rapid increase in the total population, indicating the emergence of `compact growth' with a lower per capita flat area, compared to sprawling urban areas. This trend can be observed particularly in Norway and Sweden, as well as in Belgium, the UK, Switzerland or Northern Italy. For Europe in general, however, the percentage of urban areas displaying this trend decreased substantially from around 40% to 18%±especially in small urban areas e.g., in France, Greece, Germany, Austria, and Slovakia, in favour of sprawl (or slower population growth). In contrast, a new phenomenon can be observed that characterizes cities with renewed growth, in particular [9]: density increase in growing urban areas without an expansion of residential areas. A stable or even slightly decreasing amount of residential areas can be measured as a consequence of the refurbishment of large parts of the housing stock that used to be vacant (reuse). Overall, we find this kind of densification in a large number of European urban areas after the year 2000 (10%); it is a clear sign of regrowth, which has been discussed as reurbanisation or urban resurgence in the scholarly literature [12,106,107,108,109]. Figure 5 shows that renewed growth in urban areas does not represent a major trend in any country or shows characteristic spatial concentration in regions. However, it is important to realize that this is an emerging phenomenon of increasing importance for Europe [73] and that it predominantly characterizes large urban areas, such as those in Germany, the UK, or Spain, and can even be found in post-socialist European countries that used to belong to the `pole of shrinkage' in the 1990s and 2000s.

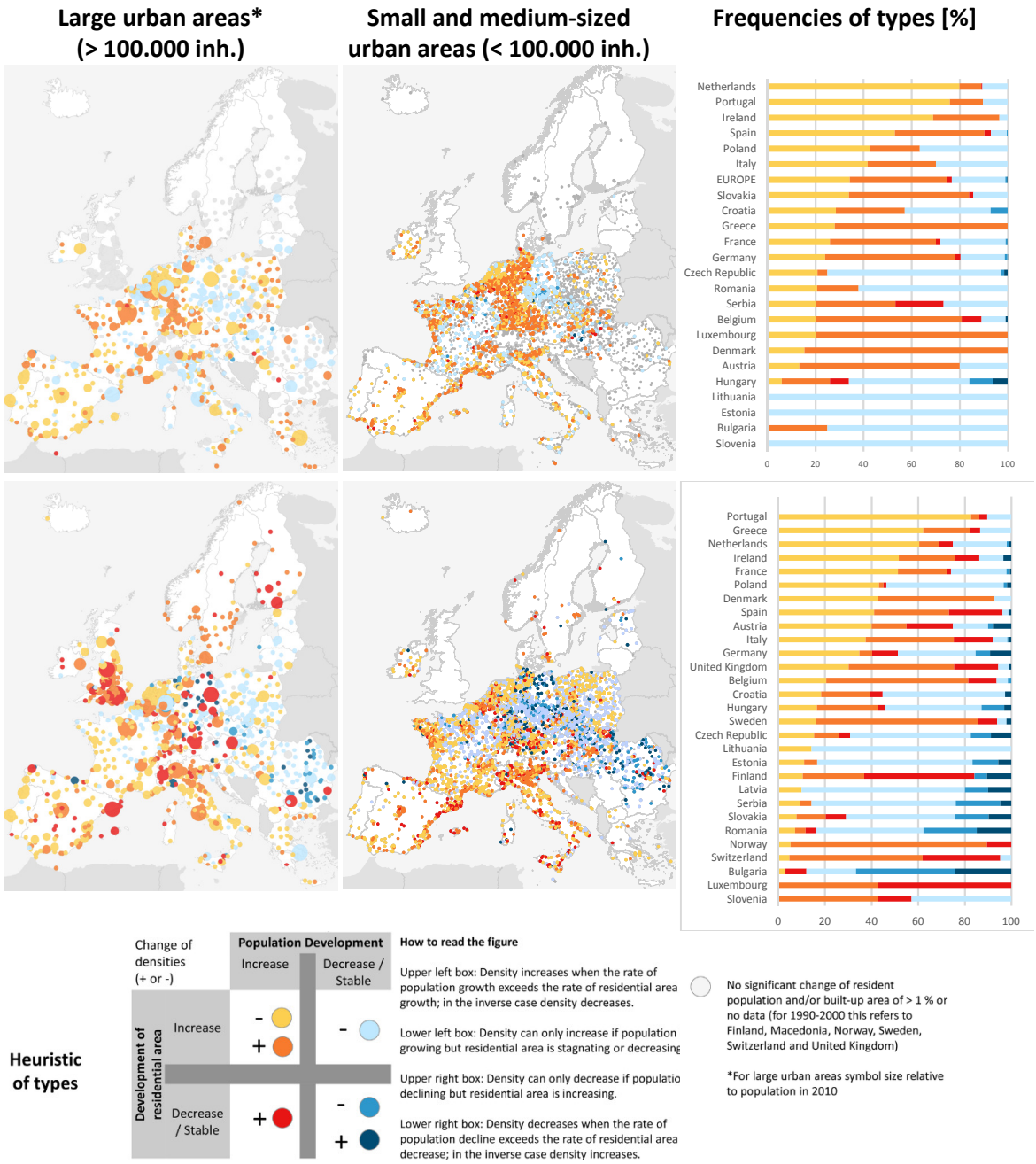

Figure 5: Spatial distribution and frequencies of density change patterns.

Discussion

To discuss our results, we return to our three initial research questions.

Are residential densities in urban areas across Europe generally declining, as the model of Angel suggests?

In several European urban areas, the residential area is increasing at a much faster rate than its population. This trend towards reduced population densities, which started back in the early

1970s, is characteristic for small and medium-sized as well as large urban areas. Sprawl and the spread of low-density settlements are costly to provide with public transportation, services and other supplies, leading to an increasing reliance on private cars air pollution, and an overexploit of natural resources [81,110]. There is no sign that this trend is slowing down and, as a result, the demand for land around urban areas is remaining a crucial issue [54,58]. Our results are therefore in line with Angel et al. [6], because more cities experienced expansive growth with increasing rates after the year 2000.

However, dedensification and growth is by no way the universal trend for today's urban areas. In contrast to Angel et al. [7], our findings stress the increasing role that shrinking urban areas are playing in dedensification processes (Figure 8 in annex). This mainly results from a considerable population decline over just a few years, particularly in post-socialist Eastern Europe and in post-industrial regions in Western Europe. Especially after 2000, rates of density decreases in shrinking urban areas reached values comparable to those of growing ones. Because the number of shrinking urban areas increased until 2010, as a consequence of negative birth rates and negative net-migration, it can be expected that population decline with ageing will probably continue all over the continent in the next decades. This is most probably accompanied by a disproportional development of physical space as population loss impacts infrastructure usage, economies, productivity, and investment decisions, which, in turn, have impacts on land use [84,111].

Extensive construction activities parallel to population decline lead to an increasing disparity between a declining housing demand and an increasing supply of residential housing [9]. The seeming discrepancy between lacking demand and large-scale investment due to subsidies has received insufficient attention in contemporary urban research [112] and has not yet been included as an urban development path by the model introduced by Angel [6,7]. Thus, sprawl under population shrinkage conditions has implications for density changes similar to those that we find in growing, sprawling urban areas. Scholars and planners can benefit from paying more attention to the strong environmental losses of expansive soil-sealing that threatens biodiversity and increases the risk of both flooding and water scarcity [84,110].

To what extent do we find differences in density changes between growing and shrinking as well as between small and large urban areas?

Densities significantly decreased in growing, sprawling and shrinking urban areas after the year 2000 (Figure 8 in annex). In both contexts, an increase in residential area does not reflect population dynamics but is predominantly driven by the expansion of residential area.

Moreover, the number of compact, growing urban areas with a stronger population influx and rapidly increasing densities decreased after 2000. Instead, we detect two increasingly important phenomena for densification processes in Europe that emerged after the turn of the millennium.

The first phenomenon characterizes urban areas with increasing densities, due to a reduction of residential areas by demolition or moratoriums on housing construction in suburban areas, in order to strengthen inward developments [107,109]. For declining urban areas, this refers to extensive demolition activities. This compact shrinkage is an interesting case of urban development because it provides an opportunity for densification and compaction based on slowed or halted population decline and a respective reduced housing demand which fosters inward growth and might lead to a smaller built-up area at the end as planning literature suggests [110].

The second densification phenomenon characterizes urban areas with a substantial population increase but without a corresponding increase in the residential area. This refers to continuously growing urban areas, such as those in Munich or Bilbao, but particularly to urban areas that experienced a considerable population loss but were able to `benefit' from the refurbishment and reuse of existing vacant building structures, providing clear evidence of reurbanisation and regrowth of cities in Europe such as in Leipzig [9,20,113,114].

Both processes the demolition of buildings in declining urban areas and renewed growth driven by population gain are of increasing importance, fostering densification processes in Europe. Thus, these types of dynamics would have to be added to the types introduced by Angel [6,7,70], whereby the regrowth process, in particular, contributes substantially to a densification of urban land area (Figure 8 in annex). Moreover, we identify an increasing polarization between growth and shrinkage when it comes to city size. Larger urban areas benefit more from population influx without the need for further expansion of residential areas, so far (reurbanisation), whereas smaller ones may grow at the expense of their hinterland, leading to decline in the near or more remote future. Although we basically agree with Angel et al. [7] that density change rates are lower for larger European urban areas (>100,000 inhabitants) than for small and medium-sized ones, we emphasize that regrowing urban areas represent an exception here: Their rates of density increase exceed those of other types, basically because the residential area does hardly expand that fast.

Which driving factors might explain the observed trends?

Density change rates for European urban areas are diverging for what different factors come into play. Factors such as growth in GDP, purchasing power and household income are only able to explain land consumption to a certain extent [55,71]. Moreover, we would like to discuss three factors which share high explanation power for our analysis; their empirical investigation is, however, beyond the scope of this paper and thus requires further research.

Planning and institutional factors. A major reason for the variety of density changes lies in planning differences, in particular in national planning systems, the size of local governments and institutional fragmentation [55,115]. Changing spatial planning systems and a lack of trust in planning regulations has led to extensive sprawl in post-socialist Europe (the Baltic States, Ex-Yugoslavia, Ex-Czechoslovakia, Poland) from the early 1990s onwards [116,117]. As a consequence, massive construction activities with few constraints on land use or in the absence of master plans are observed in growing but especially in shrinking urban areas, which is especially pronounced in Romania and Bulgaria [118,119]. At the same time, national planning authorities hardly estimate the impact which a reinforced population loss might have on their urban systems [117]. Consequently, sprawl of growing urban areas is observed also in larger (capital) urban areas in Eastern Europe (Poland, Hungary) but also in Southern (Spain, Greece, Italy) and Western Europe (Ireland, France) confirming previous studies [5,54,55]. However, the East German example (e.g., Leipzig, [9,11]) shows that the increase in construction activities in shrinking urban areas is also part of a strategy targeted at stabilizing the housing market, especially because of a neglected building stock. For many countries the variety of responsible administrative actors at different levels is an additional barrier for comprehensive planning. However, several countries follow integrated planning approaches from the national down to the local level focusing on compact inner-city development. This goes along with a strong role of local planning such as in Germany, Scandinavia, Switzerland or the UK, leaving urban sprawl much less attractive behind and lead to a high percentage of compact urban growth [19,80].

Housing market mechanisms. The way supply and demand is balanced on the housing market is essential influencing density changes of cities. First, the share of rented vs owned flats impacts the residential choice of households and can pull certain household groups e.g. young and single households into rented apartments with the flexibility to move again within the housing market. Second, this is determined by the actor constellation as in the European context larger cooperatives, partly owned by municipalities, hold a high share of flats and essentially determine to what extend an extension of residential area is necessary or obsolete.

Third, the privatization of the housing stock together with cheap and available land [17] has led to extensive construction activities more sparsely, as free-standing and hence more space-consuming building structures [20,80,120] in particular in Eastern and Southern Europe, also driven by the growth of coastal tourism in Spain or France [59]. Planning need to counteract this dedensification trend by, for example, repurchasing private land and prevent it from further speculative housing stock [107].

Investments and economic interventions. In some regions, residential area was adapted to population loss which in turn resulted in different expressions of density changes. Thereby, national (transfer) programs particularly pronounced in welfare states, for example, in Germany or in the UK, had considerable impact on this urban development [9,10]. The large restoration state programme in eastern Germany, “Stadtumbau Ost”, aimed at removing housing surplus as well as adapting social and technical infrastructure facilities (e.g. schools, kindergardens, transportation, energy and water supply). This is an obvious difference e.g. to US-cities which are largely influenced by private investments for construction and refurbishment. These public investments stabilized the housing market has led to the phenomenon of regrowth and an associated population growth without land expansion [9]. The stabilization of population numbers and reuse and revitalization usually start in selected inner parts of cities, which offer better infrastructures, cultural and educational facilities, as well as green and recreational spaces [10,11,107,109]. Finally, the German example shows that urban sprawl significantly slowed down with the phasing out of state-initiated tax policy supporting single-family houses in 2006.

Conclusions

Our study showed that dedensification did not slow down but, instead, intensified after the turn of the millennium and has therefore continued to dominate urban development in Europe [6,54,55,121]. However, in comparison to the concept introduced by Angel et al. [6], we can draw conclusions about three basic differences, or the fine-tuning that is required with respect to our findings:

1. We need a more differentiated view on the continental scale: All data values analysed are very well spread, compared to the diagram presented by Angel et al. [6], which shows the overall difference between the European sample and the global sample that the authors used. Apart from urban sprawl, the patterns identified by Angel et al. [6] are more similar to those patterns that shrinking urban areas with decreasing densities show, in our European sample. It is worth asking about the extent to which urban shrinkage plays a role

in the concept established by Angel et al. [6] and about the extent to which the patterns of their global sample are a result of a slowing in population growth. A reinforced population loss, an adapted residential area within urban areas as well as an increasing polarization between larger and smaller cities in Europe, which is largely dominated by smaller settlements, are three trends which result in interrelation to the various drivers mentioned above to different expressions of density changes that might be specific for Europe, e.g. compared to US cities. Although Europe shows tremendous regional variations such as between (post-socialist) Eastern and Southern Europe and can thus not be regarded as having a uniform continental trend, a continental perspective following Angels' ideas, would help to uncover the multiple dynamics that have been described.

2. There is a need to enlarge the perspective: It should be emphasized that population dynamics fluctuate much more than a change in the physical shape of an urban area. On the one hand, housing and infrastructure investments tend to have a long life-span and show a considerable inertness with slower rates of change. On the other hand, international and local migration patterns may change very quickly, leading to different density changes, depending on the size and the location of the urban area. The sample used in this study encompasses the entire range of city size and demonstrates that certain processes, such as sprawl, are characteristic for small and medium-sized as well as large urban areas, whereas large urban areas currently experience reconcentration processes, without any additional physical expansion. This reconcentration, which occurs parallel to (ongoing) sprawl, was already observed, in the 1980s, in Northern and Western Europe (measured by population development [121]). However, residential densities that are too high might imply disadvantages such as price increases for housing, rising infrastructure costs, pollution, and additional costs of a degraded environment and related health problems [59]. Both aspects indicate a polarization between large and small urban areas at the continental scale and are more likely to continue in the future. Therefore, a more detailed discussion of the consequences of this polarization together with the interdependencies of cities is required; this is certainly an issue for planning.
3. The analysis concept used in this paper has shown the advantage of using both indicators (the population and the built-up area) in order to reveal different patterns of density changes. This enriches the model by Angel et al. [7] by looking at both shrinking and growing urban areas and demonstrates trends that could remain hidden from view at a larger (e.g., global) scale of analysis. This helps to better understand why population growth alone is not sufficient to explain the growth in urban land consumption [17,54,116]. However, the explanatory power of our study is limited by the data used and

further empirical research is needed in order to fully uncover the drivers mentioned above. As various local indicators such as GDP is hardly available nor comparable the quantitative detection of density patterns presented in this paper can be combined by national to local focused studies. First, a local governance analysis covering one up to several case studies can be performed within a regional or national planning context [115] in order to investigate the of planning for the extension or reduction of housing supply together with an analysis of compactness, adaptation and amenity measurements of local authorities. Second, an analysis of economic development should be necessarily accompanied by an investigation of housing supply and demand. This involves different residential migration groups as well as price-ownership constellation and public to private investments into housing and infrastructure. We strongly recommend for both future research orientations to spatially focus the study to regions or nations and necessarily include the urban hinterland into the observation as cities are not isolated entities [122].

Based on the typology presented here, it can be expected that existing structures are impacting on future evolution, continuously driven by land prices, as well as people's preferences and lifestyle. Thus, the approach provides some anchor points for a more context discussion backed up by multiple data, which is desirable for policy and planning aiming at compact structures. It should therefore be seen as a starting point and an initial endeavour that pleads for a differentiated and contextualized view on urban density changes and its explanatory power in complex settings.

