

Neumann, Uwe

Working Paper

Are My Neighbours Ageing Yet? Local Dimensions of Demographic Change in German Cities

Ruhr Economic Papers, No. 319

Provided in Cooperation with:

RWI – Leibniz-Institut für Wirtschaftsforschung, Essen

Suggested Citation: Neumann, Uwe (2012) : Are My Neighbours Ageing Yet? Local Dimensions of Demographic Change in German Cities, Ruhr Economic Papers, No. 319, ISBN 978-3-86788-368-9, Rheinisch-Westfälisches Institut für Wirtschaftsforschung (RWI), Essen, <https://doi.org/10.4419/86788368>

This Version is available at:

<https://hdl.handle.net/10419/61382>

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RUHR

ECONOMIC PAPERS

Uwe Neumann

Are My Neighbours Ageing Yet? Local Dimensions of Demographic Change in German Cities

Imprint

Ruhr Economic Papers

Published by

Ruhr-Universität Bochum (RUB), Department of Economics
Universitätsstr. 150, 44801 Bochum, Germany

Technische Universität Dortmund, Department of Economic and Social Sciences
Vogelpothsweg 87, 44227 Dortmund, Germany

Universität Duisburg-Essen, Department of Economics
Universitätsstr. 12, 45117 Essen, Germany

Rheinisch-Westfälisches Institut für Wirtschaftsforschung (RWI)
Hohenzollernstr. 1-3, 45128 Essen, Germany

Editors

Prof. Dr. Thomas K. Bauer
RUB, Department of Economics, Empirical Economics
Phone: +49 (0) 234/3 22 83 41, e-mail: thomas.bauer@rub.de

Prof. Dr. Wolfgang Leininger
Technische Universität Dortmund, Department of Economic and Social Sciences
Economics – Microeconomics
Phone: +49 (0) 231/7 55-3297, email: W.Leininger@wiso.uni-dortmund.de

Prof. Dr. Volker Clausen
University of Duisburg-Essen, Department of Economics
International Economics
Phone: +49 (0) 201/1 83-3655, e-mail: vclausen@vwl.uni-due.de

Prof. Dr. Christoph M. Schmidt
RWI, Phone: +49 (0) 201/81 49-227, e-mail: christoph.schmidt@rwi-essen.de

Editorial Office

Joachim Schmidt
RWI, Phone: +49 (0) 201/81 49-292, e-mail: joachim.schmidt@rwi-essen.de

Ruhr Economic Papers #319

Responsible Editor: Christoph M. Schmidt

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ISSN 1864-4872 (online) – ISBN 978-3-86788-368-9

The working papers published in the Series constitute work in progress circulated to stimulate discussion and critical comments. Views expressed represent exclusively the authors' own opinions and do not necessarily reflect those of the editors.

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Bibliografische Informationen der Deutschen Nationalbibliothek

Die Deutsche Bibliothek verzeichnet diese Publikation in der deutschen Nationalbibliografie; detaillierte bibliografische Daten sind im Internet über:
<http://dnb.d-nb.de> abrufbar.

<http://dx.doi.org/10.4419/86788368>

ISSN 1864-4872 (online)

ISBN 978-3-86788-368-9

Uwe Neumann¹

Are My Neighbours Ageing Yet? Local Dimensions of Demographic Change in German Cities

Abstract

In the discussion about demographic change, the regional dimension so far has played a subordinate role. Based on municipal data for the period between 1998 and 2008, this paper examines to what extent recent demographic change has affected the population of cities and neighbourhoods, focusing on the largest urban agglomeration in Germany, the Rhine-Ruhr conurbation in North Rhine-Westphalia. The local outcomes of demographic change are modified considerably by regional migration and interrelate closely with regional prosperity. The survey provides a precise outline of the interrelation between basic demographic characteristics and shifts in the composition of neighbourhood populations over the study period. The analysis shows that in the most thriving cities, there is a particularly strong tendency of young adults to separate from other demographic groups. In neighbourhoods where there is no such influx of younger people, particularly in low-density residential areas on the urban fringe, rapid demographic ageing affects neighbourhood populations and local economies.

JEL Classification: J11, R23

Keywords: Demographic change; neighbourhoods; segregation; migration

February 2012

¹ RWI. – For helpful comments, I am thankful to Christoph Ehlert, Sandra Schaffner and Christoph M. Schmidt and to the colleagues taking part in a recent RWI study on regional change and governance in the Ruhr. – All correspondence to: Uwe Neumann, RWI, Hohenzollernstraße 1-3, 45128 Essen, Germany, E-mail: uwe.neumann@rwi-essen.de.

1. Issues

In the discussion about demographic change and in the literature on migration until fairly recently the regional dimension was, by and large, overlooked. In the past two decades, the demographic and economic consequences of international mobility have been vividly demonstrated by the westward shift of population out of post-communist Central and Eastern Europe. In Europe, the implications of demographic change, i.e. declining population figures and changes in the age structure, have only just begun to affect societies as whole. Several regions, however, have already experienced severe losses in population, while others have continued to grow.

Many of the issues implied by demographic change have to be addressed by national policy, e.g. education, labour or social issues. Yet, given an increase in the importance of individual and interpersonal knowledge factors in constituting regional competitiveness (Camagni 2002), serious demographic challenges arise at the regional level. First and foremost, accentuated by regional migration, demographic change affects the composition of urban neighbourhoods. Migration can be interpreted as an adaptation of individuals and households to spatial disparities, which may reinforce the local consequences of demographic change. At the local level, changes in neighbourhood demography are likely to affect various markets, e.g. for housing, retail, catering, consumer services and the demand for infrastructure.

Due to a fairly advanced stage in demographic ageing, some German cities have managed to combine economic growth with stagnation or even a decline in population figures better than cities in most other European countries. Apart from Eastern

Germany, the old-industrialised Ruhr is one of the German regions which have already been affected by a severe loss in population and a fundamental change of the population structure over the past decades. The Ruhr is part of the largest urban agglomeration in Germany, the Rhine-Ruhr conurbation, which is the study area of this analysis. This paper examines

1. to what extent the demographic composition of the residential population (age structure, fertility, migration) differs between and within cities,
2. in what way demographic change and regional migration affect the population of neighbourhoods, and
3. how current dynamics of demographic change at the neighbourhood level relate to basic characteristics of cities and regions.

