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New measurement approaches to identifying spatial concentrations of poor and low-income households in German city regions

Stefan Fina, Julian Schmitz, Sabine Weck, Carmella Pfaffenbach, Diane Dobusch

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Abstract

The question of whether 21st-century urbanization dynamics are leading to a suburbanization of poverty in Western city regions has been on the agenda of spatial researchers and housing policymakers for over a decade now. Persistent reurbanization trends are putting increased pressure on inner-city housing markets, resulting in affordability problems for low-income households. Evidence from the US and the UK shows that financing mechanisms in the real estate sector were severely disrupted in the aftermath of the financial crisis in 2009 and subsequent years, with many households losing their homes and being forced to move. Though social security

systems and social housing policies generally have a moderating effect, they vary widely across Western countries. Against this background, this paper presents three spatial observation methods tailored to the spatial analysis of poverty concentrations in Germany. The methods are based on three popular conceptualizations of poverty: material poverty, relative poverty, and the concept of neighbourhood deprivation. The main novelty presented in this paper is a cold-spot analysis of purchasing power in 33 city regions using interactive map visualizations and complemented by socioeconomic indicators. Expert feedback verifies the validity of the approach which addresses a 'blind spot' in assessing poverty in Germany, where many low-income households are increasingly exposed to risks of poverty despite not qualifying for social benefits.

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Keywords: Measurement approaches ■ suburbanization ■ spatial poverty concentrations ■ low-income households ■ affordable housing ■ cold-spot analysis

Neue Messansätze zur Detektion räumlicher Konzentrationen armer und einkommensschwacher Haushalte in deutschen Stadtregionen

Zusammenfassung

Seit über einem Jahrzehnt gehen Raumwissenschaftler der Frage nach, ob die Urbanisierungsdynamiken des 21. Jahrhunderts zu einer Suburbanisierung von Armut in westlichen Stadtregionen führen. Persistente Trends der Reurbanisierung verstärken den Druck auf innerstädtische Wohnungsmärkte, einkommensschwache Haushalte sind so erheblichen Engpässen für bezahlbares Wohnen ausgesetzt. Forschungsergebnisse aus den Vereinigten Staaten und Großbritannien verweisen

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auf die Nachwirkungen der Finanzmarktkrise 2009 und ihre disruptiven Auswirkungen auf die Eigenheimfinanzierung, als in der Folge zahlreiche Haushalte umziehen mussten. Sozialpolitik und soziale Wohnraumversorgung sind zwar generell dazu konzipiert, diese Effekte nach Möglichkeit abzufedern, sie funktionieren in den westlichen Industrieländern allerdings sehr verschieden. In diesem Zusammenhang präsentiert der vorliegende Beitrag drei Ansätze zur räumlichen Analyse von Armutskonzentrationen in Deutschland. Die Messmethoden basieren auf drei verbreiteten Armutskonzepten: der materiellen Armut, der relativen Armut und dem Konzept der benachteiligenden Lage. Die zentrale Neuerung des Beitrags besteht in einer Cold-Spot Analyse der Kaufkraft in 33 Stadtregionen, die als interaktive Kartendarstellung im Internet verfügbar ist und durch sozioökonomische Indikatoren ergänzt wird. Rückmeldungen aus Expertengesprächen bestätigen die Passfähigkeit der Messmethode im Hinblick auf einen ‚blinden Flecken‘ in der deutschen Armutsforschung. Dieser betrifft eine hohe Zahl einkommensschwacher Haushalte, die zwar keine Sozialhilfe erhalten, aber dennoch zunehmend armutsgefährdet sind.