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Annex

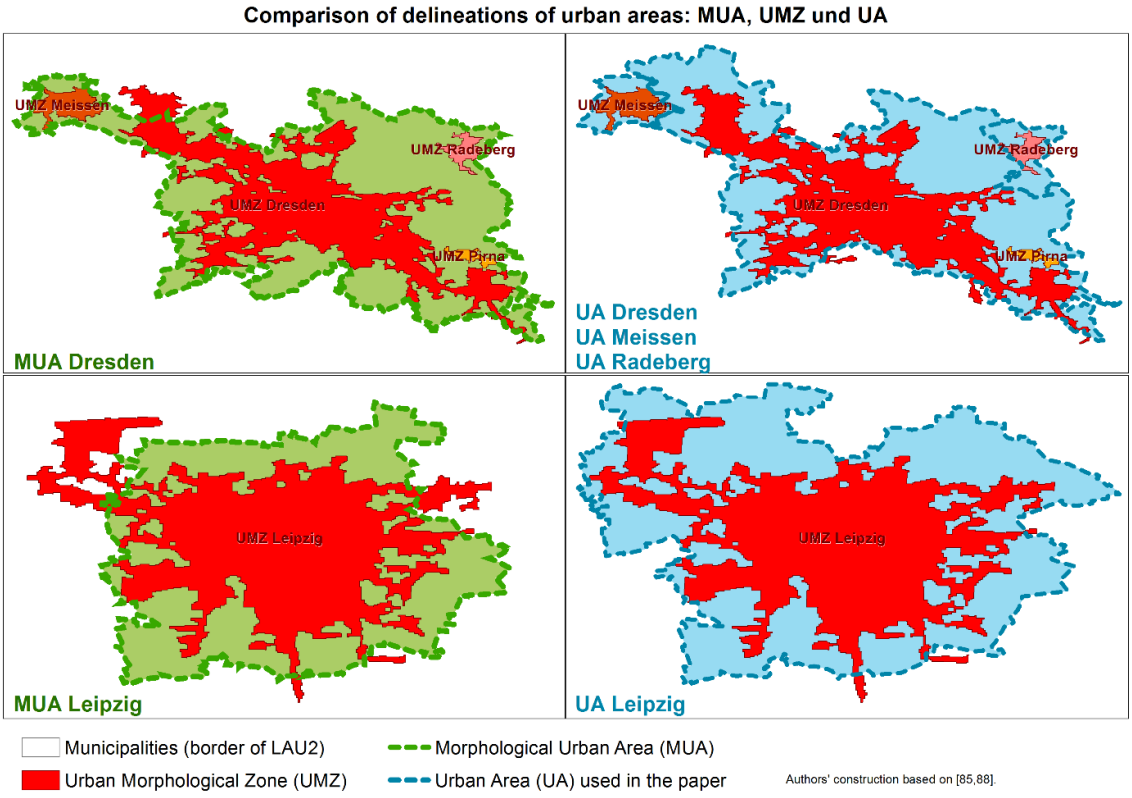


Figure 6: Comparison of delineation of urban areas – Morphological Urban Area (MUA), Urban Morphological Zone (UMZ) and Urban Area (UA) – used in the paper.

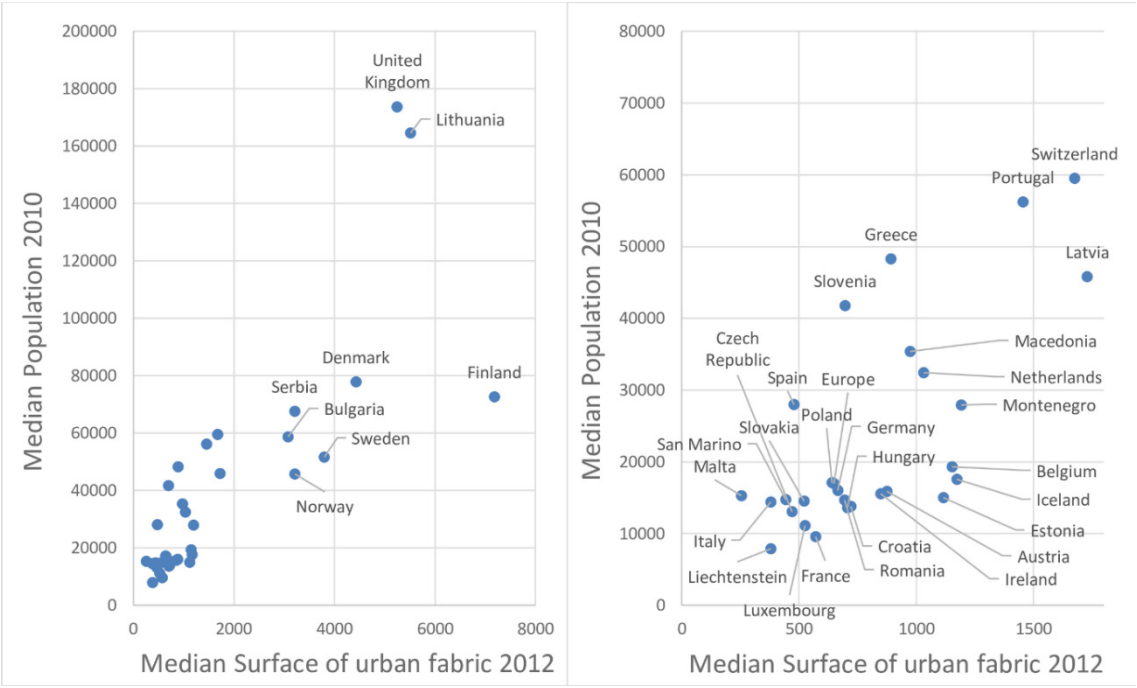


Figure 7: Comparison of median values of population size and surface of residential area (urban fabric) for countries (authors' calculations).

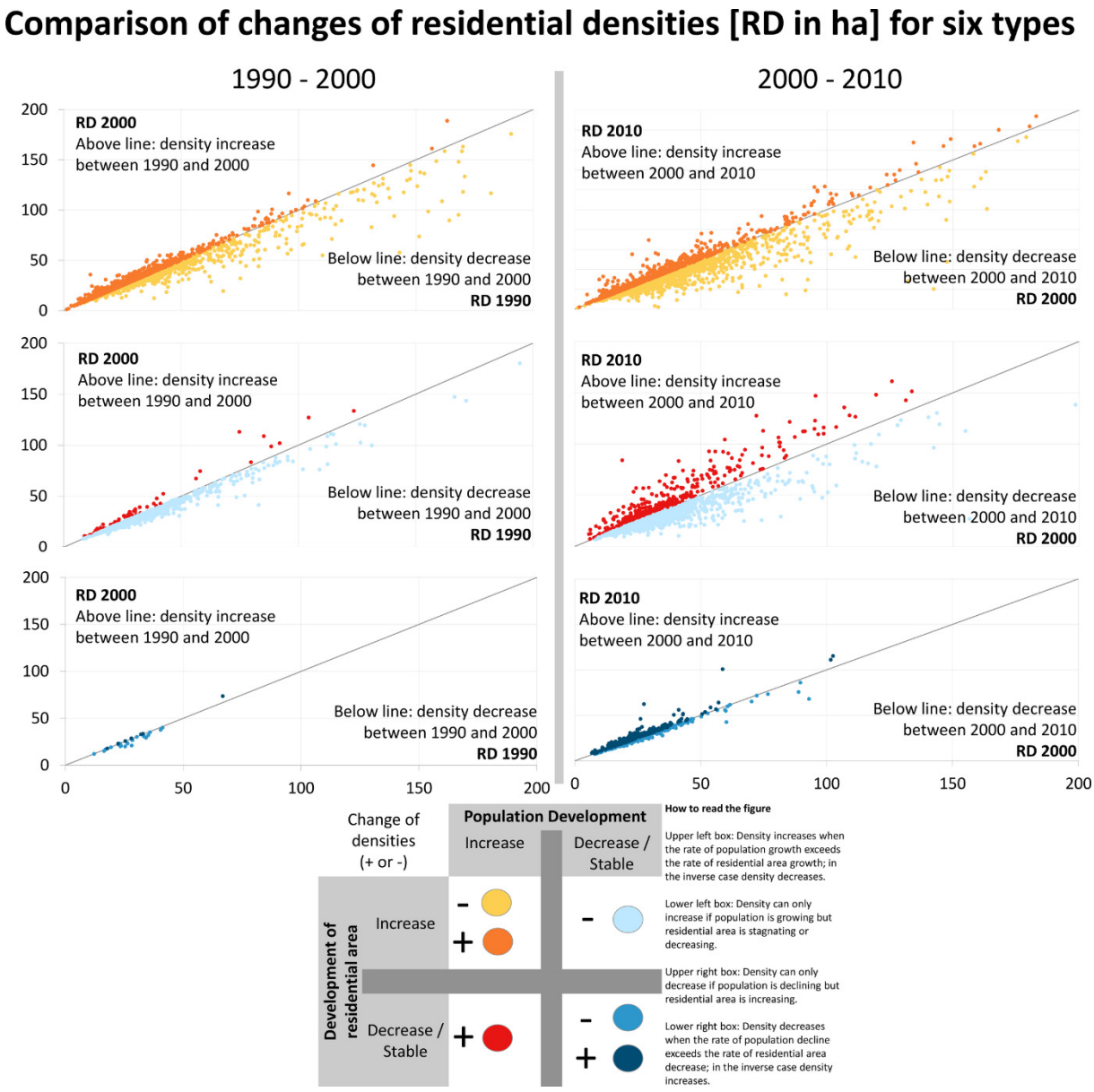
Table 3: Basic statistics for countries.

Country	Number of urban areas	Population in urban areas 2010	Residential area in urban areas 2012 (ha)	Average net density 2010 (persons/ha administrative area)	Average residential density 2010 (persons/ha residential area)	Average share of residential area on administrative area (%)	Average change of residential density 2000-2010
Austria	82	4,384,139	152,758	3.2	20.1	14.3	-0.89
Belgium	158	10,501,375	532,188	8.4	22.1	28.8	0.70
Bulgaria	34	4,000,919	112,756	2.8	31.7	6.4	-0.36
Croatia	58	2,557,841	80,400	2.4	25.5	9.1	-2.72
Czech Republic	209	6,569,496	182,212	3.5	30.7	11.2	-1.46
Denmark	14	2,770,473	116,145	2.6	18.5	12.1	-0.04
Estonia	19	904,185	40,631	2.9	19.4	14.0	-3.73
Finland	20	3,005,148	219,710	0.7	11.0	6.0	0.85
France	943	40,410,540	1,435,395	2.5	20.2	12.0	-1.86
Germany	1,309	60,368,699	1,870,184	3.5	26.7	12.8	-2.63
Greece	51	6,823,189	91,975	5.6	56.1	12.8	-11.13
Hungary	160	6,371,278	199,689	2.1	23.9	8.3	-0.91
Iceland	3	223,008	9,770	1.0	18.5	4.8	-0.89
Ireland	29	1,952,151	62,560	10.7	21.5	50.2	-0.57
Italy	815	37,671,132	703,800	4.4	46.7	9.7	0.17
Latvia	10	1,110,683	30,138	7.6	28.8	26.4	-8.26
Liechtenstein	2	15,800	758	1.9	20.5	9.2	2.56
Lithuania	8	1,623,645	48,697	5.6	38.7	12.6	-6.09
Luxembourg	7	288,261	10,518	4.2	24.6	16.5	2.53
Macedonia	9	885,279	13,990	2.8	52.0	5.2	-3.02
Malta	6	383,631	5,771	10.4	56.4	18.1	10.79
Montenegro	2	55,850	2,386	1.2	23.6	5.1	-2.87
Netherlands	214	15,193,569	384,933	5.0	35.2	13.5	-2.52
Norway	24	2,470,411	134,385	1.7	16.0	10.2	1.25
Poland	502	24,079,667	755,168	6.8	27.8	23.7	-10.59
Portugal	29	6,119,816	131,686	4.4	41.3	10.3	-9.37
Romania	232	10,598,292	256,210	3.5	29.7	9.9	-7.11
San Marino	1	14,722	444	4.4	33.2	13.2	-7.43
Serbia	22	3,185,381	95,365	1.7	25.7	5.7	-4.56
Slovakia	104	2,843,761	80,926	3.3	31.3	10.5	-1.71
Slovenia	13	813,667	18,049	3.2	46.0	7.5	0.86
Spain	404	35,146,846	445,622	6.7	70.5	10.9	0.82
Sweden	52	5,873,060	286,698	1.2	17.6	5.7	0.59
Switzerland	40	8,195,095	179,842	8.7	34.2	24.9	2.88
United Kingdom	107	45,505,556	1,196,547	7.5	34.5	20.9	0.55
Europe	**5,692**	**352,916,565**	**9,888,306**	**4.2**	**32.5**	**13.4**	**-2.43**

Table 4: Basic statistics on changes [Δ] of population, residential area, and density.

	Absolute values (urban areas)			Relative values in % (urban areas)		
Δ Population	**1990-2010**	**1990-2000**	**2000-2010**	**1990-2010**	**1990-2000**	**2000-2010**
≤ -3,0	1,187	822	1,148	21.8	15.1	21.1
-0,15 to -3,0	386	754	785	7.1	13.9	14.4
0,15 to -0,15	43	83	86	0.8	1.5	1.6
0,15 to 3,0	467	871	905	8.6	16.1	16.7
≥ 3,0	3,352	2,905	2,511	61.7	53.4	46.2
Total	**5,435**	**5,435**	**5,435**	**100.0**	**100.0**	**100.0**
Δ Residential area (hectare)						
≤ -3,0	475	32	661	8.7	0.6	12.2
-0,15 to -3,0	212	57	280	3.9	1.0	5.2
0,15 to -0,15	151	2,344	198	2.9	43.2	3.6
0,15 to 3,0	464	915	556	8.5	16.8	10.2
≥ 3,0	4,133	2,087	3,740	76.0	38.4	68.8
Total	**5,435**	**5,435**	**5,435**	**100.0**	**100.0**	**100.0**
Δ Residential density (persons/hectare)						
≤ -3,0	2,192	826	1,959	40.3	15.2	36.0
-0,15 to -3,0	1,330	1,680	1,639	24.5	31.0	30.2
0,15 to -0,15	138	345	189	2.6	6.3	3.5
0,15 to 3,0	952	1,975	973	17.5	36.3	17.9
≥ 3,0	823	609	675	15.1	11.2	12.4
Total	**5,435**	**5,435**	**5,435**	**100.0**	**100.0**	**100.0**

Figure 8: Six different types of density changes for growing and declining urban areas in different periods.



4.5 The impact of urban regrowth on the built environment

Paper 5: *Manuel Wolff, Annegret Haase, Dagmar Haase, Nadja Kabisch*

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The impact of urban regrowth on the built environment

Manuel Wolff
Helmholtz Centre for Environmental Research – UFZ, Department of Urban and Environmental Sociology, Germany

Annegret Haase
Helmholtz Centre for Environmental Research – UFZ, Department of Urban and Environmental Sociology, Germany

Dagmar Haase
Humboldt Universität zu Berlin, Department of Geography, Lab for Landscape Ecology, Germany; Helmholtz Centre for Environmental Research – UFZ, Department of Computational Landscape Ecology, Germany

Nadja Kabisch
Humboldt Universität zu Berlin, Department of Geography, Lab for Landscape Ecology, Germany; Helmholtz Centre for Environmental Research – UFZ, Department of Computational Landscape Ecology, Germany

Introduction

During the last two decades, a number of cities in Europe have exhibited a phase of growth after shrinkage. Unlike continuous population growth and decline, this growth following decline has been interpreted by urban scholars of long-term cyclic urban development (e.g. Champion, 2001) as reurbanisation, in accordance with van der Berg's well-known urban life cycle-model (van der Berg et al., 1982). Reurbanisation and related population growth, as current empirical evidence has shown, is not a new phenomenon. This sequential development was first observed in the United States and Western Europe in the late 1980s and early 1990s (Champion, 1995; Cheshire, 1995; Kujath, 1988; Stead and Hoppenbrouwer, 2004). Interestingly, the number of cities that have faced this development has increased over recent years in some countries, for example in Germany and the UK (Cheshire, 2006; Couch et al., 2009; Herfert, 2007; Rink et al., 2012) where cities such as Glasgow and Liverpool are affected. There are even examples in the post-socialist part of Europe, known for its widespread urban shrinkage; examples include Plzen, Pécs, Varna, Tallinn, Dresden and Leipzig. Currently, the turnaround in the direction of population growth following population decline can be observed in approximately 11% of European cities (Haase et al., forthcoming).

Since growth occurs after several decades of shrinkage, regrowth is, in a qualitative sense, distinct from continuous growth. A variety of aspects, related to urban amenities and affordability, make some locations more attractive for urban dwellers than others (Couch et al., 2009; Kabisch et al., 2009), leading to selective developments such as an uneven distribution and co-existence of new, small-scale (re)growing parts and ongoing decline in others. The resulting inhomogeneous impacts of population changes on a smaller city scale require shifting the scale of observation from the city to the district and neighbourhood level (Brühl et al., 2005; Polster and Voy, 1989).

How cities and their districts are affected by new growth after shrinkage depends much on the supply of housing and available residential qualities. For shrinking cities, declining population numbers are usually accompanied by vacancies, leading to demolition of parts of the housing stock, to brownfields and to declining rents (Bernt, 2009). When cities enter new growth after shrinkage, the question if and where new constructions are needed or if demolition should be continued in order to further stabilise the housing market by reducing vacancies depends to a large extent on the demand for housing and the availability of investments. This explains why land use changes and demographic trends do not necessarily evolve in parallel (Kroll and Haase, 2010). Built-up areas do not necessarily decrease as population declines because of decreasing household sizes and an increase in housing demand (Couch et al., 2009; German

Federal Environment Agency, 2003). In contrast, the built-up area does not necessarily increase when the population grows due to high vacancy rates and buildings that can be reused. This leads to a mosaic of small-scale developments such as new constructions, refurbishment, residential vacancies and brownfield sites (Großmann et al., 2014).