Even though in Germany demographic characteristics are registered in great detail and accuracy by public authorities, there is no standard of aggregation of demographic indicators at the sub-city statistical level. Perhaps surprisingly, due to a lack of comparative sub-city data from administrative sources, it is therefore relatively difficult to analyse demographic change at the neighbourhood level in Germany. For the purposes of this analysis, a comprehensive data set comprising the whole of the Rhine-Ruhr conurbation was compiled. It is a task for further analysis to examine in what way local markets adapt to population change at the neighbourhood level, i.e. to highlight the (effective) local economic consequences of demographic change. This paper takes a first step by outlining to what extent regional migration and demographic change affect relative scarcities due to shifts in neighbourhood populations at the local level.

The analysis suggests that demographic change and regional migration have reinforced demographic segregation patterns, since younger working-age residents tend to agglomerate in selected central city quarters and because a larger share of young children grow up in inner city areas, while the share of senior citizens in low-density suburban surroundings increases rapidly. The paper starts with a brief review of the relevant literature in chapter 2. Chapter 3 presents the data base and outlines the basic characteristics of demographic change in the study region. Chapter 4 examines demographic change at the neighbourhood level. The final chapter 5 discusses the findings and local economic implications.

2. Literature review

While there is a wide literature on international migration (cf. Bauer et al. 2004, Haug 2008) and demographic change at the national level (e.g. Batini et al. 2006, Börsch-Supan 2003, European Commission 2007), regional and urban aspects so far have played a minor role in this discussion. As a step forward, regional demographic heterogeneity in labour supply, productivity, human capital and R&D has been documented for the 264 NUTS 2 regions in the EU-27 by Tivig et al. (2008). In the strategic guidelines for EU cohesion policy in the current 2007-2013 period, demographic change was seen as an issue affecting labour market and health policy, yet it was not characterised as a fundamental challenge implying a comprehensive policy approach (European Council 2006). With the Barca (2009) report on an agenda for a reformed cohesion policy though, which suggests six priorities for future cohesion

policy (innovation, climate change, migration, children, skills, and ageing), issues of demographic change were assigned a much more prominent position.

In urban research, even though it has been documented by many studies that segregation by age and household type (e.g. single person, family with children) is typical of cities throughout the Western world (cf. Gans 1962, Coulson 1968, Heinritz and Lichtenberger 1991, Knox 1995), in the more recent literature relatively little attention has been paid to demographic segregation. Analysis of segregation in North American cities has typically been concerned with ethnic groups (Sethi and Somanathan 2004, Johnston et al. 2007) or the tenure status (Hoff and Sen 2005). In Europe, the main attention has been paid to socioeconomic disparities (e.g. Harvey 1973, Hamnett 1994, Burgers and Musterd 2002) and ethnic segregation (Peach et al. 1981, O'Loughlin and Glebe 1984b, Friedrichs 1988, Johnston et al. 2002).

In the analysis of structural change in the Ruhr industrial area until recently, demographic aspects were also regarded as a minor aspect. An exception is the analysis of Steinberg (1978), which provides a review of development of the Ruhr population during the 19th and 20th century. More recently, a study of Klemmer (2001) activated a widespread discussion about the consequences of demographic change in the Ruhr (e.g. Wehling 2003, Lehner 2006, Neumann and Schmidt 2006). Different aspects of ethnic, social and demographic segregation in the study region, mainly focusing on individual cities or subregions, have been analysed by O'Loughlin and Glebe (1984a, 1984b), Glebe and Dehling (1998), Strohmeier (2002), Dittrich-Wesbuer et al. (2008), a review for North Rhine-Westphalia was provided by ILS (ed.) (2010).

Focusing on the demographic perspectives of different types of neighbourhood in the Ruhr, Strohmeier (2002) identifies groups of urban districts differing according to age, family type, ethnicity, mobility and income. The analysis finds that it is a specific characteristic of cities in the Ruhr that social and ethnic segregation overlap, i.e. neighbourhoods with a very high share of foreigners among the residential population are usually low-income areas. The following analysis adds to this literature by providing a more systematic outline of the extent to which demographic segregation had been reinforced by migration and demographic change during the period from 1998 to 2008 and in what way these dynamics have related to basic demographic and economic characteristics of cities in the study region.

3. Demographic change in the study region

Even though aggregate data frequently provide a reliable basis for detailed descriptive analyses of the processes shaping urban regions, they might fail to represent the heterogeneity experienced at the level of “neighbourhoods”². This paper draws on data from administrative statistics in Germany. By and large, they represent historical “neighbourhoods” or housing estates, which are perceived as spatial entities³. While there is no obligatory standard concerning sub-city statistics, municipalities define their own sub-city statistical districts for purposes of administration and urban development. Even though a private market for data with reference to small spatial entities has

²A specific aspect of these methodical challenges has been described as the modifiable areal unit problem (MAUP). Firstly, a statistical bias may emerge if the size of the population represented by statistical districts varies to a great extent. Secondly, statistical results may vary even if only the shape (not the size) of districts is changed (e.g. from census districts to postcode areas) (Openshaw 1984).

³In the future, it may be desirable to apply data aggregated at smaller levels such as building blocks or spatial grids to sub-city analysis. For the time being, sub-city districts defined by the municipalities offer a territorial reference suitable for the analysis of intra-city differentials in Germany.

emerged, the accuracy of municipal registers makes them preferable as an empirical base of demographic analysis. On a voluntary basis, over 100 cities (almost all with more than 100,000 inhabitants) have agreed to cooperate in a working group (AG KOSTAT) and to distribute a (largely restricted) set of standardised sub-city data.

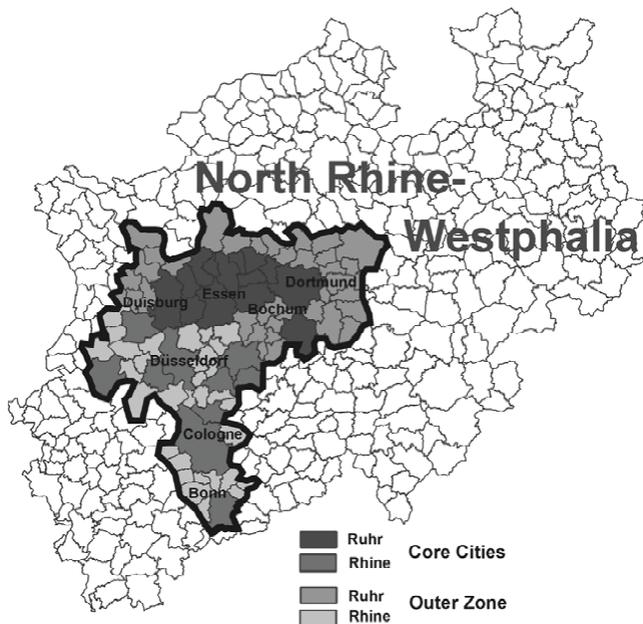
By combining information from this source with data provided by the statistical office of North Rhine-Westphalia (IT.NRW), a unique data base comprising the whole of the inner and outer zone of the Rhine-Ruhr conurbation was compiled for the purposes of this analysis⁴. The delineation of the Rhine-Ruhr conurbation follows the concept defined by the regional development plan for North Rhine-Westphalia (LEP NRW) (MURL 1995) (Figure 1). On average, around 11,000 inhabitants live in the statistical districts on which the study is based⁵. Since even in smaller cities there are no very small districts (Table 1), it can be assumed that the effect of small unit bias on statistical results will be avoided.