Schlüsselwörter: Messmethoden ■ Suburbanisierung ■ räumliche Armutskonzentration ■ einkommensschwache Haushalte ■ bezahlbares Wohnen ■ Cold Spot Analyse

1 Introduction

The suburbanization of poverty is often considered a significant new spatial development trend in the Global North, with poor and low-income households being forced to move away due to rising living costs and few affordable housing options in gentrified inner-city neighbourhoods that attract affluent households. Much research has been published on the dynamics and drivers of the related processes of gentrification and the places where this happens. At the same time, little is known about the destinations of those forced to leave. Studies from the United States and the United Kingdom hint at locations on the fringe of urbanized regions, as witnessed by new concentrations of low-income households (Kneebone/Garr 2010; Covington 2015).

In some countries, these findings are discussed from the perspective of the moderating role of social security systems and their performance in the face of economic turmoil and multiple crises. In Germany, for example, local authorities are obliged to subsidize housing for people within their jurisdiction who qualify for social benefits. Though low-income households can apply for financial support to fund housing costs, the shortage of affordable housing in certain neighbourhoods is projected to worsen further. This comes at a time when new waves of immigration from abroad are

pushing up demand for housing, while the housing sector continues to struggle to build sufficient new housing. The issue of affordable housing has thus sparked highly controversial debates, from grassroots citizen movements up to the high courts (Mösgen/Rosol/Schipper 2019; Marquardt/Glaser 2023).

Against this background, this paper, based on the research project “Suburbanization of Poverty: New spatial (de)concentrations of low-income and poor households in German city regions” conducted by the authors between April 2021 and September 2022, addresses the following two questions: (1) Which dynamics and locational conditions lead to the emergence of new concentrations of low-income households? (2) Which spatial analysis techniques and data options are available and necessary to detect and monitor concentrations of low-income social groups in German city regions? The present paper uses conceptual input from the literature to address the first question. The focus, however, is on the exploration of methodological options to address the second question in Germany. The research was conducted in the 33 largest German city regions targeted by a spatial monitoring system called “ILS StadtRegionen” (English: ILS city regions)¹, a multi-theme monitoring system used to analyse spatial development trends between core cities and their commuter sheds (Fina/Osterhage/Rönsch et al. 2020).

The following section briefly outlines the theoretical background for research question (1) stated above. Alongside clarifying terms and concepts, the section summarizes previous research findings on the spatial dynamics of low-income household displacement. It then moves on to assess selected data-driven analysis methods with regards to their aptness for monitoring spatial concentrations of poor and low-income households as a key input for answering research question (2). The subsequent section explains in detail which data and methods were ultimately used in the project context. A critical assessment of the results, including expert feedback from workshops, concludes the paper’s main sections. In the final sections we discuss the usability of the presented methods in a wider research context.

The paper contributes to methodological knowledge on measuring poverty in a German context, whereby the key results of the stakeholder feedback are published in related project articles (i.e. Weck/Dobusch/Pfaffenbach et al. 2023, Pfaffenbach/Dobusch/Weck et al. 2023).

¹ <https://ils-stadtregionen.de> (01.08.2023).

2 Background

Over the last 20 years, urban development in the Global North has been characterized by a substantial change in the locational preferences of different social groups. In the wake of the *New Urbanism* paradigm shift that characterized urban planning strategies in the 1980s and 1990s, persistent reurbanization trends attracted investment in neglected neighbourhoods and derelict industrial estates, predominantly in inner-city locations (Katz 1994; Grant 2006). Modernized apartment blocks designed for city dwellers, attractive public spaces and the advantages of close-by social and cultural resources are key drivers of the urbanism movement. Large-scale improvements in such features attract not only affluent households, but also new arrivals in search of urban lifestyles and job or business opportunities (Keil 2017).

These reurbanization drivers are mirrored by dynamic suburbanization drivers (Markley 2018). In this respect, the motivation to move to the suburbs to escape environmental pressures and social discord in inner cities has changed over the last decades. Industrial emissions have become either manageable through technological innovations or have been relocated to designated industrial areas away from the most populated neighbourhoods, freeing up space for new residential and mixed-use developments, while the 21st-century labour market provides attractive job and business opportunities for knowledge workers and creatives. The corresponding increase in the purchasing power of highly qualified sections of the urban population further boosts the attractiveness of urban lifestyles, paralleled by processes of residential self-selection and social segregation at metropolitan level (Keil 2017; Kabisch/Haase/Haase 2019; Hahn 2022).