This mosaic is related to differences in residential densities. Density is a fundamental element of urbanisation processes because not only does it reveal the spatial structure of a city, it also aids in understanding how much land is in urban use and why it varies across time and space (Shlomo et al., 2010). Thus, it represents a widely used indicator of land consumption related to the rate of population growth (Howley et al., 2009) and reveals to what extent 'morphology of urbanization reflects societal processes' (Haase and Nuisl, 2010: 125). Due to declining population numbers, de-densification processes in large parts of a city can cause the underutilisation of housing or infrastructure systems such as sewage or transport networks, thus requiring an adaptation of these systems. Re-densification, a process that usually occurs during periods of post-shrinkage regrowth, demands, in turn, other adaptations of these infrastructures including the re-adjustment or even the construction of new housing. This changing demand requires precise and context-specific information on the (expected) impacts, e.g. on the built environment, that can then allow planners to react appropriately to the changing demands.

Against this background, this article seeks to bring together the debates on land use changes and population trends in a post-shrinkage regrowing city. The city of Leipzig was chosen because it represents one example of a regrowing city in Europe with some specific characteristics that derive from its East German context (see case study description). We define post-shrinkage regrowth as the emergence of new population growth after several decades of decline. This is constitutional for our understanding of regrowth and our decision to define it as a distinct development that differs from continuous growth. Therefore, this article uses the term regrowth for describing this turnaround of the population development in a city, in line with other authors (Ferrari and Roberts, 2004; Rink et al., 2012). We use the indicator of population change at city level to distinguish between growth, shrinkage and regrowth, since it is one of the most commonly used indicators to describe dynamics in urban studies (Beauregard, 2009; Turok and Mykhnenko, 2007). We analyse the implications of these different phases on the urban space and the change and persistency of the built-up area, using a conceptual approach. We assume that the spatial implications in regrowing cities differ significantly from those happening e.g. under the condition of continuous growth or shrinkage. In order to demonstrate this, an operationalisation of density change patterns at the district level was developed that included factors on the demand and supply side. Several settlement

density patterns can emerge, depending on how population numbers and built-up areas evolve. With this approach, the following research questions are addressed:

- How do densities change during regrowth, compared to the previous phase of shrinkage, and to what extent are the emerging patterns of density changes demand- or supply-driven?
- To what extent are the density patterns during regrowth interrelated with other patterns that emerged in previous periods?
- How do these patterns help to better understand regrowth and its implications for the development and use of urban space?

The article is structured as follows. The case study city of Leipzig is presented. Focusing on processes and impacts of population change, the second section reflects on the role of densities and presents a conceptual approach for investigating the impact of regrowth on the built environment, together with factors on the demand and supply side. Based on this, the third section provides an operationalisation of densities that is applied to the case study Leipzig in the fourth section. The empirical results are discussed with respect to the research questions and the reviewed literature in the fifth section, before we present some conclusions in the final section.

Study area – the city of Leipzig

Favoured by industrialisation and urbanisation, Leipzig was one of the fastest growing cities in Europe before the Second World War. Subsequently, Leipzig experienced tremendous population losses, thus ranging among the fastest shrinking cities in Europe with the longest period of decline. The constant decline in population numbers was, on the one hand, determined by negative natural population growth rates. On the other hand, the city also experienced massive outmigration, due to a 'constant decay of the industrial base combined with poor housing conditions and ecological degradation' (Rink et al., 2012: 165) during the GDR era. Figure 1 shows that, after German reunification in 1990, Leipzig lost about 20% of its population in just 10 years, a process that was particularly driven by long-distance out-migration to Western Germany, resulting in a dramatic drop in fertility rates. Additionally, Figure 1 makes it clear that suburbanisation to the surrounding municipalities, from 1994 onwards, reinforced the population loss.

However, after 1998, migration balances became positive and, by the turn of the century, the population of Leipzig had started to recover. Due to less out-migration and strong in-migration, Leipzig's regrowth remained stable from 2006 onwards. Since 2012, Leipzig has seen considerable regrowth, basically due to strong in-migration, with an annual increase of more than 2% p.a., which made Leipzig the fastest (re)growing city in Germany (Destatis – Federal Statistical Office of Germany, 2014).

Due to the very long shrinkage period and the scope of regrowth within recent years, Leipzig is an interesting case study. In Leipzig, urban shrinkage led to an enormous number and surface area of brownfield sites in the 1990s, as well as to very substantial housing and commercial vacancies, revealing the 'legacy' that post-shrinkage regrowth had to build on (Rink et al., 2012). Therefore, Leipzig shows the dynamics of shrinkage and regrowth in a very prominent manner and scope. This might be, on the one hand, specific and typical for the city itself as an East German case, due to the overall shrinkage dynamics in this region during the 1990s. Moreover, Leipzig's regrowth benefited from massive public and private interventions and investment. The general processes and dynamics described here for Leipzig can, however, also be found in many other cities across Europe, as some studies show. Some of them compare Leipzig with other cases (Couch et al., 2009; Rink et al., 2012). Thus, we can conclude that Leipzig, despite all its specifics, which should not be underestimated, represents a broader trend of a certain type of multifunctional city across the continent that sees an upswing after a longer period of decline. Studying both typical and particular characteristics will allow us to clearly point out what we can learn from this case for a more general perspective and what might be unique aspects that hardly serve to explain the interplay of population and built-up area and the corresponding density changes in other cities.

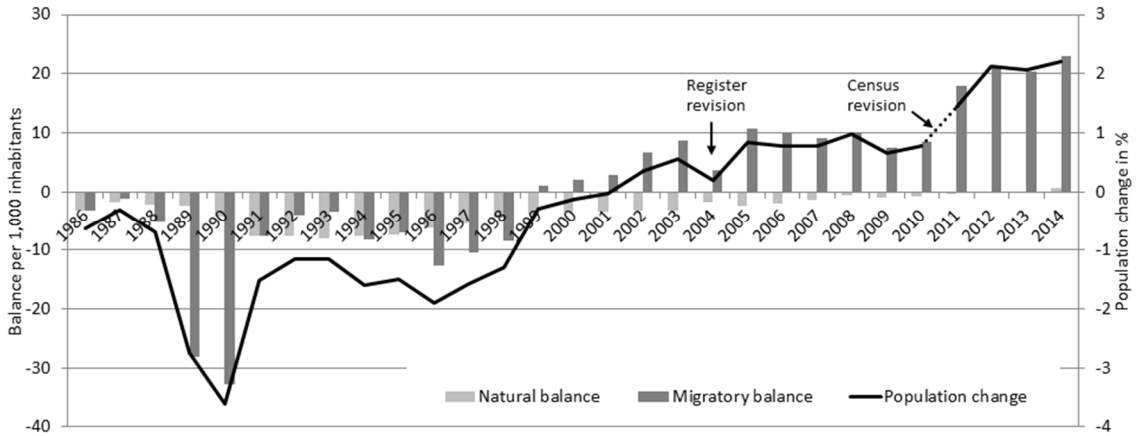


Figure 1: Demographic development for Leipzig 1986 to 2014.

Conceptualizing the nexus between changes of population and built-up area: the role of density

Figure 2 shows the conceptual linkage between population numbers and built-up area. Changes in population numbers are defined as shrinkage and regrowth and allow one to easily identify the context of these different phases of urban development. However, the impact of different population developments on land use is complex, because the built environment is affected non-uniformly (Haase, 2014). Increasing or decreasing population numbers leads to changes in the built environment, as the demand changes (Artmann and Breuste, 2014) in terms of changes of land use, densities and the extent of the built-up area (Nuissl and Siedentop, 2012: 5788). A change in population number and/or built-up area in a city can result in changes of the population density, reflecting the relationship between the supply of built-up area and the demand for it by a certain number of people.

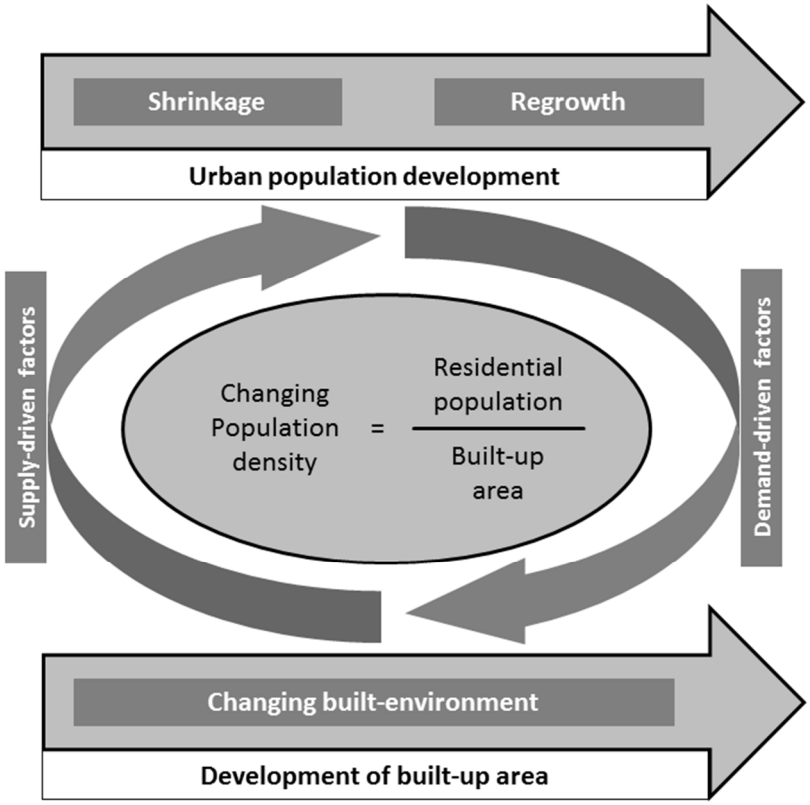


Figure 2: Conceptual linkage between urban population and built-up area development.

In shrinking cities, densities most probably decrease because the population decreases. This leads to an oversupply and underuse of urban land, namely of housing stock, infrastructure

and services, as well as to higher per capita maintenance costs (Nuissl and Siedentop, 2012). The amount of built-up area either stagnates under population decrease, leading to vacancies and abandonment, or even declines in the case of demolition due to decreasing demand (Bernt, 2009). The amount and the speed of demolition can, in turn, result in both decreasing and increasing densities (Nuissl and Rink, 2005; Großmann, 2007). Further, weak housing markets and low prices for land facilitate new construction of buildings, e.g. single-family homes at the city's fringe or town houses in the inner city, for households with large per capita living space and small household sizes, and lead to correspondingly low densities (Nuissl and Rink, 2005).

Increasing densities are usually associated with population growth, infill and even further expansion of the built-up area. In particular, a constant physical expansion of a city, with newly built housing, commercial and industrial sites, can even lead to decreasing densities, which is a common characteristic of many cities worldwide, leading to high land consumption and mobility costs (Shlomo et al., 2010). In contrast, especially in regrowing cities, densities can increase without an expansion of the built-up area, even in the context of ongoing demolition of some decayed buildings, due to the refurbishment of the existing housing stock that was previously vacant and that is now absorbing the increasing demand.

In sum, we identify different density changes under the same conditions of land contraction/expansion and population decrease/increase. The way built-up area and population is changing depends, on the one hand, on drivers on the demand side such as socio-demographic (household and age-specific preferences) as well as mobility-related trends that impact residential choices in combination with the attractiveness of a location. On the other hand, factors such as the availability of construction land, tax and subsidy policies of public actors as well as economic strength and available jobs reveal drivers from the supply side (BMVBS, BBSR, 2009).

Materials and methods

Having conceptualised the link between built environment and population, we will now operationalise density as the key indicator for this approach. Compared to other land use indicators, density changes, in particular, reflect the relationship between the physical supply and the demand for it by a certain number of people and allow conclusions to be drawn on over- and under-use of urban infrastructures (BMVBS, BBSR, 2009; Nuissl and Siedentop, 2012) and on changing demands for housing, public utilities, transport and supply networks. A change in both built-up area and population can induce a change in population density.

However, they might progress independently of each other and not necessarily in one direction, resulting in different constellations in which population density is increasing or decreasing. This means that there is a certain risk of misleading, or even false, interpretation when the focus is only on density changes. Therefore, it is necessary to introduce a straightforward typology highlighting how the development of the two variables (population number and built-up area[1]) contributes separately to different patterns of population density changes.

Figure 3 mirrors this. With an expansion of built-up area but even faster increasing population numbers, densities usually increase, e.g. as a consequence of building multi-story houses. In turn, the amount of built-up area can increase faster than the respective population (e.g. building single-family houses with large living spaces), leading to decreasing densities. A contrasting example involves population loss and a reduction of built-up area, leading to decreasing densities, e.g. through demolition of large housing estates with a fast outflow of people, or even increasing densities, e.g. through demolition of buildings with few households. Decreasing densities can also appear if the built-up area is expanding, e.g. through new construction, but population numbers are dropping, leading to housing oversupply. Finally, population growth without an expansion of built-up area indicates a reuse of existing buildings while adjacent, decayed buildings are demolished.

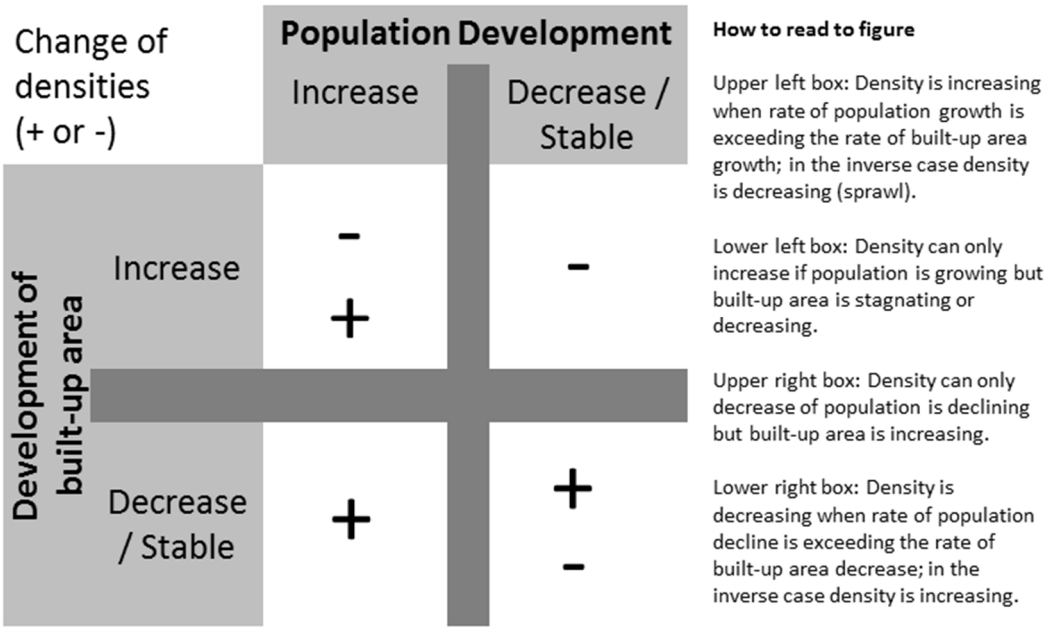


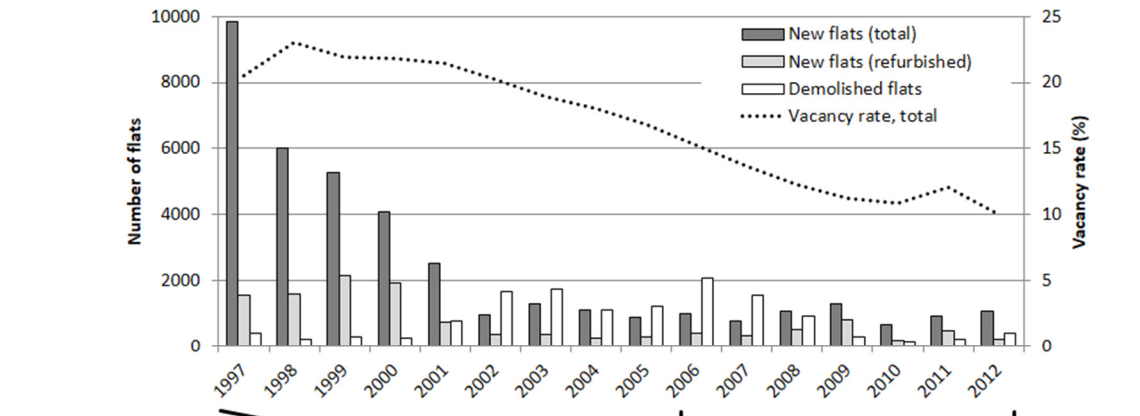
Figure 3: Operationalisation of population density changes under different constellations of the development of urban population and built-up area.