Due to its internal diversity, as explained the Rhine-Ruhr conurbation is well-suited as a case study of local demographic change under varying regional conditions. The most obvious subdivision separates between the Ruhr (commonly defined as the administrative area of the Ruhr Regional Association, RVR) and Rhine subregions (Figure 1).

⁴The KOSTAT data set currently comprises the following indicators: population at primary and secondary residence, male and female population, foreigners, age groups (under 18, 18-29, steps in tens up to 59, 60 and over), number of households. The only available indicator representing immigrants is the number of holders of a foreign nationality (excluding those with a double, i.e. German and foreign nationality and not providing any information on sub-groups, e.g. by age or sex).

⁵In the municipal districts (Kreise) of the outer urban zone, the municipality as smallest statistical unit replaces the sub-city district level. The municipalities of the outer zone on average represent a similar total population as the sub-city districts of the cities (kreisfreie Städte) in the core zone. All population figures in this analysis refer to the permanent population.

Figure 1
Rhine-Ruhr conurbation
 According to Regional Development Plan for North Rhine-Westphalia



Fine lines depict municipal boundaries

Table 1
Size of statistical districts in the data base
 2008

City	Total Population	Number of Districts	Average Population per District
Largest 5			
Cologne	995,420	85	11,711
Dortmund	584,412	61	9,581
Düsseldorf	584,217	49	11,923
Essen	579,759	50	11,595
Duisburg	494,048	46	10,740
Smallest 5			
Hamm	182,459	29	6,292
Mülheim/Ruhr	168,288	28	6,010
Herne	166,924	17	9,819
Leverkusen	161,322	16	10,083
Remscheid	112,679	50	2,254
Conurbation	10,076,956	922	10,929

Author's calculation based on data from AG KOSTAT and IT.NRW (Statistics North Rhine-Westphalia)

Table 2
Rhine-Ruhr cities in European comparison
 Ranking among 329 cities taking part in the Urban Audit (2004)

City	rank among 329 cities by					population change 2001-2004 (in %)
	GDP/head (in PPS)	patent intensity*	share of population < 5 (in %)	share of population 35-45 (in %)	share of population > 60 (in %)	
<i>Rhine</i>						
Bonn	49	26	99	4	65	101
Cologne	37	66	127	7	109	193
Düsseldorf	4	10	164	10	76	184
<i>Ruhr</i>						
Bochum	103	128	241	22	44	227
Dortmund	115	83	163	70	59	210
Essen	68	69	215	89	24	231

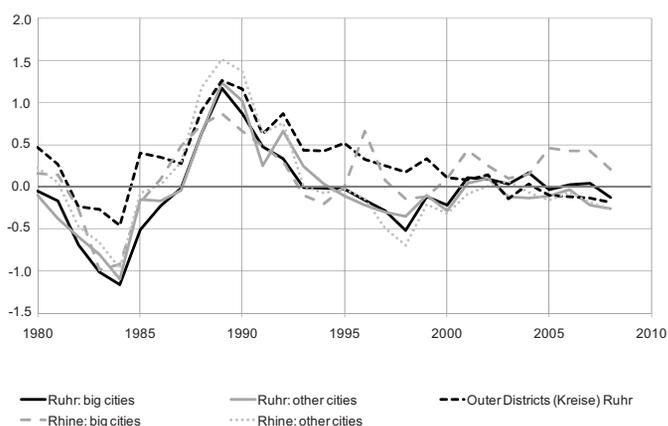
Author's calculation based on Urban Audit and PATSTAT. - *patent applications per 100,000 inhab.

In Europe-wide comparison, the large cities of the Rhine subregion (Bonn, Cologne, Düsseldorf) rank among the top group of cities concerning “income” (as measured in GDP per head) and innovation (patent intensity) (Table 2). Economic prosperity in these cities combines with a very high concentration of 35-45 year-old working-age inhabitants. Cities from the Ruhr (here represented by Bochum, Dortmund and Essen) rank in a middle position among 329 cities from all EU countries taking part in the European Urban Audit data collection (European Communities 2004) in terms of economic prosperity and innovation. They rank relatively highly in the share of 35-45 year-olds, although considerably lower than the Rhine cities.

The Ruhr cities are characterised, however, by a very low share of small children (under 5) and a very high share of senior citizens (>60). They rank in the bottom third of all cities regarding city growth between 2001 and 2004. As an outcome of job-related migration, particularly to the more dynamic regions of Southern Germany, some time after the beginning of the decline of the coal and steel industries, the total population of the Ruhr began to shrink in the 1960s (Steinberg 1978: 146). The total population of the Ruhr declined from 5.72 million in 1962 to 5.18 million in 2007, i.e. by 540,000

inhabitants (-9.4%). In the other parts of North Rhine-Westphalia the total population increased by over 20% in the same period (RVR 2009). Combined with a decrease in fertility affecting German society as a whole, by the 1980s there was a higher surplus of deaths over births in the Ruhr than in other regions of North-Rhine Westphalia. Apart from long-distance migration there was an ongoing suburbanisation process within the region, resulting in continued net migration gains (or comparatively lower losses than in the inner zone) in the outer urban zone during the 1980s and 1990s⁶. During the past decade, however, net migration to the outer zone has come to a halt (Figure 2).

Figure 2
Net migration
 Arrivals – departures in % of the total population

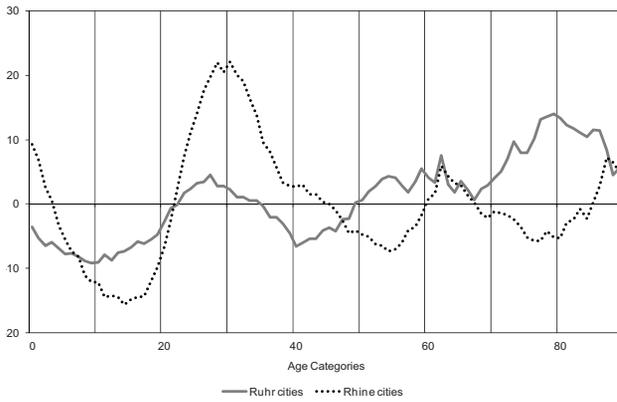


Author's calculation based on data from IT. NRW (Statistics North Rhine-Westphalia). - Ruhr, big cities: Bochum, Dortmund, Duisburg, Essen; Rhine, big cities: Bonn, Cologne, Düsseldorf

Today, in the Ruhr working-age residents are only over-represented to a very limited extent (Figure 3) or even underrepresented (age cohorts 35-48) in comparison with all other regions of North-Rhine Westphalia (NRW).