Part of the reurbanization movement is driven by groups with rather limited financial resources – young people in education or at an early stage of their careers as well as unqualified new arrivals from abroad –, putting pressure on the market for affordable housing options. The upgrading of inner-city structures all too often leads to a loss of such options in favour of modernized dwellings with higher rents, to the detriment of low-income households when housing policy fails to encourage affordable options. Such segregation can lead to new dynamics of deprivation and exposure to locational disadvantages. Many observers conclude that the unequal distribution of resources intensifies patterns of spatial injustice and ultimately leads to critical socioeconomic disparities (Lees/Slater/Wyly 2013; Curran/Hamilton 2018).

It is frequently unclear, however, whether new poverty concentrations are (1) the result of the gentrification-driven

relocation of low-income households in search of affordable housing, (2) the ‘second choice’ location of new arrivals unable to find suitable and affordable housing in preferred locations, or (3) the deprivation dynamics of an aging local resident population struggling to cope with increasing living costs (Hochstenbach/Musterd 2018). In Germany, there is evidence that all three hypothetical explanations for new poverty concentrations play a role, but not for all low-income households. Households on benefits² are usually provided with social or subsidized housing. However, in the period 2006–2019, the stock of social housing almost halved to 1.1 million as municipalities sold off their housing assets to boost their finances.³ The shortage of such low-cost options is leading to ‘lock-in’ effects where any wish – other than for employment reasons – to move to more suitable accommodation must either be denied by the authorities or leads to social downscaling and hardship (Holm/Lebuhn/Junker et al. 2018).

These housing market dynamics and the concomitant competition and relocation pressure also affect the ‘working poor’, i.e., low-income households who do not qualify for social benefits or social housing.⁴ This can either be due to their income slightly exceeding certain thresholds or because they simply do not apply for social housing for specific individual reasons (e.g., shame, attitudes, language barriers; see also Günther 2018). Rent hikes and the shortage of affordable housing are putting such households at risk of poverty, possibly contributing to the formation of poverty concentrations (Nollmann 2009).

The problem is exacerbated by forecasts of a decrease in the amount of social housing available in the near future, caused not only by rising demand but also by the privatization of large swathes of the social housing stock. Though this might seem paradoxical at first glance, it can be explained by past neo-liberal housing policies. In the early 2000s and even now, many city-owned social housing estates were sold to private investors, only to be modernized and subsequently let for higher rents on the free market. At

² Households on benefits are defined by Germany’s social security code as households where one or more members are unemployed and receive (long-term) unemployment benefits (SGB II), or retired people whose income is below a certain level (SGB XII).

³ <https://www.bpb.de/kurz-knapp/zahlen-und-fakten/soziale-situation-in-deutschland/341826/sozialmietwohnungen/> (01.08.2023).

⁴ The use of the generalized term ‘working poor’ for low-income households that do not qualify for benefits does not imply that households on benefits do not work.

the same time, expiring social housing contracts⁵ between city administrations and private developers to provide social or subsidized housing have not been replaced in a volume sufficient to meet future demand (Deutscher Bundestag 2017).

3 Data and methods

Despite the societal importance of the problem, quantitative methodologies to analyse the relocation pressures on low-income households caused by housing shortages have substantial limitations. Due to data protection issues and the heterogeneity of data sources in Germany's federal setup, official data on low-income households is only available at the aggregate level of regional statistics, so it is not sufficiently fine-grained to analyse the spatial dynamics of poverty concentrations. Larger city administrations are the only ones with more detailed data on demographic and migration patterns, albeit limited to the city's population. Relocations to smaller localities outside city limits can only be analysed in city regions with special coordination agreements. However, such agreements are scarce and frequently lack key attributes needed to differentiate households by socioeconomic status and demographic characteristics. Indeed, researchers frequently have to rely on personal contacts to obtain data from understaffed data centres (Milbert/Fina 2021).