For the case study of Leipzig, the periods of shrinkage and regrowth serve as the context and are defined by analysing the city's population development between 1985 and 2012 (Destatis – Federal Statistical Office of Germany, 2014). The operationalisation in Figure 3 is applied to Leipzig's 63 districts. Data on the built-up area was obtained from a historical land use database for 1985, 1997 and 2003 (Saxon Cadastral Agency) and detailed official land-use data (ATKIS) for 2006 and 2012. By using population data on the district level (City of Leipzig, 2015), population densities (resident population per built-up area) and their changes[2] were calculated and analysed for the periods 1985– 1997 (which we defined as period of shrinkage), 1997–2003 (shrinkage/regrowth) and 2006–2012 (regrowth) for the 63 districts.[3]

Furthermore, we added data that reflect demand and supply factors. On the one hand, this allows us to investigate the influence of these factors on density changes, their interrelation and explanatory power. The selected indicators for measuring these factors follow other studies (BMVBS, BBSR, 2009), which makes them appropriately comparable in a wider sense. Suitability for and comparability to existing research were thus the main criteria of choice here. For the demand side we analyse, on the district level, net migration, age-related indicators reflecting different preferences, as well as household-related indicators (number, size, vacancy), mirroring the nexus between housing supply and demand. For the supply side we used city-level data on subsidies and jobs, representing essential pull factors for changes of population and built-up area (Nuissl et al., 2009). This twofold approach allows the investigation of the interrelation of population number and built-up area but also their driving factors.[4]

Results: de-densification and re-densification in Leipzig

In the following, we present our results in a twofold way. We explain Leipzig's development over the last 27 years, distinguishing three phases: 1985–1997 (shrinkage), 1998–2003 (shrinkage/regrowth) and 2006–2012 (regrowth). For each phase, we describe how different population dynamics impacted on the built structures, resulting in different patterns of density changes (six in total) that reflect the relationship between the main variables – population number and built-up area. In order to make the underlying processes of these patterns more understandable, we discuss the dominant patterns for each phase, together with driving factors, from a demand and supply perspective (Table 1 and Figure 4).



Change of supply factors	1997-2006	2006-2012	Change between periods (%)
Subsidies* in economy	1,523	863	-43.3
Subsidies* in infrastructure	1,118	185	-83.4
Subsidies* in housing, urban development	2,611	792	-69.7
Employees at place of work (%)	2.25	13.94	16.5
Employees at place of residence (%)	-0.94	22.94	21.8

*Subsidies: Sum in Euro per capita. Defined as funding of specific measures with public money. The majority of this subsidies is coming from the federal state.

Data from Statistical Office of Saxony, 2015; Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR), 2013

Figure 4: Supply factors and impact on housing market for Leipzig 1997 to 2012.

The first map in Figure 5 refers to population shrinkage between 1985 and 1997. Job-driven out-migration and declining household numbers led to extensive residential vacancies (Figure 4). The resulting underuse of housing and technical infrastructure, such as waste disposal or water supply, required the stabilisation of the housing market and adaptation to the decreasing population numbers, for which two patterns are characteristic.

Publicly funded demolition in several districts, targeting residential buildings, which evolved as a consequence of neglect and disinvestment during the GDR era, and of industrial sites, has led to ***supply-driven demolition patterns*** (yellow, Figure 5). Thus, especially in the centre of the city, densities are increasing, which is rather unusual for shrinking cities, because built-up area decreased faster than population (e.g. through demolition of multi-story tenement blocks with few households). Hence, the reduction of the surplus of residential housing has led to a substantial amount of brownfields (1999: approx. 706 ha; Muschak et al., 2009) and to a perforation of the urban space, in the form of dissolution of the street or block structure. This, in turn, led to reinforced out-migration of those who did not want to live close to dilapidated building stock or overgrown brownfields (so-called ‘urban wilderness’; Rink, 2009). Table 1 displays the emerging effects of this pattern with high vacancy rates as well as low household sizes and aging tendencies far exceeding the city average.

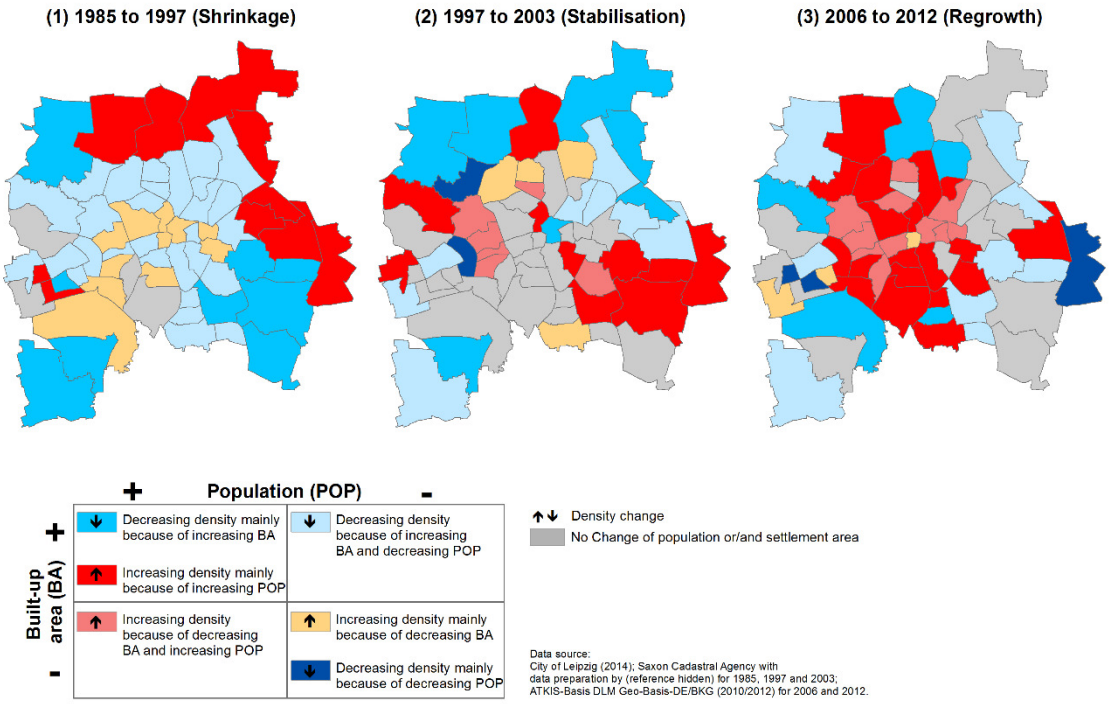


Figure 5: Patterns of population density changes under differing constellations of the development of urban population and built-up area in Leipzig 1985-2012.

In contrast, decreasing densities can be found in declining districts in a ring round the central city; this is, however, accompanied by stable or even increasing amounts of built-up area. This ***supply-driven construction pattern (light blue)*** reveals the lack of fit between a decreasing demand and an expanding housing supply and built-up area. On the one hand, this is due to the fact that vacant buildings could not be demolished immediately, due to financial aspects such as less residential tax revenues. On the other hand, constructions of new residential buildings and commercial sites had been favoured by funding and tax or credit policies within the East German context. The shortage of (habitable) housing in the early 1990s, caused by long-term neglect, required the construction of new housing such as townhouses, which led to an expansion of the built-up area in these districts. However, this housing oversupply, together with decreasing population numbers, led to underutilisation of urban land, namely housing stock, infrastructure and services suppliers, with concomitantly high vacancy rates, especially in old, multi-story building stock with low standards (Table 1).

Furthermore, residents are pulled out to the inner-urban fringe districts, where the construction of single-family and semidetached houses with a large household size has even led to decreasing densities and a characteristic ***urban-sprawl pattern (blue).*** Similar to the

inner city, these patterns are driven by subsidies and credit policies (supply). Table 1 shows that a decreasing proportion of the elderly, contrary to the city trend, and a slowly increasing number of households corresponds the attractiveness of these districts for families and a strong demand for new single-family houses.

	City	Difference to city average (* indicates more than 0.5 SD)					
Shrinkage 1985-1997	average	Blue	Red	Light blue	Pink	Yellow	Dark blue
Change of Net Migration (1993-1997)	**-13.3**	**65.5***	**128***	0.5		-17.3	
Change of Number of households (1991-1997)	**-3.6**	3.9	**14.1***	0.0		-1.1	
Change of Elderly rate (1992-1999)	**0.3**	**-0.6***	-0.2	0.1		0.4	
Vacancy Rate (1995)	**15.3**	**-9.8***	**-11.7***	-4.0		**4.8***	
Household Size (1999)	**2.0**	**0.2***	**0.2***	0.0		**-0.1***	
Shrinkage/Regrowth 1997-2003							
Change of Net Migration (1998-2003)	**2.3**	**25.9***	**31.7***	**-14.9***	**22.1***	-15	-13.8
Change of Number of households (1997-2003)	**4.0**	-1.4	-0.8	**-2.5***	0.5	**-3.8***	**-4.2***
Change of Elderly rate (1999-2003)	**0.8**	0.6	0.4	**1***	-0.2	**0.8***	**1.6***
Vacancy Rate (2003)	**19.0**	**-12***	**-13.2***	**-5***	**4.9***	**6.5***	-3.5
Household Size (2006)	**1.7**	**0.2***	**0.2***	**0.1***	0	0	0.1
Regrowth 2006-2012							
Change of Net Migration (2006-2012)	**14.3**	-3.5	**7.8***	**-12.6***	**7.7***	**-16.1***	**-11.4***
Change of Number of households (2006-2012)	**0.2**	**-0.8***	0.5	**-1.3***	**0.8***	**-1.5***	**-2.2***
Change of Elderly rate (2006-2012)	**0.3**	**1***	-0.5	**1.3***	**-0.6***	**0.6***	**1.1***
Vacancy Rate (2011)	**12.1**	**-5.4***	-0.2	**-4.9***	2.6	**3.3***	1.7
Household Size (2012)	**1.7**	**0.2***	0.1	**0.3***	0	**0.2***	**-0.1***

Table 1: Demand factors for different phases and patterns (data from City of Leipzig, 2015).

The second map in Figure 5 shows the phase between 1997 and 2003, with the progression from shrinkage to growth. The south-eastern districts experienced a second wave of suburbanisation with strong inmigration, increasing household numbers and the construction of single and semidetached multi-family houses, leading to increasing densities and ***demand-driven expansion patterns (red)***. In contrast, economic suburbanisation was replacing the residential suburbanisation, especially in the northern and northeastern fringe districts, accompanied by a slowing down of inmigration and numbers of new households (Table 1). The expansion of the built-up area is driven by investments into the economy and transport, attracting enterprises such as Porsche and BMW to areas with good access to the main transportation networks. Figure 4 shows that, between 1997 and 2006, much money from subsidies was spent on the economy, leading to an increasing number of jobs within the city.

However, the number of new constructions decreased after its peak in 1997. Within the inner city, new constructions of residential buildings and commercial sites (light blue) are concentrated mainly in the eastern part with, however, fast out-migration and decreasing household numbers and aging. In districts north of the city centre, the reduction of built-up

area is still dominant, due to the demolition of industrial and residential structures (yellow) with, however, a fast drop of household numbers and a correspondingly high vacancy rate (Table 1). Following initiation of the federal programme Stadtumbau Ost in 2002, a substantial number of flats were demolished. This demolition was concentrated in non-attractive districts with large numbers of prefabricated houses constructed during the period of state socialism, and it led to ***supply- driven demolition patterns (dark blue).*** As Table 1 shows, this demolition has substantially reduced the high vacancy rates in these districts, even though household numbers had been dropping significantly due to out-migration. It was accompanied, however, by the strongest aging tendencies in the city. In contrast, in most districts, neither population numbers nor built-up area changed significantly because demolition and loss of population came to a halt (grey areas, Figure 5).

When the city entered its regrowth period, from 2006 onwards (third map, Figure 5), the formerly highly suburbanised districts show a decreasing number of households, increasing vacancies and aging tendencies, due to the increasing attractiveness of the inner city (Table 1). All inner-city districts experienced high in-migration, which is expressed in two patterns. First, a ***demand-driven refurbishment pattern (pink)*** characterises increasing densities due to a high influx of residents and, in parallel, a decreasing or stable amount of built-up area. This pattern was already detected in the previous period, especially in the formerly highly industrialised western districts, where industrial buildings were still being demolished. The very high vacancy rate of Leipzig in the early 2000s and the cost-intensive demolition of buildings have led to a slowing down of new construction. Due to a considerable amount of funding for the modernisation of buildings, the refurbishment of the existing building stock which peaked already in 1999 intensified again in 2009 (Figure 4). These districts can be found only within the inner city and reflect that these new residents are strongly city-minded and explicitly appreciate urban environments (Engler, 2014). Table 1 shows a decreasing proportion of elderly residents and a rapidly increasing number of new and small households in these districts, above the city average, revealing that young people especially are attracted. However, the built-up area remained stable or even decreased, which confirms previous findings (Kabisch et al., 2009). Rather, several of these districts still show a large stock of run-down buildings, requiring demolition in 2006/ 2007. This is mirrored by high vacancy rates, which, however, dropped significantly due to an intensified refurbishment that peaked in 2009 (Figure 4).

The large influx of population is also accompanied by a rapidly increasing number of jobs. Since 2006, the number of employees at the place of residence increased faster than the number of employees at the place of work (Figure 4), showing that the inner city itself became

increasingly attractive as a place to live. This high demand due to increasing population numbers in several districts, predominantly along a north-south 'corridor' through the inner city,[5] has required infill of hitherto vacant land. The increasing number of newly constructed residential housing, such as multi-story houses, led to increasing densities and a ***demand-driven infill pattern (red)*** with a strong increase in population and a decrease in vacancy rates.

Discussion

To discuss our results, we come back to our three research questions. First, we discuss how density patterns changed during regrowth, compared to the previous phases of shrinkage (1). Second, we explore to what extent these regrowth patterns depend on processes that occurred during the previous phases (2). Third, we point to some major specifics of regrowth, compared to continuous growth, in order to clarify how this development is distinctive for growth and what this means in terms of implications for the development and use of urban space (3).

1. During the last three decades, Leipzig's districts have experienced phases of decrease and increase in their population densities in terms of either shrinkage or regrowth. During shrinkage, considerable outmigration of people and households looking for jobs or single-family homes at the fringe led to a homogenous dichotomy between a strong decrease in demand for flats in the inner city and, simultaneously, to an increasing demand at the fringe. In order to overcome housing vacancies and oversupply, demolition of flats was implemented. This resulted in the simultaneous appearance of two opposing developments after 2000: redensification in inner-city districts, on the one hand, and, on the other, de-densification due to further outflows and – additionally – to demolition of housing in the large housing estates in the outer city. This is typical for many shrinking cities in Europe, where demolition mostly occurred in large housing estates (e.g. those built during the GDR era) or in older and substandard housing (e.g. semi-detached housing areas in UK cities), in order to 'balance' the housing market (Couch et al., 2009). In contrast, the supply-driven political-economic interventions and investments for new residential and commercial construction were, on the one hand, necessary due to the run-down building structure and the associated demand for quality housing, but, on the other, very specific for the East German context. However, these new constructions with patterns of decreasing densities could not mitigate the strong outflow of people and, thus, of vacancy rates. Therefore, the fringes of large East German cities show patterns of suburbanisation and even sprawl; these are also typical for growing cities. Consequently, even during Leipzig's regrowth, the housing market has remained unbalanced,

with very extensive vacancies. However, this opened up the possibility of an intensive refurbishment of the old building structure, predominantly in very representative buildings from the Wilhelminian era. The high influx of people into these districts led to regrowth-specific density patterns without larger demolition or expansion effects.

2. The emerging pattern is, on the one hand, a product of the phase itself, but, on the other hand, also a result of the successive order of the phases. The described trends during Leipzig's shrinkage reveal specific preconditions for the emergence of the typical density pattern during regrowth. The refurbishment, which provided attractive housing conditions within the inner city, also led to a further expansion of the housing supply and thus to strongly dropping prices and rents, especially for refurbished flats, compared to newly constructed flats. This allowed a large choice and a 'quasi' freedom of movement, especially for younger, small households, within the huge renting-market, ending up in an influx into districts in the inner city that also provided new parks and green spaces. These were created due to the previous and still ongoing demolition of industrial sites and run-down buildings. The simultaneous appearance of ongoing demolition, relatively high vacancy rates and refurbishment, as well as still affordable rents pulling in-migration, represents a general trend in East German (Herfert, 2002; Wiest, 2005) and European (Haase et al., forthcoming) cities. In parallel, suburbanisation started to change in such a way that the influx of residents slowed down but with the emergence of aging tendencies. Moreover, commercial suburbanisation led to further densification in specific areas favoured by good transport connection. This is accompanied by a significant increase in the number of jobs within, but especially outside, the city's administrative borders, proving the important role of the city as a place to live (Figure 4). However, this strong demand for housing has required new infill and produced an associated impact on the built environment (Figure 4). The newly increasing densities and very fast declining vacancies show characteristics similar to processes in continuously growing cities. In regrowing cities, these processes concentrate in high reputation districts around the city centre and reinforce the upgrading of these already stabilised neighbourhoods.

However, rapidly increasing densities lead to raising rents and housing prices, forcing displacement from gentrifying districts to less attractive areas (Brühl et al., 2005). In these areas, which remain cut off from the overall regrowth tendency and still experience population loss, the trend is exerting pressure on existing vacant flats/estates and, thus, we observe rising rents in all those districts that were stagnating during the shrinkage period (Rink et al., 2014).