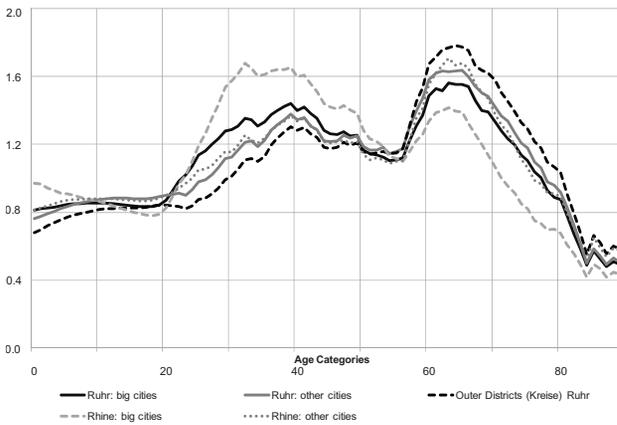
⁶ Due to immigration from former Eastern Bloc countries and the former Yugoslavia, there were temporary migration gains in all regions between 1987 and 1992.

Figure 3
Age structure of cities in the Ruhr and Rhine subregions* in comparison with rest of North Rhine-Westphalia (NRW)
 Share of age cohorts among total population, deviation from NRW average without respective group of cities in %
 (2008, in %, average of NRW without Ruhr/Rhine cities = 0)



Author's calculation based on data from IT.NRW (Statistics North Rhine-Westphalia). *Kreisfreie Städte; Ruhr cities: Bochum, Bottrop, Dortmund, Duisburg, Essen, Gelsenkirchen, Hagen, Hamm, Herne, Mülheim/Ruhr, Oberhausen; Rhine cities: Bonn, Cologne, Düsseldorf, Krefeld, Leverkusen, Mönchengladbach, Remscheid, Solingen, Wuppertal

Figure 4
Projection of age structure in 2030
 Age cohorts in % of the total population



Author's calculation based on data from IT.NRW (Statistics North Rhine-Westphalia). – Ruhr, big cities: Bochum, Dortmund, Duisburg, Essen; Rhine, big cities: Bonn, Cologne, Düsseldorf

All age cohorts above 48 are overrepresented. In the cities from the Rhine subregion, age cohorts from 22 to 44 are (highly) over-represented and most age cohorts above 44 (slightly) under-represented. Accordingly, Klemmer (2001) found that as a result of regional migration during the past decades the Ruhr precedes the overall demographic ageing process of Germany as a whole by about 25 years.

Analysis of current regional migration flows suggests that the largest cities in the conurbation succeed in attracting working-age residents and are likely to do so in the future. According to current population projections for 2030, the Ruhr population will shrink by another 415,000 inhabitants (-8%) up to 2030 (IT.NRW 2009). Among the Ruhr population of 2030, the share of senior citizens (age cohorts over 60) is expected to be particularly high in the outer districts (Figure 4). The share of younger working-age residents, on the other hand, is expected to be higher and the share of senior citizens lower in the biggest cities (Bochum, Dortmund, Duisburg, Essen) than in the smaller cities and outer zone. In the three most important cities of the Rhine subregion (Bonn, Cologne, Düsseldorf), working-age residents can be expected to remain the prevailing group, while in the smaller cities of the Rhine subregion the age structure in 2030 is likely to resemble that of the smaller Ruhr cities.

Within the conurbation, regional migration has resulted in a considerably unbalanced distribution of the residential population in terms of age and family structure across cities. Even though it is difficult to predict in what way residential location preferences may change (again) over the forthcoming decades, demographic segregation between parts of the urban agglomeration is likely to increase. The following chapter substantiates the spatial analysis by “zooming in” on the neighbourhood level.

4. Demographic change at the neighbourhood level

Based on data from 2008, a typology was derived by regional factor and cluster analysis, which classifies a set of 922 sub-city districts (neighbourhoods) into characteristic “types”. According to the analysis, residential patterns observed in this region reflect a number of basic neighbourhood characteristics identified by previous research in other regions throughout the Western World (Shevky and Bell 1955, Murdie 1969, Knox 1995). Three dimensions (factors) represent most of the differentiation observable by the original indicators (cf. Table A1 in the appendix)⁷. Based on the factor values of each statistical district, six neighbourhood types (cf. Table 3) were identified⁸: They can be described as

1. central city commercial areas and surrounding neighbourhoods with a high share of one-person-households, few children and a relatively high share of foreign nationals,
2. “urban” areas with a mixed composition of age groups, household types and ethnic groups,
3. “ageing” urban areas with a mixed household structure, a low share of foreign nationals and an above-average (and increasing) share of senior citizens (over 60),

⁷The first factor represents young working-age adults (18-40), including foreign nationals. The second is a family factor representing a high share of children (under 18) and an above-average household-size. Factor three represents older working-age residents (40-50 age cohorts), who agglomerate on the urban fringe (as parents) and in more central urban residential areas (without children). The first two factors are inversely correlated with the share of older-age residents, i.e. in their residential priorities families, young city-dwellers and foreigners separate from over 60 year-olds.

⁸The typology is based on a four-step analysis: 1. Principal component analysis (varimax rotation), 2. Hierarchical cluster analysis (Ward’s method), 3. Optimisation of cluster analysis by k-means clustering, 4. Final correction by discriminant analysis.

4. “aged” (and relatively wealthy) urban residential areas with a very high share of seniors (over 60),
5. inner city areas with a very high share of foreigners (and children), inhabited by (low-income) families, and
6. low-density residential areas, inhabited mainly by (high income German) families.

While typical central city neighbourhoods with very small households, few children and a high share of working-age residents emerge in all of the large cities, in Cologne and Düsseldorf they dominate among the total spectrum of neighbourhoods to a greater extent than in the large cities of the Ruhr (Figure 5 and Table 4).

In Duisburg and Essen, the northern zone suffered more than the southern districts from job losses due to disintegration of the industrial base throughout the past decades (Wehling 1991). In some of these neighbourhoods, the share of migrants (who came to Germany predominantly as “guest workers” themselves or as part of their families) is very high.