In an ideal world, data (un)availability should not drive approaches to scientific analysis. Yet this is the case in Germany, a country that features a data protection culture that frequently goes beyond legal requirements. This means that the achievements of international scholars in analysing poverty cannot easily be reproduced in the German context. Methods are needed that respect the intellectual value of poverty concepts while finding new and creative ways to implement them with the available data.

Different forms of poverty are detailed in the international literature (see for example Boltvinik 1999; Milbourne 2010; Alkire/Foster 2011; Ziulu/Meckler/Hernández Licona et al. 2022):

- material poverty⁶, understood as the absence of basic material goods like food and shelter,

- relative poverty⁷, a negative deviation from an average income level for a defined population, and
- concepts of neighbourhood deprivation where disadvantaged social groups are exposed to a lack of resources and limited access to opportunities in their residential surroundings.

There is ample literature portraying applications of these concepts in a variety of methodological implementations, though a comprehensive evaluation of these efforts is beyond the scope of this paper. Commonalities in terms of difficulties in data mining, however, are an important determinant in the search for a research method for analysing the emergence of spatial poverty concentrations in Germany (Dang/Jolliffe/Carletto 2019).

In this respect, the findings of Airgood-Obrycki (2019) showcase a common problem of any poverty analysis. The authors interpret an apparent persistence of economic stability in suburban locations in the United States compared to core US cities as potentially distorted by data aggregation. Average household income values for large administrative units are not suitable for detecting local variations that can differ from block to block, with more detailed analysis revealing that especially derelict and unattractive post-war housing developments attract low-income households in spatially small concentrations (Airgood-Obrycki 2019: 2949). These findings support the need for further empirical data collection and field observations to complement and revise what (aggregated) data analysis suggests.

Another strand of literature concerned with the measurement of poverty concentrations employs regression analysis based on block-related data or small-area estimates. Regression analysis is demanding as it requires a comprehensive conceptual design to populate explanatory variables for a dependent variable. Despite all attempts to verify results with statistical validation options, regression analysis with spatial variables frequently leaves leeway for interpretation. Omitted variable biases, incompatibilities in the up-to-dateness of variables or distortion effects in aggregated or estimated data can challenge the validity and interpretability of results. Spatial analysis also frequently requires data to be harmonized for pre-defined spatial units like city blocks or districts, using rules-based transformation routines. Robust regression analysis is therefore very demanding in terms of

⁵ Housing developers in Germany have access to public subsidies to build social housing. Taking up such funding means that rents are capped for a period of 12-20 years (dependent on which German state (*Bundesland*) grants the subsidy). Once this period expires, owners are free to raise rents to market levels.

⁶ Sometimes also referred to as absolute poverty or material deprivation (see Goedemé/Rottiers 2011).

⁷ A widely used version of this concept is the at-risk-of-poverty rate, defined as 60% of the national median equivalized disposable income after social transfers (https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:At-risk-of-poverty_rate; 01.08.2023).

data preparation and subject to data manipulation requirements (Kamenetsky/Chi/Wang et al. 2019).

This applies especially to the neighbourhood deprivation concept, which requires additional data on neighbourhood conditions, as the neighbourhood is viewed as determining whether residents succeed in life. Popular representations of this understanding can be found in the capability approach postulated by Amartya Sen and the life-situation concept first developed by Gerhard Weisser. These both address the lack of neighbourhood resources and exposure to pressures as important determinants of deprivation, or – vice versa – the presence of opportunities and the absence of adverse pressures as key to escaping poverty (Sen 1985; Weisser 1978; see also Leßmann 2005; Bundesregierung 2022).