Finally, demand- and supply-driven factors play a different role during shrinkage and regrowth, leading to specific spatial patterns of population and built environment densities. Regrowth in Leipzig has led to a changing driver constellation, from former supply-driven patterns towards demand-oriented trends. Huge public and private investments in housing, office space, etc. helped the city to recover (Rink et al., 2012), associated with an increase in the overall built-up area. During regrowth, state funding and subsidies for demolition, modernisation and infrastructure slowed down (Figure 4), in parallel with a considerable population increase in Leipzig, especially in the attractive inner-city districts. The housing market no longer needed to be stabilised from the supply side but became increasingly demand-dominated, due to increasing population numbers, densities and constantly declining vacancy rates.

3. These demand-driven trends can also be found in continuously growing cities – however, in regrowing cities, they encounter the legacies of previous shrinkage. This makes regrowth distinctive, in contrast to continuous growth, especially with respect to how and where new demand for housing/ living space leads to new built-up structures or uses of urban space. The following facts support this argument:

a) Regrowing cities underwent a longer phase of shrinkage in the past. Even when seeing new growth again, the city has to cope with the legacies of shrinkage, including ongoing underuse of infrastructure, vacancies, oversupply of housing, etc. Any new development that might change population development, land use, construction and densities thus will occur within this ***specific frame for population (re)densification***, which is rather unique for regrowth. Due to the reuse of existing buildings, the pressure on the built-up area is low. As we observe in our sample city of Leipzig, these characteristics are not just meeting the demands of people moving into the city; they are also crucial factors for regrowth itself, due to the combination of attractive built structures with affordable land and rents caused by weak housing markets (Haase et al., 2012).
b) The legacies of shrinkage also provide a ***specific framework for new land uses***. Abandonment and vacant land offers space for reuse, alternative and interim uses, as well as infill developments. However, the individual parts of the city are unevenly affected by the new growth, as they were by shrinkage, too. As a result, we have, today, a mosaic of shrinking and regrowing districts next to each other. This constellation is fairly typical for regrowing cities but it is distinct from the relatively homogenous density patterns in cities with linear growth.

c) ***The drivers that are pushing forward new population gains*** in regrowing cities are different from those that we find in continuously growing cities. Regrowing cities see inner-city in-migration, especially by young and small households mainly looking for refurbished but still affordable housing. The intense refurbishment of pre-war inner-city housing stock, as well as post-Second World War infill developments, have led, over a short period of time, to a change from a supply surplus market to one that is much more demand-oriented, with developments that target especially those districts that are already attractive. Consequently, the pressure now is not so much on urban land but on the housing market and on rental costs for residents. In contrast, the slowing down of external subsidies should not conceal the fact that Leipzig still depends on external funding and faces financial constraints, like many other regrowing cities. This leads to limited strategic steering opportunities, compared to continuously growing cities. Thus, we assume that, especially in regrowing cities, a small- scale mosaic of patterns of population and housing density changes will remain, even though the cities experience strong redensification.

d) Because regrowing cities look back to an earlier phase of shrinkage, they often hold many lots of unused/abandoned land that was partly transformed into new green spaces, urban gardens, interim-use sites or afforestation areas (Haase et al., 2014). The strong influx of people lessens environmental impacts of undeveloped land but also increases the ***competition of demand*** for new buildings and the demand to maintain open land or green space qualities that were developed during the phase of shrinkage. Particularly, open and green spaces that are perceived as a pull factor for re-attracting population might be in danger of disappearing, due to redensification. As a result, we find a juxtaposition and proximity of areas seeing re-densification and new construction of housing and areas that still have vacant housing, large-scale open areas and brownfield sites and, as a consequence, low densities.

Conclusions

The objective of this article was to better understand urban regrowth and its implications for the development and use of urban space. Therefore, the implications of the different phases of shrinkage and regrowth for the urban space and the change and persistency of the built-up area have been analysed for the city of Leipzig by focussing on patterns of density changes, together with their driving processes.

The study has demonstrated that population growth is not necessarily accompanied by an increase of the built-up area, or vice versa: We either find densification within an already built-

up area, or that new built-up areas are developed without a direct connection to housing demand. Shrinkage in Leipzig shows a dichotomy of increasing and decreasing densities between the core and the fringe of the city. This is related to the impact of public subsidies for newly built housing in the core, despite population losses in the 1990s. Regrowth, by contrast, reveals a small-scale mosaic of different densities that shows clear impacts of the previous period of shrinkage (vacancies, low housing costs in many areas, new green spaces) but also of demand-driven factors determining the new growth (demand for inner-city housing by young reurbanites after 2000). Thus, regrowth should be understood as a spatially selective process because it is distributed very heterogeneously across the city area, with spatial effects that are partly rooted in previous periods. Depending on the scope of former shrinkage and abandonment, the heterogeneity of patterns will be visible for a long time and will determine the overall picture of land use and population distribution. The emerging patterns and conditions in a regrowing city show, therefore, several differences, compared to continuously growing cities. First, it is important to consider the context of former shrinkage when looking at new growth, e.g. in terms of development of urban land and housing. Second, it is crucial to consider the specific drivers and conditions of supply and demand in regrowing cities that, although they are becoming more similar to continuously growing cities, still differ from them. However, further research is needed on the effects that different migration groups have on the continuity of the regrowth process as well as its spill-overs and impacts on the built environment to the surrounding hinterland.

Doubtlessly, a straightforward, density-oriented analytical approach as presented here can serve, first and foremost, as an initial prerequisite and template for structuring the spatio-temporal patterns in urban settings that are characterised by a strong dynamics and non-linear evolution (as is the case in Leipzig). The approach introduced to conceptualise urban regrowth by calculating density changes through population and built-up area reflects the complex relationship between a changing demand for housing and its impact on land use. On this basis, the concept shows the simultaneity of de-densification and (re-)densification, how this changes over time and where growth is concentrating and thus requires, or does not require, an adaptation of the built environment (where the capacities of districts are exceeded). Furthermore, the analysis of drivers helps to identify possible reinforcing, independent or mitigating processes, in order to better understand the impact of urban regrowth on the built-up area.

Thus, the presented two-step methodology, focussing on the interrelation of population (demand) and built-up area (supply), does not merely help to estimate what a new or reinforced population growth (or even decline) would mean for the physical space and its

implications (Schlomo, 2010). Rather, it can support local planning authorities to analyse, understand and evaluate the dynamics, drivers and impacts of land use change in their respective area of competence or jurisdiction. In light of the duality of promotion of infill development for high-density compact structures and the need to protect sufficient high quality green areas in cities, criteria or thresholds for evaluating (re)densification and arguing in favour or against new density strategies do not exist (Artmann and Breuste, 2014; Nuissl et al., 2009). In this vein, the presented concept and its application deliver precise and context-specific information on the (expected) effects; such information is needed by planners to estimate where to invest public money for what (new constructions or demolition) and to coordinate actions reacting to the changing demand.

This type of information will be of increasing relevance because the strong migration flows to cities all over Europe, including those that were shrinking and see new growth today, will raise the question about comparative work and easily applicable operationalisation approaches. Thus, the presented concept fulfils a twofold function: it accounts, on the one hand, for the complexity and multidimensionality of density changes by combining both demand and supply perspectives and, on the other hand, it reduces the mentioned complexity (by using only two variables) in a way that makes its results comprehensible, informative and interpretable for practitioners, as well as easy to apply to other contexts. In this regard, further research is needed within the provided framework, in terms of both comparable approaches and case studies of growing, shrinking and regrowing cities, in order to achieve a deeper understanding of the impact of population evolution and the corresponding changes in the built environment and their underlying drivers.

Notes

1. Built-up area includes residential, commercial and industrial areas, thus reflecting the whole range of population demand for housing and employment.

2. In order to exclude fluctuations, a change of resident population and built-up area that exceeded 1% was registered.

3. The break between 2003 and 2006 is due to the land use data which are not directly comparable but which allow the analysis of the evolution of land uses from a historical as well as a contemporary perspective.

4. Due to limited data availability for three districts, the reference year 1987 was interpolated using adjacent years. The trend remains the same.

5. The city centre itself is losing population, but basically because flats are being replaced by offices and shops.

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5. Summary of results and discussion

Urban shrinkage is not a new phenomenon (Martinez-Fernandez et al. 2012a), but the extent of its patterns is new. Considering variations in space and time, it can be stated that urban shrinkage is not an isolated phenomenon but is part of the long-term transformation of urban systems towards uneven development, which interacts with growth and follows specific patterns. Following the objective of this dissertation – the identification of the specific role shrinking cities play in the context of uneven development – this chapter summarizes the major results in fact boxes, according to the three research questions and discusses their contribution to the scientific discourse. Thereby, figure 8 reflects the key messages which address the research gaps and figure 9 reflects the corresponding trends in a generalized map. Diagonally to the three questions, a fourth fact box gives evidence of the polarization between growth and shrinkage in Europe. Finally, a reflection on the thesis' approach and on its practical relevance supplements and finishes this chapter.

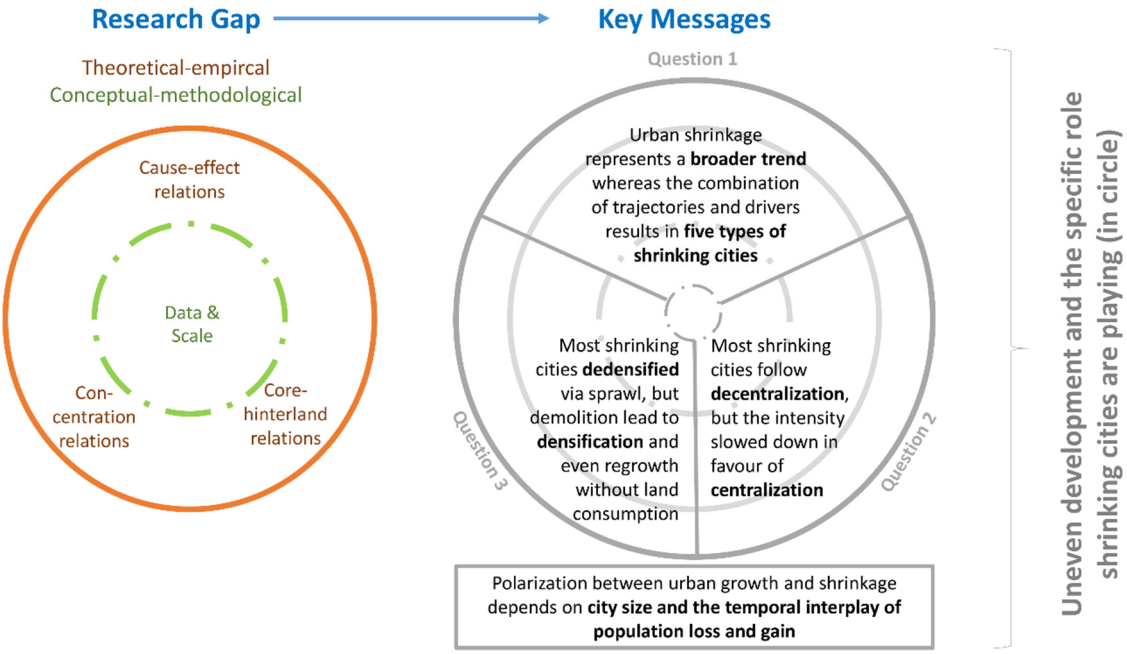

Figure 8: Key messages addressing the research gaps, structured by research questions.

5.1 Main findings and contribution to scientific discussion

To what extend does urban shrinkage represents a broader trend in Europe and what are basic drivers on macro and local level?

FACT BOX I: Urban shrinkage represents a broader trend whereas the combination of trajectories and drivers results in five types of shrinking cities.

With 1 out of 5 cities which have faced substantial population losses between 1990 and 2000 spread over 33 out of 36 European countries, urban shrinkage represents a ***broader trend in Europe***. This trend is especially pronounced in former post-socialist countries such as the Baltic States, Bulgaria, Romania, the Czech Republic, Serbia, and Croatia, with more than half of their cities experiencing population decline. Other Eastern European countries have a share of cities with population losses slightly above the European average (25 – 50 %), for example, Hungary and Poland, whereas the large Western European countries, Germany and France, belong to a group in the range of the European average with shares between 15 and 25 % (see also figure 9).

Considering also short-term fluctuations, a typology of ***population trajectories*** underlines that almost half of all the 7 742 European cities analysed have faced some kind of population loss. Of these 3 784 cities, 37 % show long-term population loss: 14 % with continuous population losses over the observed period and another 23 % experienced episodic losses over the majority of the period, especially between 1995 and 2005. Moreover, among the 2 396 short-term or temporarily shrinking cities (63 %), 883 cities were affected by recent population losses from 2005 on, whereas several medium and large cities (> 50 000 inhabitants) ceased to shrink (337 cities). This underlines that there are regions all over Europe where urban shrinkage has become a familiar pattern, persistent in several cities, whereas in others it has spread to adjacent areas where cities are marked by a recent population decline. The intersection of these trajectories with their major drivers at a regional level reveals five ***types of shrinking cities*** (figure 9).

- ***Natural decline and outmigration:*** A combination of demographic change and deindustrialization is driving long-term shrinkage, especially in post-socialist countries such as Romania, Bulgaria, Poland, Croatia, and Eastern Germany. Unable to adjust to the new market conditions relatively quickly, these basically mono-industrialised cities with a predominance of heavy, extractive and textile industries saw their economies declining, with rising unemployment rates and age-selective outmigration. These trends reinforce the long-term population loss due to the lack of births and a surplus of deaths.
- ***Deindustrialisation and economic disadvantages:*** Long-term shrinkage as a pure effect of

deindustrialization and a constant job-driven outmigration is characteristic of Northern France and Southern Italy but also of several mono-industrialised cities in the New Member States. Structural disadvantages led to inflexible labour markets and a very low proportion of highly qualified employees in the tertiary sector, indicating that these cities can hardly compete with advanced economies but are rather marked by increasing unemployment rates which especially affect young people.

- ***Demographic change and natural decline:*** Natural decline drives long-term shrinkage, basically in less dense regions like the Iberian Peninsula, Hungary, Central France, parts of Western Germany and Austria. Although most of these regions are economically strong, outmigration of young jobseekers, low attractiveness for families and absence of immigration due to a loss of functions such as supply, administration and health services, gave full rise to the impact of natural decline in these cities and led to strongly declining birth rates after 2000 and lower economic growth rates. Significantly, this trend is increasingly affecting cities that accelerate in high shares of recent urban shrinkage: 46 % of cities with population loss after 2005 are located in regions dominated by natural decline.
- ***Imbalanced labour market and crisis exposure:*** Paradoxically, short-term population losses of cities can also be detected in regions with high immigration, such as Spain or Italy. In these regions, cities benefited from the lack of job-opportunities outside the cities, especially during the 2000s. First, this immigration mitigates the low birth rates and the strong ageing process and thus hides the potential of cities to shrink, and second, it leads to imbalanced labour markets with high unemployment as some of these regions are characterized by the production of low-value and non-competitive industrial products. Thus, the corresponding low productivity makes these cities especially exposed to the effects of economic crises, leading to short-term population losses due to outmigration during the 2000s, such as in Ireland, Belgium and the Netherlands.
- ***Recent decline and competition:*** In densely populated and economically advanced regions, an increasing gap between demographics and a growing productivity is measurable. Residential preferences for urban amenities, together with the increasing mobility of a well-educated and trained labour force, indicate that shrinkage is less associated with economic performance and is rather a product of competition between cities. In France, this form of urban shrinkage can be observed in small cities basically located close to larger agglomerations that especially pull out young people looking for jobs and education. Consequently, the positive natural balance is constantly decreasing, leading to increasing impacts of demographic change in the future.