It is well-known that change in the residential composition of neighbourhoods is driven mainly by intra-urban migration (O’Loughlin and Glebe 1984a). Interregional mobility is mainly job-oriented and interrelates with education and qualification (Jackman and Savouri 1992). The decision to migrate within a region or city, however, is likely to be motivated by matters of the personal life-cycle (Boehm et al. 1991). In general, even though the overall likeliness to migrate correlates with different personal characteristics (e.g. education), within the life-cycle, mobility is usually highest in early adulthood (cf.

Schwartz 1976). Neighbourhoods favoured by young adults can therefore be expected to experience a relatively high influx of mobile residents.

Table 3
Demographic characteristics of neighbourhood types of the Rhine-Ruhr conurbation
2008

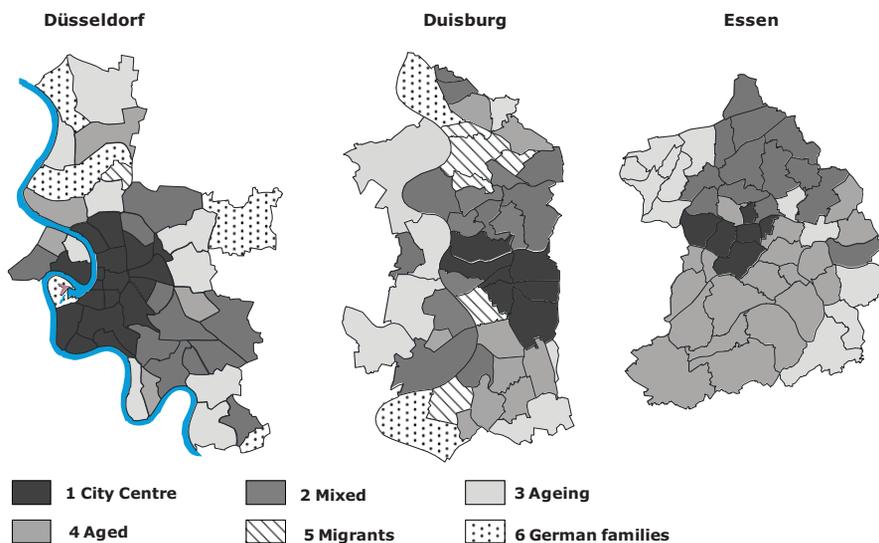
	Type						Total
	1	2	3	4	5	6	
total population	1,168,290	3,498,521	3,242,929	1,191,484	551,434	424,298	10,076,956
thereof (in %)							
foreigners	18.3	13.8	7.8	7.3	24.3	7.4	11.9
under 18	12.7	17.6	16.8	14.3	21.4	19.6	16.7
18 – 30	18.9	14.4	12.4	11.9	16.4	12.2	14.0
30 – 40	18.4	12.7	11.6	11.1	13.5	12.3	12.9
40 – 50	16.1	16.3	17.6	15.8	14.9	19.6	16.7
50 – 60	11.7	13.5	14.4	13.9	12.4	13.9	13.6
over 60	22.2	25.4	27.3	31.6	21.3	22.4	26.0
persons per household	1.6	2.1	2.1	2.0	2.2	2.3	2.0

Author's calculation based on data from AG KOSTAT und IT.NRW - Typology: 1 = city centre, 2 = "urban mix", 3 = ageing, 4 = high-age, 5 = migrant families, 6 = German families, 923 observations

Figure 5

Neighbourhood typology

Demographic neighbourhood types of Rhine-Ruhr conurbation in Düsseldorf, Duisburg and Essen, 2008



Author's calculation based on data from AG KOSTAT and IT. NRW (Statistics North Rhine-Westphalia)

Table 4
Demographic and socioeconomic characteristics of cities in the Rhine-Ruhr conurbation 2008

	Cologne	Düsseldorf	Dortmund	Duisburg	Essen	Smaller Cities	Outer Zone
demographic characteristics							
total population	995,412	584,217	584,412	494,048	579,759	2,776,270	2,925,406
<i>thereof (in %)</i>							
foreigners	17.1	18.4	12.6	15.1	10.3	11.9	9.1
< 18	15.7	14.8	16.3	16.9	15.7	17.1	17.5
30-40	15.9	16.3	13.2	12.6	12.6	12.2	11.9
> 60	23.2	25.2	25.9	26.6	27.6	26.7	26.0
in neighbourhood type..							
1: city centre	40.5	44.8	16.7	14.5	19.1	3.8	0.0
2: "urban mix"	23.2	27.3	24.6	35.8	28.1	40.9	38.5
3: "ageing"	12.6	17.5	25.5	15.3	9.8	26.0	54.2
4: "high-age"	7.1	5.6	19.8	19.3	36.0	17.4	0
5: foreigners	9.6	1.0	9.4	13.0	7.0	7.7	0
6: fringe: German families	6.9	3.8	4.1	2.1	0.0	4.1	7.3
population change 1998-2008	2.6	2.3	-1.5	-5.7	-4.3	-3.9	-7.1
(socio)economic characteristics							
GDP/head in % of NRW	146.0	234.2	102.6	100.8	122.7	94.2	80.2
employment in services (in %)	82.1	82.9	80.0	66.6	78.0	66.9	63.9
Δ empl. serv. 1980-2008 (in %)	45.4	35.6	36.3	18.3	26.0	35.0	80.2
unemployment rate (in %)	12.0	10.7	15.1	14.4	13.6	11.3	8.5

Author's calculation based on data from AG KOSTAT and IT.NRW (Statistics North Rhine-Westphalia). – employment in services = at workplace; Δ empl.serv. 1980-2008 (in %) = change of number of employees (at workplace) in service sector 1980-2008 in %; unemployment rate = annual average 2008

Table 5
Population change in neighbourhood types of the Rhine-Ruhr conurbation 1998-2008, in %

	Type						total
	1	2	3	4	5	6	
total	0.3	-2.8	-1.4	-3.6	-1.6	9.4	-1.6
foreigners	-6.5	-6.4	-12.9	-4.0	-7.8	2.5	-7.8
under 18	-6.6	-10.3	-11.5	-12.6	-7.4	2.4	-9.8
18 – 30	10.1	-2.4	-5.1	-4.4	-0.6	5.7	-1.3
30 – 40	-10.0	-26.1	-32.4	-31.8	-16.3	-27.6	-26.1
40 – 50	20.4	13.5	18.2	9.9	9.6	41.1	16.3
50 – 60	-6.7	6.0	6.4	-2.6	3.3	18.7	4.0
over 60	-2.0	5.3	14.3	5.6	5.5	23.4	8.0