Methods analysing local situations in this context have, for example, emerged from research concerned with the environmental justice movement. Initially, environmental justice was understood as the combined effect of multiple local environmental pressures on public health (Browne/Gunn/Davern 2022), measurable by a compound index that weights and summarizes individual indicators for each environmental pressure. An enhanced understanding divides environmental justice into the following components: procedural justice, equity of access and a fair spatial distribution of resources (Bolte/Bunge/Hornberg et al. 2018; Bunge/Rehling 2020). This understanding comes close to what other researchers define as deprivation – a concept where spatial justice and the distribution of and access to resources are similarly determinants of spatial disadvantage in relation to opportunities in life. The similarity of these concepts is first and foremost of a methodological nature and is useful for informing data-driven analysis choices.

Implementation of such concepts was piloted in preliminary project contexts, the main one being the so-called ILS Community Panel (*ILS Kommunalpanel*). In this project, the main author's lab has, since 2015, entered into cooperation agreements with selected cities to pilot and establish research data structures for social space monitoring at neighbourhood level (Fina/Gerten/Gehrig-Fitting et al. 2018). Alongside the experience gained from working with a community panel, methodological know-how stems from a range of international socio-economic disparity studies. In these, spatial variables representing disadvantageous locational factors and the validity of results were discussed with national policy experts in several European countries. Multi-criteria analysis was performed via a spatial clustering of selected representative indicators, whereby the finest-grained input is the municipality, as reported in the study

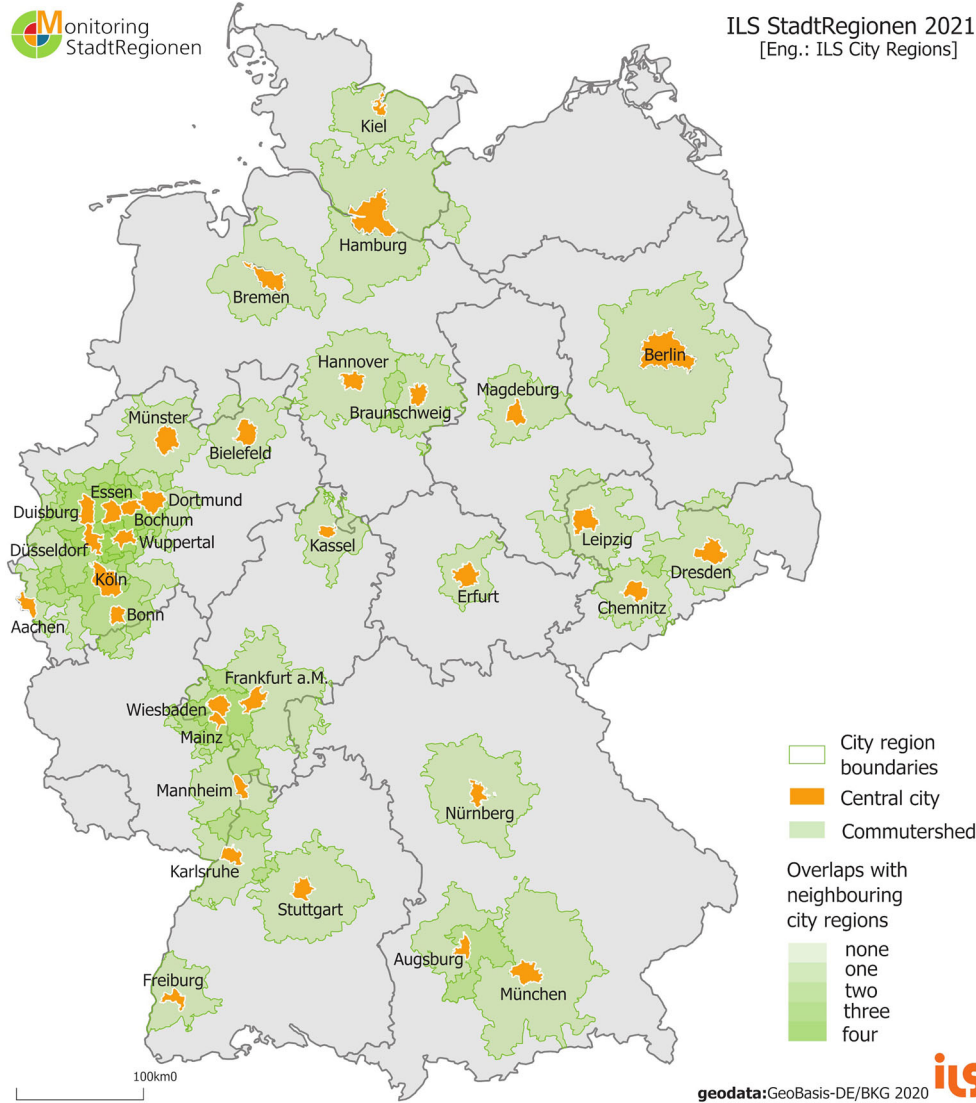
of Fina, Fromhold-Eisebith and Volgmann (2021).⁸ One important lesson learned is that web-mapping technologies can add transparency to multi-criteria analyses. While information on the spatial variation of inputs is removed in the final product of the cluster analysis, web maps allow both to be shown – the final output and layers of input variables and indicators – in an easy-to-use and accessible way.