Paper 1: *Wolff, Manuel and Wiechmann, Thorsten (2017): Urban growth and decline: Europe's shrinking cities in a comparative perspective 1990-2010. European Urban and Regional Studies. Vol. 25 (2), pp. 122 – 139.*

Paper 2: *Wolff, Manuel; Fol, Sylvie; Roth, Hélène and Cunningham-Sabot, Emmanuèle (2017): Is planning needed? Shrinking Cities in the French urban system. Town Planning Review. Vol. 88 (1), pp. 131-145.*

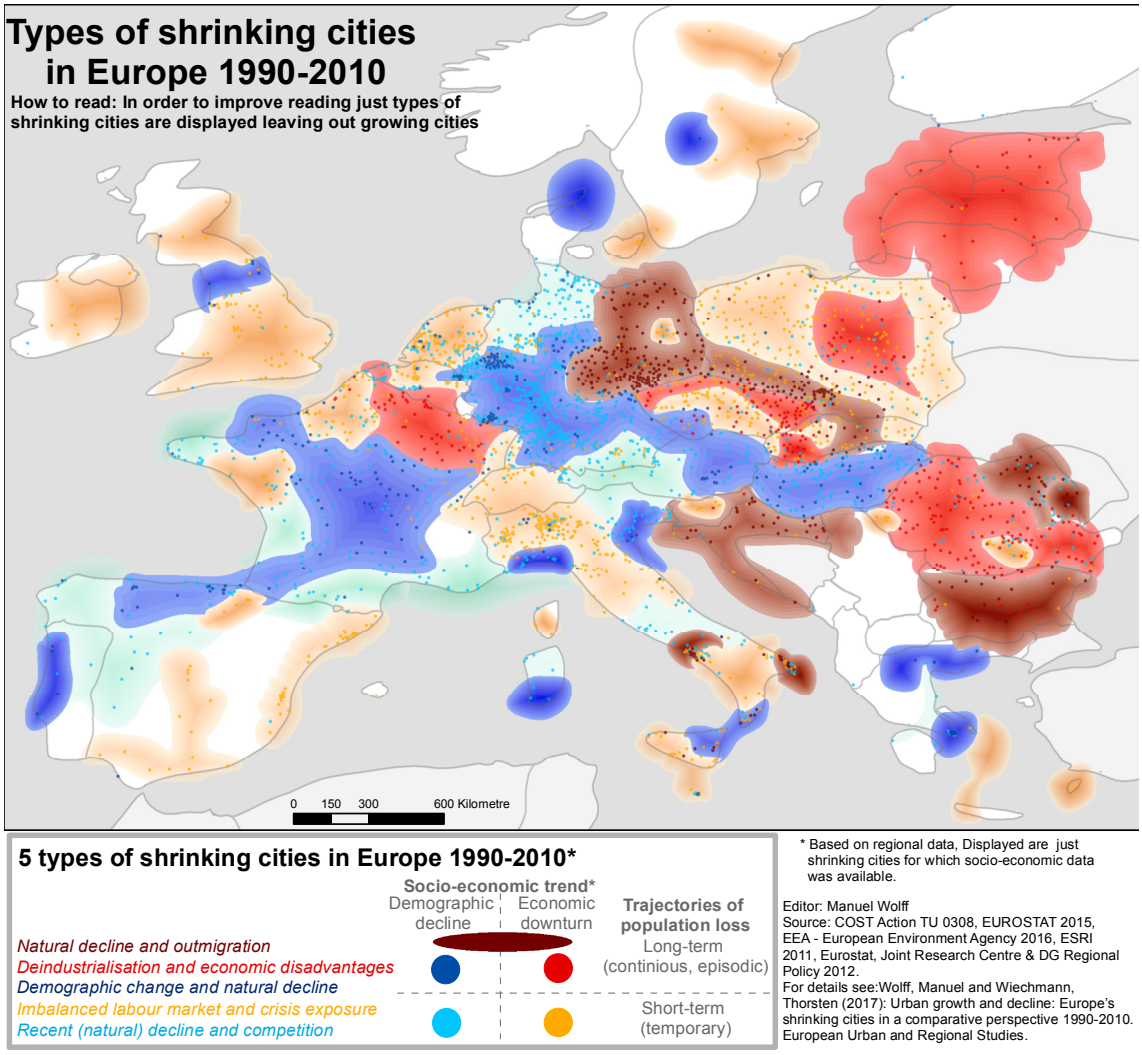

Figure 9: Five types of shrinking cities in Europe 1990-2010 (for details see fact box I).

The applied measurement framework reveals that ***process-specific and spatial-selective aspects*** are deemed most significant for theoretical reflections on shrinking cities. It can be underlined that shrinking cities are a product of multiple processes or drivers, whereas the same drivers do not lead automatically to similar population trends. Nevertheless, the interplay between macro drivers and local factors essentially determine if a city shows short-term losses or follows long-term urban shrinkage (Mallach et al. 2017). Variations of dynamics

depend on the spatial location of a shrinking city within its regional and national context that requires a multi-scale perspective of drivers and effects. The balance between macro drivers and local conditions leads to inter-regional differences in the dynamic of a spatial system, whereas the scattered picture of shrinking cities (types) is thus a manifestation of uneven development. To understand the process of shrinkage, the combination of drivers in various scales and their impacts on local trajectories need to be considered, in both a heuristic and an empirical fashion, in order to fully elaborate theories on urban shrinkage, in line, for example, with the network society perspective (Castell 2000).

In line with the applied model the analysis confirmed that multiple and self-reinforcing negative factors push urban shrinkage towards a ***structural phenomenon*** (Martinez-Fernandez et al. 2012a). The extraordinary speed of urban shrinkage in Eastern Europe, for instance, is clearly a product of the interplay between a lack of births, a surplus of deaths (Müller and Siedentop 2004; Steinführer and Haase A. 2007) and economic erosion. Macro drivers and supranational decisions like the 2004/07-EU enlargement have led to changing migration patterns and even rising GDP in almost all New Member States (Birch and Mykhnenko 2009). Moreover, the impacts of macro trends are not evolving in a similar way everywhere, leading to ***specifications*** of the model. Changes of demand, production, and market conditions have led to a downturn of products (Kaniss 1981; Deaton 2005), affecting cities all over Europe. However, the structural disadvantages of specific cities have led to inflexible labour markets (Ferrerol 2010), a further decreasing diversity of the local economy and a decreasing adaptability to changing production factors on the global scale in terms of labour, capital, technical progress, etc. (Acemoglu 2009), thus leading to long-term shrinkage especially in old-industrialized Western European regions (Baron et al. 2010). Neo-classical growth theories help to understand the reasons for the corresponding structural economic problems of a shrinking city but they hardly explain why these cities are kept in the process of long-term shrinkage. Better explanations are needed following post-Keynesian theories which allow the feedback loops of socio-economic processes on different scales to be understood, especially in terms of the mobility and volatility of capital, workforce and investments, and the corresponding political-economic interventions which made cities more exposed or resistant to economic crises during the 2000s (Haase A. et al. 2014; Pallagst et al. 2014; Salone et al. 2016).

Understanding feedback loops will also help to detect under which conditions urban shrinkage mutates to a structural phenomenon**.** However, for several European regions, the decoupling of population trends from economic success is significant, for which the dissertation approach

identified ***variations*** from the model assumption. Neither does economic downturn automatically lead to urban shrinkage, which is observable in Southern Europe, nor does the economic success of a region prevent its cities from shrinking. In light of the upcoming demographic recession, urban shrinkage is intensively driven by lack of births, which is visible as soon as immigration to cities is absent. Productivity growth and economic investments have fewer effects on the labour market and thus on population changes, thus refuting clear economic-demographic cause-effect relations in large parts of Europe. However, ***demographic-economic feedback loops*** could be taken into account to further develop the theory of SDT which gives valuable explanation as to why fertility levels remain so low based on the increasing impact of individualism and the pursuit of personal development (EP 2008; Lesthaeghe 2010). Due to higher job offers, rising living standards and technological innovations influencing the reproductive behaviour of whole countries such as Germany, the impacts of natural decline are expected to increase, even in economically advanced regions (Ferry and Vironen 2010). The economic consequences are a lack of job-starters for certain industries, and an increasing discrepancy between a qualified demand and an unqualified supply (Hannemann 2003) demanding further vocational training of elderly employees (EC 2014). This, in turn, discourages economic activities, entrepreneurship and private and public investments, making cities more exposed to changing forms of production, functional aggregations of industry in space and strategic decisions (Massey 1984; Scott 1988) with corresponding migration decisions of their residents.

Are cities[16] decentralizing or centralizing and are there differences between growing and shrinking cities?

FACT BOX II: Most shrinking cities follow decentralization, but the intensity has slowed down in favour of centralization.

Urban shrinkage affected 29 % of all European cities between 1990 and 2000 and the share even increased to 35 % after 2000 – especially among those cities with declining hinterlands. Two major trends characterized the relation between shrinking cities and their hinterlands: cities that start to shrink due to decentralization, and a trend towards centralization among shrinking cities.

The application of the life-cycle model underlines that absolute ***decentralization in shrinking cities***, which is expressed as suburbanization with stronger hinterland growth rates and core

[16] In this text the term 'city' is used throughout the text whereas in the corresponding paper the term 'urban area' is used for methodological reasons. Thus, the share of shrinking cities (according to fact box I) differs from the share of shrinking urban areas (fact box II).

decline, is especially visible in East-Central Europe, France, and Ireland, where the numbers even increased, due to migration into the hinterland after 2000 (figure 10). Decentralization is especially fast for growing cities in Southern Europe, Northern France and the Benelux countries, with constantly increasing growth rates in their hinterlands. Similar to Spain, especially larger centres in Southern France report high decentralization rates characterized by high but stagnating employment rates in the cores and fast increasing rates in the suburbs, accompanied by a decreasing share of young people in the core and rising unemployment rates. However, this decentralization is driving growing cities towards shrinkage, especially in Northern France, Poland, and Slovakia – all leading to a hollowing out of the core city with aging and decreasing birth rates. In North-Eastern France, cities have reported high and increasing outmigration since 1975, accompanied by high unemployment rates, whereas their hinterlands report immigration of young people.

In most parts of Europe, urban shrinkage is especially pronounced when the corresponding hinterland declines, leading to relative decentralization with stronger population loss in the cores, or centralization with more pronounced hinterland losses. After 2000, the number of cities characterized by these stages increased to 7 %, underlining the fact that urban shrinkage is of increasing relevance. By measuring the intensity of the observed core-hinterland processes, it is obvious that the general trend of shrinking cities reveals a slowing down of decentralization in favour of ***centralized decline***; in other words, population decline in the cores slowed down and the hinterland lost population faster, as is especially pronounced in Western and East-Central Europe (figure 10). The slowing down of core losses is basically due to the immigration of elderly people into cores that can still provide social and technical infrastructure after 2000 but led to a strong core aging. This trend pushed 104 cities with former stronger losses in the core to centralized decline after 2000, for example in Eastern Germany and Hungary.

Even more significant is the constant weakening of the hinterland, with stronger population loss and marked aging, compared to the declining cores: Although the average losses significantly increased, the hinterland still lost population faster than the cores. This indicates that these cities survive at the expense of their (rural) hinterlands and, perhaps, turn to pronounced shrinkage, due to the absence of immigration and to natural decline. An intensified out-migration of young people in particular from the cores, a slowing down of immigration from rural areas and a drop in the number of children pushed 101 declining cities from centralized to decentralized decline after 2000. This trend is most significantly in Romania and Bulgaria, with a strong increase of the dependency ratio – the highest among all European

regions.

Paper 3: *Wolff, Manuel (2017): Understanding the role of centralization processes for cities – evidence from a spatial perspective of urban Europe 1990 – 2010. Cities. Vol. 75, pp. 20-29.*

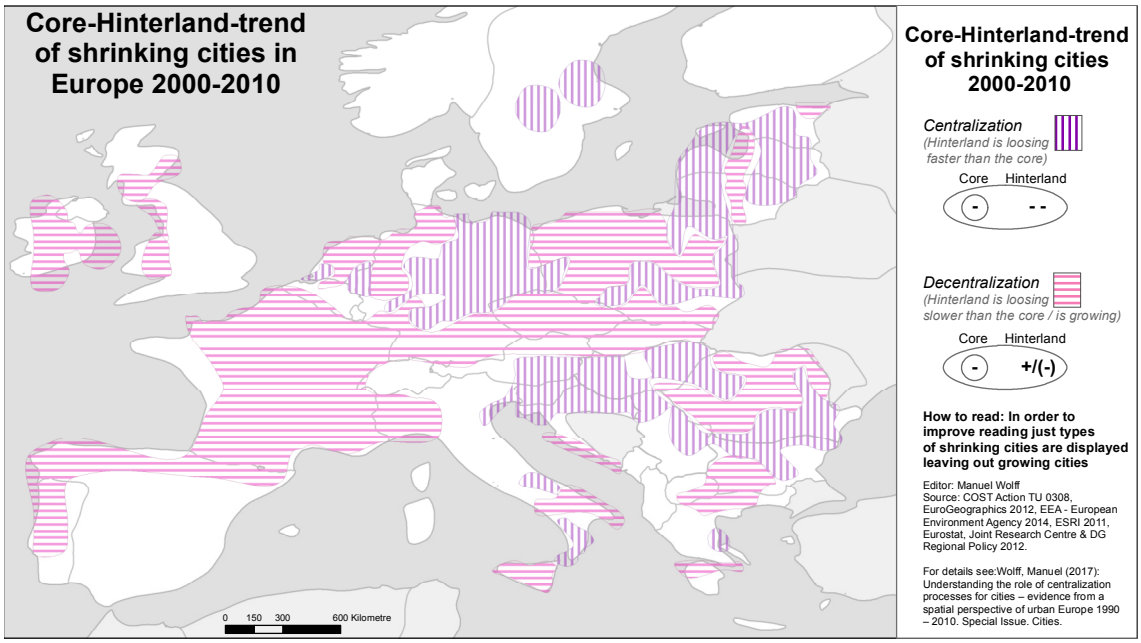

Figure 10: Core-Hinterland-trend of shrinking cities in Europe 2000-2010 (for details see fact box II).

This dissertation underlines that the development of the city's core also depends on the role of the hinterland. Thereby, an increasing polarization of centralizing and decentralizing growing cities and a trend towards centralized decline was identified, all of which represent manifestations of uneven development. Besides decentralization tendencies in the heart of Europe, the hinterland is losing importance for both growing but especially for shrinking cities. These trends rarely follow a successive order of urban life-cycle models; instead, they show some self-reinforcing processes, such as aging, leading to brief fluctuations between stages, whereas others remain persistent over decades. The life-cycle model is very effective in capturing the current state of (national) urban systems with regard to their core-hinterland relationships. However, the consecutive order of the model's stages hardly captures the changes between centralization and decentralization processes after 2000 due to ***complex development trends*** such as migration and the extensive differences between countries (see also Nyström 1992; Champion 1995; Cheshire 1995; Kabisch N. and Haase D. 2011) as an expression of uneven development. This requires the extension of life-cycle models, as the approach has demonstrated, as well as a redefinition of cities' role for their hinterlands - not as isolated territorial containers but, rather, as having interrelationships with their hinterlands. By

applying a four-stage model, which does not assume a consecutive order of stages, as well as the measurement of (de)centralization and shifts in age groups the approach provides insights into deviations from the life-cycle model, the speed of changes and the role of different age groups.

For growing cities, centralization and decentralization trends are interrelated, especially in central parts of Europe, whereby both stages seem to rotate, rather than to follow one single path. It can be concluded that suburbanization is to a large extend not separate from urbanization (Champion 2001). Moreover, it is hard to imagine that the core cities of highly suburbanized cities in economically strong regions in Western and Northern Europe will lose population according to the model developed by van den Berg et al. (1982). Instead, an increasing ***polycentric pattern*** might be expected, with suburbanization still playing a role in future core-hinterland-relations which used to be dominant since the 1970s in Western Europe and in the 1990s in Eastern Europe (Cheshire 1995; Kotus 2006). In some regions, shrinkage proceeds from growth towards shrinkage via suburbanization in line with the model (Champion 2001; Kabisch N. and Haase D. 2011). However, this does not always coincide with a general decline in the economic activity of the city, because people moving to the suburbs may keep their jobs in the city as is measurable in shifts of the age structure (see also Baccaïni and Levy 2009). This also explains why suburbanised long-term shrinking cities are located in regions that perform well in terms of economy and labour. Consequently, it needs to be questioned whether suburbanization should be understood more as a spatial consequence driven by economic (income or welfare) or demographic (single family houses) factors rather than as a causative driver of urban shrinkage such as economic transformation.

Although the majority of shrinking cities have decentralized, the intensity significantly slowed down in favour of centralized decline, with stronger population losses in the hinterland and an unfavourable age structure. However, the ***speed of these trends and the shifts in age groups*** make it uncertain that these cities will turn to growth in keeping with the van den Berg et al. (1982) model. Thereby, different age groups show different behaviour, for example, in terms of mobility and residential choices, and contribute unevenly to natural growth (elderly vs. young). However, those cities currently benefiting from immigration of the elderly would be tied to the continuous supply of people and capital. These centralized declining cities with retirement pensions can be regarded as future shrinking cities (EP 2008). Due to their current age structure and the speed of aging and centralization, it is hardly imaginable that these shrinking cities will turn to growth along the life-cycle model. Rather, the strong hinterland decline suggests, instead, a return to decentralized decline, inverse to the model, as soon as the hinterland is ‘empty’, as is visible in South-Eastern Europe. The spatial clustering of

declining cities dominating whole countries points to the impact of international migration, for example for jobs, leading to increasing numbers of decentralized declining cities in departure countries with abandonment in the hinterland. Moreover, out-migration and the absence of immigration give rise to the impact of natural decline, leading to rapid population decline, which is already indicated by the growth rates among centralized declining cities. Thus, it can be concluded that the majority of shrinking cities are locked in a disurbanization stage, with a trend towards centralized decline and a possible turning point that will push them back to decentralization in the future.

What is the impact of a changing human demand under conditions of growth and shrinkage on density changes within a city?

FACT BOX III: Most shrinking cities dedensified via sprawl, but demolition led to densification and even regrowth without new land consumption.

Although one third of all cities (29 %)[17] experienced population loss between 1990 and 2010, a significant reduction in residential area is valid for just 9 %. However, in the complex setting of changes of population and residential area, two trends of density changes after 2000 can be detected: sprawl parallel to population decline as well as densification in shrinking cities.