Author's calculation based on data from AG KOSTAT und IT.NRW - Typology: 1 = city centre, 2 = "urban mix", 3 = ageing, 4 = high-age, 5 = migrant families, 6 = German families, 923 observations

In fact, in the Rhine-Ruhr conurbation, between 1998 and 2008, only the central city quarters (Type 1, +0.3%) and the "family"-dominated neighbourhoods (Type 6, +6.1%) gained in population (Table 5). Due to further ageing of the now 40-50 year-old "baby-boomers" born in the 1960s, in about one and a half decades, low-density (type 6) neighbourhoods will belong to those with a high share of over 60 year-olds, unless

many of them decide to move elsewhere in the near future (which is, of course, an improbable scenario). Already in the study period from 1998 to 2008, the over 60-year-old population increased most rapidly (+23.4%) in these low-density residential neighbourhoods. Most likely, this demographic “ageing” process will affect (among others) local service and housing markets.

In the literature on segregation it is common to describe the extent to which selected parts of the population agglomerate in specific neighbourhoods. For example, the index of segregation (IS) as suggested by Duncan and Duncan (1955) measures the inequality in the distribution of one sub-population compared to all other parts of the population over a range of units, e.g. sub-districts of a region⁹. It is calculated as follows:

$$(1) IS = \frac{1}{2} \sum_{i=1}^n \left| \frac{a_i}{A} - \frac{b_i}{B} \right|$$

where a_i is sub-population a in subregion i ($i = 1, 2, \dots, n$), b_i is the rest of the total population of subregion i , A and B represent sub-populations a and b in the total region. Calculation of the IS for selected sub-populations of the Rhine-Ruhr conurbation reveals a relatively high inequality of the spatial distribution of foreign nationals over sub-city districts. Still, IS values of up to 35¹⁰ are moderate in comparison with those (IS over 70) measured for African Americans in the census tracts (2,000 – 8,000 inhabitants) of many large US cities (Iceland et al., 2002). Furthermore,

⁹The index value is usually interpreted as the share of those members of the sub-population, who would have to relocate in order to come to an equal dispersal of this group across all districts. However, this interpretation is limited in many ways, since as explained in connection with the modifiable areal unit problem (MAUP) before, the index value varies with the size and layout of districts and with the size of the sub-group in relation to the total population. For purposes of city comparison, therefore, the index of segregation is only suitable if calculated for sub-groups of, by and large, similar size and provided that the sub-districts are of similar size and layout. As explained, the municipal database compiled for the Rhine-Ruhr conurbation fulfils these basic requirements.

¹⁰IS values according to the formula applied by Duncan and Duncan (1955) range from 0 to 1. Here, they have been multiplied by 100.

remarkably little changes have taken place between 1998 and 2008. In the five largest cities of the conurbation (Cologne, Dortmund, Düsseldorf, Duisburg, Essen), the IS levels of foreigners and age groups have shown only moderate variation over this period. As far as the segregation of foreigners is concerned, O'Loughlin and Glebe (1984b) measured similar IS levels in Düsseldorf (0.19) already in 1981. In Duisburg, the index level even decreased from 0.34 in 1981 to below 30¹¹.

Among the ten-yearly age categories disclosed in the KOSTAT data base, the IS levels of the young working age cohorts, i.e. 18-30 and particularly 30-40 have increased to some extent in the five largest cities of the conurbation over the most recent years. For example, in Düsseldorf the IS of 18-30 year-olds increased from 10.2 (2003) to 11.1 (2008). While intra-urban mobility and demographic change obviously combine with a moderate increase in the magnitude of demographic segregation in large German cities, as explained the data allow no direct analysis of the underlying migration flows or even motives.

It is possible, however, to analyse in what way the dynamics of demographic change in urban neighbourhoods relate to basic neighbourhood characteristics. In the following analysis, demographic change during two periods, 1998-2003 and 2003-2008, will be examined. The pace of regional demographic change over a certain period of time depends on natural population change, i.e. the balance of births and deaths, and migration. Natural population change relates to demographic characteristics of the residential population at the beginning of the period under observation, migration to

¹¹The outline of the statistical districts of Düsseldorf and Duisburg in the study by O'Loughlin and Glebe (1984b) is identical to that in the KOSTAT data base.

various regional characteristics. In the theory of economic growth, the concept of conditional convergence describes a similar relation between basic regional characteristics and growth (Sala-i-Martin 1996: 1330). Borrowing from this concept the formal specification of neighbourhood-level demographic change is

$$(2) \quad y_{i,t+5} - y_{i,t} = \alpha + T_{t=1998}(\beta_1 X_{i,t} + \beta_2 C_i + \beta_3 R_i) + T_{t=2003}(\beta_4 X_{i,t} + \beta_5 C_i + \beta_6 R_i) + \beta_7 T_{t=2003} + \varepsilon_i$$

where $y_{i,t}$ is the population of neighbourhood i ($i = 1, 2, \dots, 922$) or, alternatively, the share of residents from a specific demographic group in this neighbourhood at time t ($t = 1998, 2003$), $t + 5$ is the population or share of the population five years hence, X is a set of neighbourhood characteristics, C a dummy variable representing central city quarters according to the neighbourhood typology derived above¹², R comprises three regional dummy variables for (i) the large Rhinefront cities (Bonn, Düsseldorf, Cologne), (ii) the large Ruhr cities (Bochum, Dortmund, Duisburg, Essen) and (iii) the other core cities of the conurbation (Gelsenkirchen, Hagen, Hamm, Herne, Krefeld, Leverkusen, Oberhausen, Mülheim/Ruhr, Remscheid, Solingen, Wuppertal) (the outer zone serving as base category) and T is a dummy variable representing the base years 1998 and 2003 and ε_i is a normally distributed error term¹³.

The analysis suggests that the influence of the determinants of neighbourhood growth changed from the first to the second sub-period to some extent (Table 6). In both sub-periods, neighbourhoods in the big Rhine cities (Bonn, Cologne, Düsseldorf) grew at an above-average-rate (compared to the outer zone, which is the reference category), while

¹²The neighbourhood type dummy variable represents a large group of central city quarters (1 = types 1 or 2 from the typology derived above; 0 otherwise) with a relatively diverse range of demographic characteristics. These neighbourhoods comprise almost half of the total population in the conurbation (46% in 2008). Multicollinearity between the neighbourhood type dummy and neighbourhood characteristics is thus avoided.