The data used in these studies is not, however, easy to collect at neighbourhood level. This problem is compounded by the scope and requirements of the methods used to analyse developments over time and the need to establish long-term monitoring frameworks. In this context, researchers emphasize the continued availability of comparable data. Monitoring frameworks frequently resort to using spatial indicators in consistent time series, either as single or multiple indicators (Malczewski 2006). Their choice is highly dependent on a conceptual framework for the research objective in question, in our case poverty concentrations. Material poverty, for example, can be measured by defining basic goods that households possess or lack. Similarly, relative poverty can be measured using the spatial and social variation of household incomes. By contrast, enhanced poverty concepts like deprivation require several indicators relating to the quality of neighbourhood resources and social milieus (Nolan/Whelan 1996).

The methodology presented in the following sections is made up of a series of analysis options for the three categories of poverty mentioned above (material poverty, relative poverty, neighbourhood deprivation), reflecting the data options available in Germany and including a novel concept to measure relative poverty concentrations in German city regions (see Textbox 1). There are two reasons for selecting this combination of concepts. First, the author team needed a suitable method to select experts to be interviewed in the context of the case study (see the candidates in the supplementary material in Table S1-S6 and Pfaffenbach, Dobusch, Weck et al. 2023 for results) and a subsequent detailed analysis of local deprivation in the project context. Second, the identified method produces baseline data for the ongoing monitoring of poverty concentrations in German city regions and for enhancing the spatial monitoring system ILS StadtRegionen.

⁸ All other studies are published on the 'Unequal Europe' website of the political foundation that commissioned the studies, available at <https://www.fes.de/en/politics-for-europe/unequal-europe> (01.08.2023).

Textbox 1: ILS city regions explained



The delineation of city regions for long-term spatial monitoring uses an approach based on population and employment figures and travel times within commuter sheds.^a In the first step, the largest cities (with more than 200,000 inhabitants and more than 100,000 employees^b) are selected. The surrounding region is defined by car travel time, where the cutoff value depends on the attractiveness of the core city as an employment location. The maximum driving time for a city region is based on computations of ‘predictive travel times’, including estimates of delays and congestion times.^c For the commuter shed of Germany’s largest city region (Berlin), maximum driving time is set to 60 minutes, while for the smallest one (Erfurt), it is set to 30 minutes. The driving time for all other city regions is computed via an attractiveness function based on the number of employees in the core city, varying between 30 and 60 minutes. The resulting travel time thresholds are applied to central locations of municipalities as defined by the Federal Office of Cartography and Geodesy in the point-of-interest dataset ‘Geographical Names’. In some cases, smaller municipalities share administrative responsibilities so that statistical information is only available for their entirety. In such cases the travel time threshold was applied to the largest settlement (Fina/Osterhage/Rönsch et al. 2019; Fina/Osterhage/Rönsch et al. 2020).