Decreasing densities are basically driven by the disproportionate development of physical expansion and population development. This refers to ***deconcentration and urban sprawl (sprawl shrinkage)*** with increasing rates of land-taken faster than population grows (figure 11). The corresponding share of growing cities increased to 37 % between 2000 and 2010 in countries such as Greece and France or the Netherlands, Spain and Italy. However, decreasing densities are also measurable for shrinking cities due to expanding residential area although population number declined. This trend of sprawl without population growth covers 27 % of all, but especially small, cities. Their corresponding rates of density change increased after 2000 and dominate the post-socialist countries such as Poland and the Czech Republic and have also increased particularly in Slovakia, and also in Germany.

One example is the city of Leipzig which experienced strong population losses due to suburbanization and job-driven outmigration accompanied by extensive residential vacancies. The lack of fit between a decreasing demand and an expanding housing supply and residential area expresses a supply-driven construction pattern. Constructions of new residential buildings

[17] In this text the term ‘city’ is used throughout the text whereas in the corresponding paper the term ‘urban area’ is used for methodological reasons. Thus, the share of shrinking cities (according to fact box I) differs from the share of shrinking urban areas (fact box III).

and commercial sites had been favoured by funding and tax or credit policies within the East German context. The shortage in (inhabitable) housing in the early 1990s due to long-term neglect required the construction of new housing such as townhouses which led to an expansion of the residential area in the inner-city districts. Furthermore, residents were pulled out to the inner-urban fringe districts where the construction of single-family and semi-detached houses with a large household size was favoured by subsidies and credit policies. This tremendous housing oversupply and dropping population numbers led to under-utilization of urban land, namely housing stock, infrastructure and services suppliers, with comparable high vacancy rates especially in old building stock with low standards in the inner city – a typical characteristic of post-socialist cities.

After 2000, a 'physical adaptation' in terms of decay and demolition of buildings can be observed for an increasing number of shrinking cities. Although the residential area in these cities (8.4 % of all cities) was reduced, the corresponding decline in densities shows that population loss is faster than the physical infrastructure can be adapted, for example in Bulgaria and Romania but also in peripheral regions of the Baltic States, Austria and Slovakia. In contrast, the rate of demolition can even exceed the rate of population loss, leading to the paradox of increasing densities in shrinking cities and to ***compact shrinkage*** (figure 11) which is – in absolute numbers – particularly visible in Germany as a result of large-scale demolition programs. This type of 'right-sizing' or compact shrinkage is also associated with the reduction of residential areas through the conversion to other land use forms such as transport or commercial area and even parks.

In Leipzig, publicly funded demolition led to a supply-driven demolition pattern of density changes. Due to the demolition of residential multi-story tenement buildings which were run down as a consequence of neglect and disinvestment during the GDR era, and industrial sites, especially in the central part of the city, densities increased. This is rather unusual for shrinking cities, because the residential area decreased faster in relative terms than the population. Moreover, after initiating the federal program Stadtumbau Ost in 2002, a substantial number of flats were demolished in non-attractive districts with a high number of prefabricated houses constructed during the period of state socialism**.** Hence, the reduction of the surplus of residential housing has led to a substantial number of brownfields and to a perforation of the urban space in the form of dissolution of the street or block structure. However, this demolition has substantially decreased the high vacancy rates and thus stabilized the housing market as an essential precondition for the upcoming regrowth.

Paper 4: *Wolff, Manuel; Haase, Dagmar; Haase, Annegret (2018): Compact or spread? A quantitative spatial model of urban areas in Europe since 1990. Plos-ONE. Vol. 13 (2): e0192326*

Paper 5: *Wolff, Manuel; Haase, Annegret; Haase, Dagmar; Kabisch, Nadja (2016): The impact of regrowth on the built environment. Urban Studies. Vol. 54(12), pp. 2683–2700.*

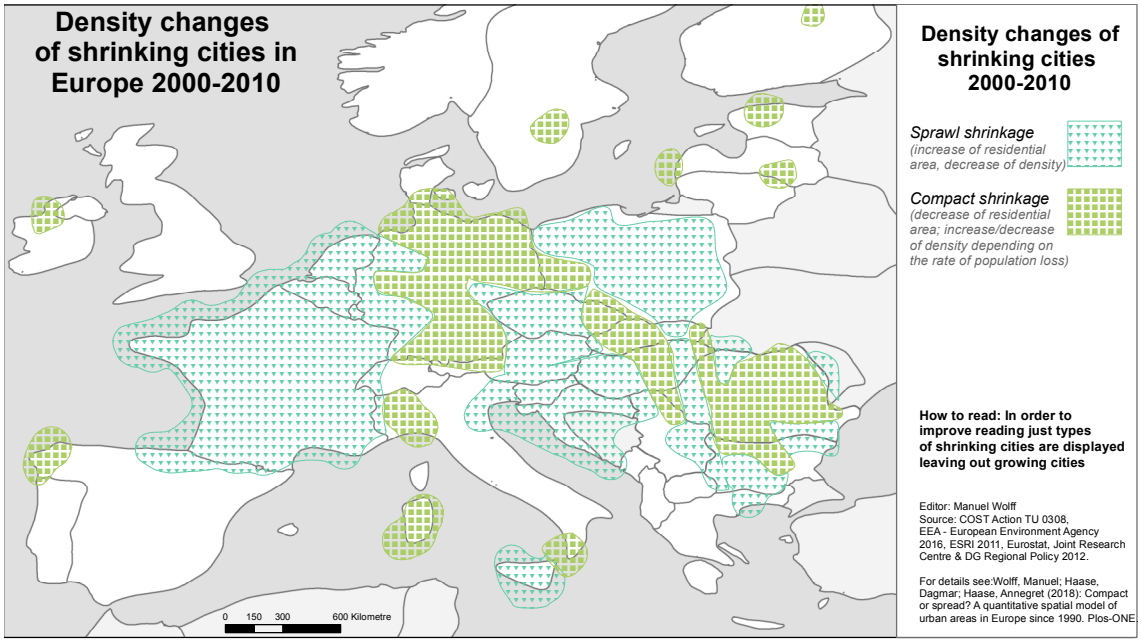

Figure 11: Density changes of shrinking cities in Europe 2000-2010 (for details see fact box III).

Using a model which was developed for a global sample (Angel et al. 2010; Angel et al. 2011), the approach used in this dissertation detected trends of density change which are ***unique for Europe***. Europe is the continent where urbanization significantly slowed down, with faster population loss in cities after 1990. Population dynamics fluctuate much more than a change in the physical shape of a city because housing and infrastructure investments tend to have a long life-span and show a considerable inertness with slower rates of change, whereas migration patterns in particular may change very quickly. Consequently, different expressions of density changes can be found which are differently distributed over the continent and follow different driver settings. Moreover, this dichotomy of increasing and decreasing densities is also visible when changing scales, such as to districts, pointing to different trends in the city's neighbourhoods like the example of Leipzig has shown. The analysis of drivers helps to identify possible reinforcing, independent or mitigating processes in order to better understand the specification of densification and dedensification in shrinking cities compared to growing cities.

Undoubtedly, considerable population decline over just a few years, particularly in Eastern Europe and in post-industrial regions in Western Europe, has led to dedensification in shrinking cities. However, the extensive construction activities parallel to population decline substantially contributed to these decreasing densities. This ***sprawl under shrinkage conditions*** led to an increasing disparity between a declining population demand and an increasing supply in terms of residential areas and housing. The effects were similar to those that we find in growing, sprawling cities such as infrastructure underutilization, consolidated economies, productivity and investment decisions (Rosenthal and Strange 2004; Fons 2014). All of these effects have, in turn, impacts on land use, such as an increasing pressure on ecosystems and soil-sealing that threaten biodiversity and increase the risk of both flooding and water scarcity (Fons 2014). In contrast to growing cities, economic or income growth can only explain land consumption in shrinking cities to a certain extent (Chin 2002; Siedentop and Fina 2012). Rather, changing housing preferences – for example, for detached or semi-detached houses built more sparsely as free-standing and hence more space-consuming building structures – determine the decreasing density in the centre and at the fringe of shrinking cities (Kasanko et al. 2006; Siedentop and Fina 2008; Kroll and Haase D. 2009). Even more significant for density changes in shrinking cities are differences in ***national planning systems and regulation***, including institutional fragmentation and the variety of responsible administrative actors at different levels (Tosics et al. 2010; Siedentop and Fina 2012). In post-socialist Europe, for instance, changing spatial planning systems, privatization of the housing stock, cheap land and a lack of trust in planning regulations led to extensive sprawl from the early 1990s onwards (Kotus 2006; Haase A. et al. 2013b). As a consequence, massive construction activities with few constraints on land use or in the absence of master plans are observed in growing but especially in shrinking cities (Steinführer and Haase A. 2007; Bauer et al. 2013). In contrast, Eastern Germany is a particular case for the supply-driven political-economic interventions and investments for new residential and commercial constructions. The case of Leipzig has shown that the increase in construction activities in shrinking cities is also part of a strategy targeted at stabilizing the housing market, especially because of a neglected building stock and the associated demand for quality housing (Kabisch N. et al. 2009). External public and private investments into housing, businesses, infrastructure, and public services, framed by national tax policies and planning regulations, have fostered this trend.

Similar to decreasing densities in shrinking cities, ***national political-economic interventions*** are considerably impacting density increases in shrinking cities what was achieved due to a reduction of residential areas by national demolition programs, such as ‘Stadtumbau Ost’ in

Eastern Germany. Because the population was constantly dropping, this program aimed at overcoming housing vacancies and oversupply, stabilizing the housing market and adapting infrastructure facilities and networks in addition to moratoriums on housing construction in suburban areas (Couch et al. 2009; Rink et al. 2012). As Leipzig has shown, this resulted in the simultaneity of two opposing developments after 2000: redensification in inner-city districts on the one hand, and dedensification due to further outflows and – additionally – demolition of housing in the large housing estates in the at the inner fringe of a city. This is typical for many shrinking cities in Europe where demolition mostly took place in large housing estates (e.g. built during the socialist era) or in older and substandard housing (e.g. semi-detached housing areas in UK cities) in order to 'balance' the housing market (Couch et al. 2005).

Generally, push and pull factors that operate beyond the cities' administrative borders (governmental policy regulations, taxation, investments in transportation, and the economy) require more attention from research. Although national interventions play a major role in the development of shrinking cities, more attention needs to be paid to the ability to reduce the physical area depending on welfare systems such as in Germany or the UK (Haase A. 2015) in contrast to other national systems. This is necessary as these interventions strongly interrelate with local factors such as land use regulation, planning regimes or available space for construction (Seto et al. 2011). Still, this compact shrinkage is an interesting case because it provides an opportunity for densification and compaction based on slowed or halted population decline, which may stimulate inward growth.

Polarization of regrowth and shrinkage

FACT BOX IV: The polarization between urban growth and shrinkage depends on city size and the temporal interplay of population loss and gain.
City size plays an important role in urban shrinkage. In absolute numbers, smaller cities are predominantly more affected by shrinkage, especially during the 2000s when a substantial proportion of small cities lost population of more than 2 % p.a. such as in Western and South-eastern Europe. In France, 74 % of the 69 shrinking cities have less than 50 000 inhabitants. However, in relative terms, a positive ***relationship between city size and shrinkage*** is visible. In Europe, the proportion of shrinking cities with less than 10 000 inhabitants is very low at 17 % but increases with city size up to 30 % among medium-sized cities between 300 000 and 500 000 inhabitants. However, this relationship does not hold for the largest cities of over 500 000 inhabitants. Their growth rates increased after 2000 in particular, as in Northern and

Western Europe (figure 12).

Focussing on the non-linear ***interplay of population loss and gain***, the trajectory typology presented in fact box I reveals that among the large number of 2 396 temporarily shrinking cities, 883 cities were affected by recent population losses after 2005 – predominantly small cities. In contrast, the majority of the 337 cities which ceased to shrink after 2005 are medium-sized and large cities (> 50 000 inhabitants). Residential decisions targeting basically larger cities accompanied by the stagnation of suburbanization and (international) immigration led to the regrowth of cities, most significantly after 2005, as in Germany, the UK, Spanish-French Mediterranean areas, in Northern Italy and even in Eastern Europe, that used to belong to the 'pole of shrinkage' in the 1990s. The parallel weakening hinterland with population loss and aging expresses a strong trend towards centralization, essentially driven by young families and job-starters. However, whereas the increasingly younger age structure and the increase in the number of children in Western and Northern Europe demonstrate that these groups basically remain in the cores, strong aging and declining birth rates in Southern Europe indicate that these cities pull people from rural areas but, at the same time, serve as departure points for movement to larger cities, or even abroad.

Moreover, these regrowth processes show ***variations*** within the city with rapidly regrowing districts and still disadvantaged ones. With its regrowth, the city of Leipzig, especially the inner city districts, showed a rapidly increasing number of new small and young households and significantly dropping vacancy rates. However, this population increase occurred without a significant increase in residential area but rather with an intensified refurbishment and reuse of existing vacant building structures. This phenomenon of densification without an expansion of residential areas can be observed in large parts of Europe after 2000, covering 10 % of all cities without a characteristic spatial concentration, providing clear evidence of reurbanization and regrowth of cities in Europe. The average change in density rates of these cities significantly increased between 2000 and 2010 and even exceeded those of dedensifying growing cities. This goes along with a significantly increasing polarization between large and small cities after 2000. Whereas the number of growing densifying cities below 100 000 inhabitants decreased, its number among larger ones substantially increased. Moreover, the differences between growing and shrinking small cities significantly increased as an effect of simultaneous population growth and decline and any associated densification and dedensification processes among these small cities.

Paper 1 to Paper 5.

The non-linear perspective of this dissertation demonstrated that shrinkage is not limited to small cities but also affects the intermediate levels of the urban hierarchy in Europe. Thus, there is hardly a correlation between growth rates and city size but rather between the balance of city size and location, as well as drivers and trajectories. Small cities can also grow very fast as they benefit from 'borrowing' agglomeration effects while avoiding agglomeration costs (Camagni and Capello 2015; Meijers et. al 2015). Based on relationships and flows (e.g. transport, digital networks etc.) to neighbouring agglomerations, these cities compensate their size disadvantages by location and compete for the increasing mobile workforce like larger cities (Batey and Friedrich 2000; Sánchez-Moral 2017). This means that the function and relative importance within an urban system matters beside the pure size of a city (Kourtit and Nijkamp 2013).

However, this should not hide the fact that predominantly small cities are affected by long-term shrinkage, as they cannot provide jobs and education while struggling to revitalize their economy (Turok and Mykhnenko 2007). Small shrinking cities in countries such as France are given poor attention by policy makers as they are of little relevance for the national economy. Consequently, most of these cities do not benefit from large-scale public and private investments, with the result that they constantly rely on the growth paradigm. Their decline of population density – widely seen as characteristic of shrinking cities (EP 2008) – is basically rooted in the expansion of residential area due to site planning for building ground. As the number of shrinking cities increased until 2010 as a consequence of negative birth rates and changing migration patterns, it can be expected that population decline is most likely to continue accompanied by the disproportional developments between a declining demand by population and an increasing supply in terms of housing and infrastructure facilities – a fact that has been given too little attention by scholars and planners.

In contrast, larger cities experienced a strong regrowth after a considerable population loss - mostly referred to as reurbanization (Berry 1977; van den Berg et al. 1982) – a process which can be characterised by three points.

- City Size and drivers: As stressed by spatial economics theorists, ***large cities are able to accumulate*** both economic activities, services and a qualified workforce, not just in terms of quantity but also in terms of diversity, thus playing a key role in regional economies, innovation, and creativity (Krugman 1991; Florida 2005; Cheshire 2006; McCann 2017). Thus, large cities are more likely to be able to regrow than smaller ones. Moreover, external investments in the sense of neo-liberal governance actions (Champion 2001) essentially target larger cities and help to improve the economic diversity and other

amenities (Kabisch N. and Haase D. 2011). However, regrowing cities experienced a changing driver constellation from previous supply-driven patterns towards demand-oriented trends. The case of Leipzig has shown that during regrowth, state funding and subsidies for demolition, modernization, and infrastructure slowed down parallel to a considerable population increase in Leipzig, especially in the attractive inner-city districts (Rink et al. 2012). The stabilization of population numbers and reuse and revitalization usually start in selected inner city areas, which offer better infrastructures, cultural and educational facilities, as well as green and recreational spaces (Couch et al. 2009; Rink et al. 2012; Haase D. et al. 2014a). These are the 'spatial fixes' that concentrate investments within the physical infrastructure of a city which enters regrowth (Harvey 2000; Harvey 2006; Martinez-Fernandez et al. 2012; Haase A. et al. 2014). The housing market no longer needs to be stabilized from the supply side but becomes increasingly demand-dominated due to increasing population numbers, densities and constantly dropping vacancy rates starting in selected parts and increasingly affecting the whole city. There is no empirical evidence that these spatial 'spill-over' trends can also emerge in small cities.