¹³To allow for a straightforward interpretation of coefficients, all independent variables are interacted with the base year of both periods and an additional control for time is incorporated (cf. Yip and Tsang 2007).

those in the big Ruhr cities (Bochum, Dortmund, Duisburg, Essen) (particularly in the first period) and in the smaller cities grew at a below-average rate (or rather declined at a faster rate).

In the first period, central city quarters and those with a high share of foreigners and senior citizens (over 50), in the second sub-period those with a high share of under 18 year-olds were unlikely to grow. The share of foreigners increased particularly in central city quarters, but not in districts with a very high concentration of foreigners. During the second period, growth in the share of youths was adversely related to their overall share at the start of the period. Rather than in other parts of cities, the share of under 18 year-olds now increased in central city quarters.

Further relative concentration of 30-40 year-olds (or relatively low decline of their share in the total population, which accelerated in the second sub-period, see above) was a characteristic of neighbourhoods with an above-average share of foreigners and with a high share of seniors. Apparently, residential concentration of 30-40 year-olds shifted somewhat out of the neighbourhoods dominated by working-age residents, even though it was still more characteristic of neighbourhoods in central city locations than in other areas. Whereas in the first sub-period, 30-40 year-olds were more likely to agglomerate in any city of the inner zone of the conurbation than in the outer zone, from 2003 onwards they were more unlikely to do so. Even though the data base allows no direct observation of migration flows it can be assumed that this change relates predominantly to *in situ* ageing of the resident population. Obviously, a shift of the 30-40-year-olds into the next age category during the second period was particularly characteristic of larger cities, where this age group concentrates.

Table 6
Neighbourhood-level demographic change in the Rhine-Ruhr conurbation
 OLS regression coefficients¹, pooled cross section (1998, 2003)

	dependent variables				
	population change (in %) over five years	change over five years in share of			
		foreigners	< 18	30-40	>50
	(1)	(2)	(3)	(4)	(5)
1998 •					
<i>share (in %)</i>					
foreigners	-0.152*** (0.0194)	-0.0923*** (0.00760)	0.0281*** (0.00542)	0.0596*** (0.00555)	-0.0611*** (0.00855)
< 18	0.0412 (0.0621)	0.00825 (0.0238)	0.00496 (0.0172)	-0.0623*** (0.0176)	0.0487* (0.0271)
>50	-0.119*** (0.0417)	0.0277* (0.0159)	0.0827*** (0.0115)	0.0650*** (0.0117)	-0.113*** (0.0181)
<i>central city quarter (dummy)</i>	-0.579* (0.320)	0.737*** (0.124)	-0.0253 (0.0892)	0.156* (0.0912)	-0.630*** (0.141)
<i>dummies for sub-region</i>					
Bonn-Cologne- Düsseldorf	2.152*** (0.539)	0.710*** (0.208)	0.114 (0.150)	1.315*** (0.154)	-1.249*** (0.237)
Bochum-Dortmund- Duisburg-Essen	-2.157*** (0.524)	0.122 (0.204)	-0.191 (0.147)	1.083*** (0.150)	-0.288 (0.232)
smaller cities	-2.070*** (0.466)	0.244 (0.181)	-0.226* (0.131)	1.009*** (0.134)	-0.107 (0.206)
2003 •					
<i>share (in %)</i>					
foreigners	-0.0344 (0.0215)	-0.0448*** (0.00834)	0.0256*** (0.00602)	0.0981*** (0.00615)	-0.115*** (0.00949)
< 18	-0.172*** (0.0550)	0.00535 (0.0214)	-0.126*** (0.0154)	0.0508*** (0.0158)	0.114*** (0.0243)
>50	-0.0152 (0.0382)	0.0248* (0.0149)	0.0676*** (0.0107)	0.101*** (0.0110)	-0.137*** (0.0169)
<i>central city quarter (dummy)</i>	-0.277 (0.327)	0.279** (0.127)	0.230** (0.0919)	0.579*** (0.0940)	-0.715*** (0.145)
<i>dummies for sub-region</i>					
Bonn-Cologne- Düsseldorf	2.124*** (0.540)	0.439** (0.209)	0.581*** (0.151)	-0.497*** (0.154)	-0.709*** (0.238)
Bochum-Dortmund- Duisburg-Essen	-0.913* (0.522)	0.708*** (0.203)	-0.0687 (0.147)	-0.588*** (0.150)	-0.618*** (0.231)
smaller cities	-1.595*** (0.465)	0.393** (0.181)	-0.137 (0.131)	-1.012*** (0.134)	-0.241 (0.206)
<i>dummy for 2003</i>	-2.605 (3.473)	-0.226 (1.341)	1.805* (0.967)	-3.455*** (0.989)	1.462 (1.525)
constant	5.994** (2.570)	-1.020 (0.986)	-3.660*** (0.711)	-4.701*** (0.727)	5.717*** (1.121)
adjusted R ²	0.16	0.13	0.27	0.41	0.30
F	24.25	18.83	45.65	85.30	54.16
p-value	0.000	0.000	0.000	0.000	0.000
observations	1,825	1,842	1,843	1,843	1,843

Author's calculation based on data from AG KOSTAT und IT.NRW. - standard errors in parentheses; */**/** = significant at 10/5/1%-level

In both periods the share of seniors (>50) increased in neighbourhoods with an above-average share of children rather than in “urban” locations with a high share of foreigners or with an already high share of seniors. Rapid increase in the share of residents over a specific “seniority” age threshold (e.g. 50 or 60) has become a characteristic of low-density residential areas on the edge of cities and in the outer zone of the conurbation.

Most and for all, the analysis finds that while demographic segregation interrelates closely with regional economic disparities, under the conditions of demographic change these are being reinforced by regional migration. It is an issue for further research to investigate in what way changes in neighbourhood composition determine future migration decisions, i.e. how individuals and households adapt to demographic change by migration. Based on a survey among mobile households in Mannheim, Gans et al. (2010) find that among the motives of migration out of Mannheim, apart from moving in with a partner and job change, the (inadequate) size of dwelling was dominant. For some of these households, availability of housing in low-density areas within the municipal boundaries of the large cities may be a welcome alternative to leaving the city in favour of the suburban zone in the future.

As explained, the available data comprise no information about migration flows between neighbourhoods. However, the analysis outlines the combined impact of demographic change and migration on the composition of neighbourhood populations. With reference to the migration flows observed at the city level it can be concluded that in the study period relative shifts in the distribution of age groups across neighbourhoods have taken place, which interrelate mainly (i) with the mobility of

younger working-age people and (ii) rapid ageing of the residential population of all parts of the conurbation.

Analysis of the interrelation between neighbourhood differentials and regional disparities gives an outline of the extent to which economic activity is intertwined with its regional context at different geographical scales (Cox 1998). Regional disparities are reflected in the demographic composition of urban neighbourhoods, since relative agglomeration of working-age residents (aged 18-40) in the more competitive cities of the Rhine-Ruhr conurbation (Bonn, Cologne, Düsseldorf) is high. In these cities in particular, working-age residents tend to agglomerate in selected (central city) neighbourhoods, i.e. in their settlement pattern they are more segregated from other age groups here than in other cities.

Throughout the past decade, the tendency of (predominantly childless) working-age residents to separate from older and younger age groups (households with children) has increased. Yet, the increase in the magnitude of segregation between age-groups (agglomerated as ten-year age cohorts) between 1998 and 2008 was moderate in all parts of this largest urban agglomeration in Germany. While relatively central urban areas with a high-quality housing stock are likely to continue to attract younger mobile working-age residents, the high-income low-density residential areas of the urban fringe face considerable changes in their age structure due to decreasing fertility, a halt of net migration to these areas and *in situ* ageing of the residential population.

5. Conclusions

Decline or growth of the total population and shifts in the share of particular demographic groups imply changes in the degree to which certain goods or services are perceived to be desirable and “scarce” within neighbourhoods. Local economies in various markets, e.g. housing, health care, consumer services, and retail, are likely to be affected.

Predominantly in the Ruhr subregion and in most of the smaller cities of the conurbation, increasing agglomeration of seniors in the more well-off residential quarters may imply activation of a local economy focusing more on senior citizens. Already, housing markets in the Ruhr adapt by refurbishment of the existing stock in order to meet the needs of senior citizens and by demolition of unattractive housing built between the 1950s and 1970s. Larger housing companies and associations in cooperation with welfare institutions have begun to provide household-oriented services, e.g. cleaning, transport and daycare in their estates (Naegele et al. 2005). Other local markets affected by the ageing of neighbourhood populations include retail, health and leisure services. Mainly in the Ruhr, but also in specific areas of the Rhinefront cities, high agglomeration of migrants with a relatively low education imposes further challenges for integration policy. In some of these quarters, on the other hand, a vivid “ethnic economy” specialising on ethno-specific market segments (cf. Wahlbeck 2007), has emerged.

Certainly, discussions over the adaption of the public infrastructure to changing city demographics are well under way in the Rhine-Ruhr conurbation. Following this survey, it will be a task of further research work to evaluate various aspects of public

and private sector adaption to change in the “demographic laboratory” of the Rhine-Ruhr conurbation. For the somewhat less competitive cities, it will be crucial to encourage an influx of younger people. To attract “knowledge workers” it has become part of the urban development strategy of these cities to encourage residential developments aiming at younger working-age people. However, it will become increasingly important for cities to ensure that the public infrastructure and the “urban landscape” provide attractive conditions for different age groups and family types, including households with children.

In the large cities of the Ruhr subregion, which have just overcome being perceived as dominated by old industries and suffering from unhealthy environmental conditions, attraction of high-qualified labour will combine with an urban development policy focusing on the requirements of mobile adults. For a long time, regeneration of inner city neighbourhoods for well-off one- or two-person households has been known as “gentrification” (Smith and Williams (ed.) 1986). In the literature, it has been criticised that gentrification often results in displacement of lower-income households (Atkinson 2001). In the Ruhr cities facing a particularly rapid decline in population, so far only relatively small quarters have been “gentrified”, e.g. the Duisburg Inner Harbour. In Dortmund, a new artificial “waterfront” is part of a mixed residential and commercial area, which is being constructed on a former steelworks site. It can be argued that from the point of view of cities in the Ruhr, at the moment the limited number of “gentrified” neighbourhoods rather suggests intensified efforts to attract mobile adults than to prevent gentrification. In Düsseldorf, on the other hand, migration of working-age households into central parts of the city has combined with a more fundamental

regeneration process altering the composition of the residential population of neighbourhoods, e.g. in the Oberbilk district (Glebe and Dehling 1998). In the Rhinefront cities, it may therefore be a more important goal of urban policy to provide attractive conditions for demographic groups other than young adults.

Since regional (labour-oriented) migration favours large cities, smaller cities may find it increasingly difficult to compete. In large urban agglomerations like the Rhine-Ruhr conurbation, however, combination of a good quality public infrastructure, good accessibility and affordable high-quality housing may prove to be an advantage of smaller core cities in competition over residents, who could live in the smaller cities and work in nearby larger cities. Surely, faced with demographic segregation, it will be a particular challenge for smaller cities to develop a profile, which makes them more “visible”. This could combine with a certain specialisation on selected segments of regional economic clusters, e.g. production or service providers.

The analysis also suggests that the outer zones of urban agglomerations, which have stopped to sprawl, will be confronted with serious challenges in the process of demographic ageing throughout the forthcoming decades. This affects local economies, e.g. housing markets and the demand for health and home care services. It will be a task of further research to investigate more in detail in what way individuals, firms and communities adapt to the local consequences of demographic change and how they can be supported by public policy in this process. One such policy example is the German “Socially Integrative City” programme, which has been co-funded by the federal government, the state governments and municipalities over the past two decades. It has combined a variety of policy measures to support the long-term revitalisation of

selected urban districts in cities throughout North Rhine-Westphalia (Neumann et al. 2011). The outcome of these measures suggests that local economic development can be supported quite effectively by comprehensive local development strategies. In addition, adaptation of local economies may benefit from the willingness of firms to participate in neighbourhood improvement. Many firms have begun to support communities in the vicinity of their business location as part of their overall “corporate social responsibility” (CSR). This activity may comprise training or qualification programmes helping local residents to adapt to economic and demographic change. The public sector may function as an initiator of such private efforts.

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Appendix

Table A1
Factor analysis*of demographic neighbourhood characteristics in the Rhine-Ruhr conurbation 2008

variable	communality**	factor loadings***		
		factor 1	factor 2	factor 3
foreign nationals	0.80	0.75	0.09	-0.48
under 18 age Group	0.88	0.20	0.91	0.00
18-30 age Group	0.78	0.83	-0.15	-0.27
30-40 age Group	0.80	0.85	-0.28	-0.04
40-50 age	0.94	-0.10	0.10	0.96
above 60 age Group	0.80	-0.82	-0.32	-0.14
household size	0.86	-0.32	0.86	0.14
explained variance (in %)		33.6	27.5	25.0

Author's calculation based on data from AG KOSTAT und IT.NRW - *principal component analysis, varimax rotation, **variance explained by factor model, values between 0 and 1 possible, ***correlation between variables and factors, 922 observations