- Preconditions: As the example of Leipzig shows, specific ***preconditions*** rooted in processes which evolved during shrinkage are required for the emergence of regrowth (see also Power et al. 2010). The refurbishment provides attractive housing conditions but also an expansion of the housing supply with dropping prices and rents (Bontje 2014). This allowed a large choice and a 'quasi-free' movement, especially of younger small households, into inner city districts, providing new parks and green spaces created due to the demolition of industrial sites and run-down buildings. Thus, the side-by-side of ongoing demolition, high vacancies, refurbishment and reuse of existing buildings with affordable rents is not just meeting the demand of people moving into the city. It is also a crucial factor for regrowth itself, due to the combination of attractive built structures with affordable land and rents due to weak housing markets - a general trend of not just East German but European cities (Herfert 2002; Haase A. et al. 2005; Wiest 2005). This makes regrowth distinctive in contrast to continuous growth, especially with respect to how and where new demand for housing or living space leads to new built-up structures or uses of urban space. Depending on the scope of former shrinkage and abandonment, the heterogeneity of patterns will be visible for a long time and will determine the overall picture of land use and population distribution.
- Spatial dependencies: Regrowing cities rarely evolve according to the life-cycle model but rather share a ***quick evolution*** from shrinkage to growth, as in Germany (Leipzig) for example, whereas their hinterland and surrounding region still suffer from out-migration,

natural population loss, and economic decline. This is, first, due to the halted and inverse suburbanization and aging of former house-owners, a phenomenon already known from the US, which was essentially driven by the phasing out of funding for private housing construction since the mid-2000s in Germany. Second, regrowth occurs at the ***expense of smaller cities***, both in peripheral locations but also in closer proximity. From this perspective, it is not the structural economic disadvantages of one city but, rather, the economic growth and attractiveness of adjacent cities that leads to shrinkage in line with the polarization thesis (Häußermann and Siebel 1988). Due to cohort effects and changing residential preferences cities can experience a parallelism of regrowth and suburbanisation, shrinkage and hinterland decline or any other possible constellation of these urbanization processes. In this regard, city size seems to play an increasingly more important role in the recent polarization of the urban landscape in Europe, revealing that urban shrinkage is driven towards the backyards of urban systems away from larger metropoles. However, most regrowing cities are dependent on immigration and are not economically self-sufficient, thus raising the question as to whether these cities can manage to compensate for the 'loss of endogenous demographic vitality' in the future (EP 2008). Thus, these processes are essentially determined by the spatial and demographic dependency between weak and strong cities which requires thinking about new ways in which drivers interact.

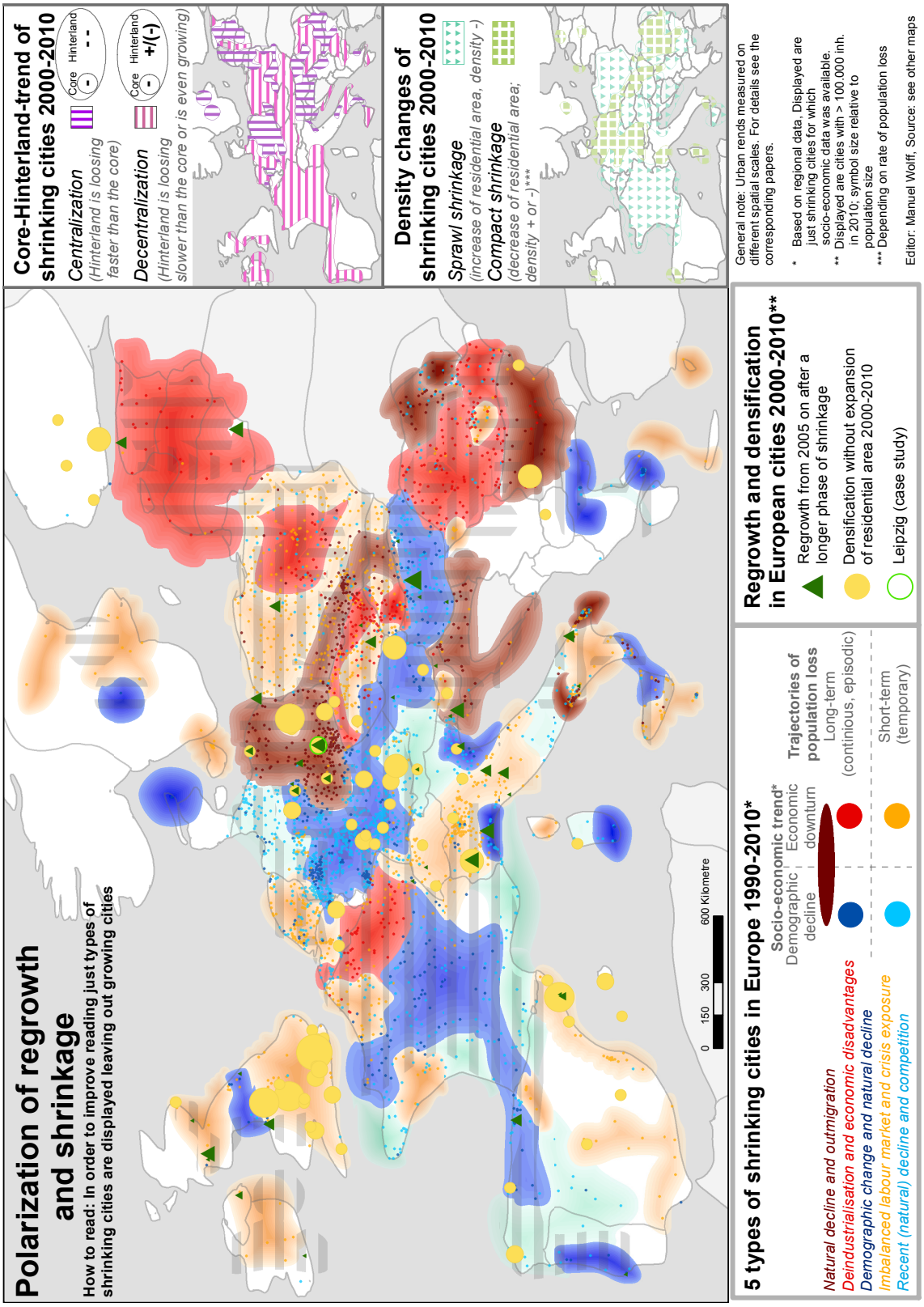

Figure 12: Polarization of regrowth and shrinkage (for details see fact boxes I to IV).

5.2 Conclusion on methods and uncertainties

Many European cities have already lost population and the rate is more than likely to increase in the future, representing a major challenge for future urban policies and urban research. Therefore, the approach developed within this dissertation thesis addresses major conceptual-methodological issues which are basically related to the challenge of scale and data. In terms of ***scale*****,** three delineations of cities have been developed that are strongly related to the research questions. The advantage of these delineations is, first, their comparability between countries which allows different models to be tested in a cross-country perspective. Second, in accordance with the research objective and the underlying model, administrative, functional and morphological definitions of cities have been applied which are based on each other[18] and allow a flexible application depending on the research question. Third, most beneficial for the performed analysis is the fact that small cities could also be studied, thus completing the picture of hitherto known studies on larger cities.

In terms of ***data***, different databases are combined. Centrally, a unique database with local population numbers was established for the years 1990, 1995, 2000, 2005, and 2010, which allows the aggregation to different delineations of cities and their hinterlands and the analysis of different periods. In order to allow comparability with other studies, population development is used as a core indicator for describing and identifying shrinking cities. Following the models under investigation, the explanatory power of population development was enriched by linking other data.

Thereby, three ***models*** have been applied and extended. First, a heuristic model of urban shrinkage (Haase A. et al. 2014) was tested for the first time, combining local population data and linking to a socio-economic database on NUTS 2 level in order to test the influence of macro drivers. Some model assumptions could have been confirmed and specified, while hitherto hardly perceived types of shrinking cities could also be detected. Secondly, by using variations of population development in the core and the hinterland, the urban life-cycle model (van den Berg et al. 1982) was tested and extended. The applied restructuring of phases and the measurement of (de)centralization and shifts of age groups (Cheshire 1995; Parr 2012) gives valuable information about mechanisms of urban-hinterland relations and reveals the differences between shrinking and growing cities. Third, a density model developed by Angel et al. (2011) was tested by linking population and land use data, and was further extended to reflect the special role of urban shrinkage in Europe. The extended approach helps to better understand why population growth alone is not sufficient to explain the growth in urban land

[18] Morphological units (question 3) have been developed based on administrative units (question1) and form the basis for functional units (question 2).

consumption. The application of all models was performed covering the very dynamic period between 1990 and 2010, accompanied by a national (France) and local (Leipzig) case study which allow the extension of the time horizon, building on a larger variety of data and thus helping to deepen the understanding and findings on the European scale.

The ***benefit*** of the conceptual-methodological answers developed within this thesis is that the role urban shrinkage plays within all three models has been identified. This overcomes some methodological problems and allows some anchor points for bridging the topic of urban shrinkage to further establish debates such as economic and environmental discourses, etc. This dissertation conceptualizes urban shrinkage as a complex and multi-dimensional process operating on different scales and expressed by (local) population loss, and thus addresses theoretical-empirical challenges. This straightforward analytical approach can serve, first and foremost, as an initial prerequisite and template for structuring the spatio-temporal patterns in urban settings that are characterized by high dynamics and non-linear evolution and thus enables a further elaboration of a 'theory of urban shrinkage'.

However, the basically descriptive results presented here do not establish clear cause-effect relations but rather conclude on these trends based on probabilities, rates, and major frequencies using different scales and data. The dissertation intends to provide a spatial picture covering Europe as a whole (figure 9) and paying attention to the specifics of urban shrinkage as much as possible from a quantitative perspective. What is beyond the scope of this dissertation is to sufficiently address local specifics (except of the case study Leipzig) which would allow place-specific causes and effects to be concluded in addition to the role certain 'path dependencies' may play, taking into account the city's historical role e.g. as an administrative centre (Mulder 2013). Moreover, further research could build on the dissertation's results and investigates the relation between population dynamics and transport, commuting or accessibility. Finally, the role of 'tipping points' can be exemplified by questioning under which conditions a city or even an urban system turns to shrinkage (Kourtit and Nijkamp 2013).6

In this regard, ***further research*** following the quantitative approach of this thesis can enrich the results in three ways. First, case studies can check for the relations between causes, trends and effects as well as the interrelations between all elements. Second, the established databases can be extended by adding additional reference years, adding other proxies such as household or migration data or combining delineations with other data such as a combination of the analysis of drivers on a district level or density changes in the hinterland. Third, alternative classification approaches can enrich the results by incorporating further local data,

the role of city size and using Principle Component Analysis (PCA) or Structural Equation Modelling. This may help to develop future perspectives for shrinking cities beyond the growth-paradigm, in order to convince practitioners that planning for shrinkage is an exciting challenge rather than a threat or something to be avoided.

5.3 Practical relevance of results

This dissertation addresses shrinking cities as a crucial matter of policy and planning in Europe. The conceptualization of urban shrinkage as a multi-dimensional phenomenon supports a deeper process-oriented understanding of the complex interrelations between demographic, economic, and social factors for European cities that are relevant for different policy levels. The chosen cross-national perspective allows a harmonized comparison of urban trends in general, and patterns of urban shrinkage in particular.

On the European level, the results can support the EU Cohesion Policy (CP), to draw their policy focus from economic related issues to a ***broader problem-oriented understanding of urban shrinkage***. In particular, the results on duration, drivers, and implications can support the implementation of regeneration strategies such as improving environment aesthetics, services, and infrastructure, encouraging the development of skills, governance partnerships, networking, collaboration of private and public, and supporting economic development (EP 2008). Monitoring the trends and patterns of urban systems is essential for any benchmark analysis of success or failure of political actions (Kourtit and Nijkamp 2013) what than encourage actors to improve the urban system keeping pace with increasingly uneven dynamics.

Moreover, the results enrich the ***European monitoring*** of spatial trends, providing evidence for local variations of uneven development (Gerőházi et al. 2011) and detecting the affectedness of regions and countries together with the various facets of urban shrinkage. The presented local variation of demographic processes does not mean that shrinkage should be considered a merely local problem. Rather, policy and planning need to understand shrinkage as a normal phenomenon of the developed world, determined by regional contexts and local preconditions, and which requires flexible answers that are sensitive to the challenges operating on different spatial scales. Thereby, the dissertation results can be used in terms of four points:

- It will be possible to continuously ***evaluate*** the impact of CP, especially in shrinking cities, which is essential to avoid long-term dependencies from external subsidies (Haase A. et al. 2013a). Trade-offs can be better coordinated such as between the growth objective by the CP and the responsible development of land uses by the Environmental Policy of the European Union in line with the idea of a compact and successful European city (EC 2005).
- The comparison of countries can help to overcome the mismatch between processes of urban shrinkage and the **perception** within national and supranational debates, which is a crucial precondition for political and planning responses. Thereby, it is possible to investigate to what extent urban shrinkage could be considered a return to a state of balance and an opportunity to reorganise the territory along more positive lines. In this vein, the presented concept and its application deliver precise and context-specific information on the different aspects of shrinking cities that are needed by planners and politicians to estimate where to intervene or even invest and to coordinate actions in reaction to the changing demand.
- The results help to conclude on different ***planning regimes*** (Tosics et al. 2010) in terms of institutional fragmentation and the variety of responsible administrative actors at different levels. From the challenges investigated within this dissertation it is obvious that revitalization strategies should necessarily go far beyond pure technological solutions within sector-silos (Lima and Eischeid 2017). Rather, social, economic and technical challenges and their corresponding demographic effects need to be tackled simultaneously across different planning sectors and policy levels. The combination of the dissertations' results with national, regional and even local planning objectives thus supports a deeper policy integration both horizontally (integrated) and vertically (local-regional-national and inter-municipal).
- As local administrative units are used for the dissertation, national and local actors are enabled to detect long-term urban shrinkage which points to structural problems (EC 2011). The results can support local planning authorities to analyse, understand and evaluate the dynamics, drivers and impacts of, for example, land use change in their respective areas of competence or jurisdiction. Local authorities might be enabled to create ***long-term strategies*** concerning population, economy, infrastructure development etc. following their local priorities, while the national government can assure the liquidity of these cities, which are crucial prerequisites to counteract the challenges of urban shrinkage (EP 2008). Thereby, shrinking cities can represent an arena for testing resilience thinking in planning practice including consequences of non-linear dynamics such as

tipping points (e.g. in terms of underutilization of supply networks) or bouncing-back notions (e.g. in terms of fiscal austerity; Audirac 2017, Mykhenko 2016).

In the vein of a continuing uneven spatial development in Europe and beyond, including shrinking and regrowing cities, the comparative work and easily applicable operationalization approaches like those presented within this dissertation will be of increasing relevance. Japan and Russia are expected to experience the strongest losses in urban population in absolute terms (UN 2015). Both the research design and methods applied can be ***transferred*** to these countries in order to perform comparisons (Uemura 2015) or to start a scientific debate such as in Russia where the phenomenon of urban shrinkage is hardly perceived (Slepukhina 2014). Thus, the presented dissertation thesis fulfils a twofold function: it accounts, on the one hand, for the complexity and multidimensionality of urban shrinkage, while, on the other hand, it reduces the mentioned complexity in a way that makes its results comprehensible, informative, and interpretable for scholars, politicians and planners as well as easy to apply to other contexts.

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Overview of scientific paper

#	1	2	3	4	5
Author(s)	Manuel Wolff and Thorsten Wiechmann	Manuel Wolff, Sylvie Fol, Hélène Roth and Emmanuèle Cunningham-Sabot	Manuel Wolff	Manuel Wolff, Dagmar Haase and Annegret Haase	Manuel Wolff, Annegret Haase, Dagmar Haase and Nadja Kabisch
Title	**Urban decline in Europe, 1990-2010: shrinking cities in a comparative perspective**	**Is planning needed? Shrinking Cities in the French urban system**	**Understanding the role of centralization processes for cities – evidence from a spatial perspective of urban Europe 1990 – 2010**	**Compact or spread? A quantitative spatial model of urban areas in Europe since 1990**	**The impact of urban regrowth on the built environment**
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Contribution of the PhD student to the paper*	Introduction: 80%, Theory: 78%, Methods: 100%, Results: 100%, Discussion: 100% Conclusion: 100%	Introduction: 67%, Theory: 70%, Methods: 100%, Results: 100%, Discussion: 100% Conclusion: 89%	Whole paper: 100%	Introduction: 77%, Methods: 100%, Results: 100%, Discussion: 89% Conclusion: 84%	Introduction: 46%, Theory: 100%, Methods: 100%, Results: 100%, Discussion: 61% Conclusion: 70%

* The percentage values represents the share of characters (without graphs, tables, figures, maps and charts) written by the PhD candidate. The corresponding text is marked in yellow in the digital versions of the papers which can be found on the CD which has been submitted to the faculty.

General note: The PhD candidate performed the following tasks independently and on his own responsibility for each paper: Collection and consistency check of data, conceptualisation of approach and extension of models, data analysis, graph and map composition and production, interpretation and conclusion, writing paper. The co-authors contributed to the discussion of the single working steps, reviewed and commented the corresponding paper and have written single parts of the text (what is not marked in the digital versions).

Declaration

Hiermit erkläre ich eidesstattlich, die vorliegende Arbeit selbständig und ohne fremde Hilfe verfasst und nur unter Verwendung der angegebenen Hilfsmittel und Quellen angefertigt zu haben. Die den genutzten Werken wörtlich oder inhaltlich entnommenen Stellen habe ich als solche kenntlich gemacht.

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