^a see also <https://ils-stadtregionen.de> (01.08.2023)

^b excluding civil servants and self-employed people who are not registered in the employee social security database

^c <https://desktop.arcgis.com/de/arcmap/latest/extensions/network-analyst/traffic-what-is-traffic-data.htm> (01.08.2023).

4 Material poverty and social beneficiaries

Based on the considerations outlined above, the search for a data-driven method starts with the explanation of a potential bias in German research output towards households on benefits. This bias has to do with the ready availability of municipal data on households registered as benefit recipients. Published as an open data source by the Federal Employment Agency, the data has become a popular source for academic and government endeavours to monitor poverty concentrations (e.g., BBSR INKAR⁹, Regionalatlas¹⁰). However, as explained above, this group of households is, at least in theory, shielded from housing market developments and profits from the ‘lock-in’ effect mentioned above. Our research question, however, asks whether there are new concentrations of poverty that emerge when people relocate to the suburbs in search of affordable housing. Since housing costs for households on benefits are covered by social welfare, the ‘working poor’ are the ones feeling the pressure as they do not qualify for benefits and social housing. Data on where such households live is not easy to come by, meaning that displacement pressure on the ‘working poor’ is a ‘blind spot’ in Germany.

Nevertheless, monitoring benefit recipients provides initial lessons for analysing the numbers of affected residents at city and municipal level.¹¹ Figure 1 shows a visualization of the 33 largest German city regions resulting from preliminary work performed by the main author’s former lab. The share of poverty is presented as the change in percentage points in the ten years between 2008 and 2017 in the core cities (x-axis), compared to that in the commuter shed (y-axis). The size of the blobs is proportional to the total

number of residents on benefits in the city region in 2017. The location of the points in the four quadrants of the graph shows the change in percentage points between 2008 and 2017 in absolute terms. Blobs in the upper right quadrant represent an increase in the share of residents on benefits in the core city and the commuter sheds, while in the lower left quadrant the opposite is true, i.e., a decrease was registered in both the core city and the commuter shed. Blobs in the upper left quadrant show where the share decreased in the core city but increased in the commuter sheds. Vice versa, the points in the lower right show only one city region with a decrease in the commuter shed and an increase in the core city (Bremen). The diagonal line helps the reader to identify all the city regions where the change rates for residents on benefits are relatively higher in the commuter sheds. Blobs below this line represent regions where the change rates are relatively higher in the core city.

The results show that the majority of German city regions have either seen higher increases of residents on benefits in suburban communities (points above the diagonal line in the upper right quadrant) or a relatively stable proportion in the commuter sheds compared to decreasing rates in the core city in the observation period (upper left quadrant). This finding backs the interpretation that residents on benefits are increasingly to be found in the suburbs of these city regions. However, it does not constitute proof of displacement and relocation from inner cities. As such households are provided with housing wherever they apply for benefits, they rarely move across municipal borders once they are granted social housing and benefits. Decreasing rates more often mean that households no longer qualify for benefits due to the successful labour market re-integration of previously unemployed persons (Brenke 2018).

This observation is further substantiated by an analysis of employment figures in the same city regions. Labour market reforms in Germany and the economic prosperity of the 2010s led to an increase of jobs in German city regions, with overall unemployment decreasing. However, social policy analysts frequently point out that a large number of the newly created jobs were in the low-income bracket and thus precarious (e.g., agency work not covered by collective agreements, fixed-term contracts, seasonal work), with the result that ‘working poor’ numbers increased. Such criticism puts a major question mark over the apparent successes of Germany’s labour market reforms (Wimbauer/Motakef 2021). Grabka and Schröder (2019) observe that the share of working poor had already increased a few years earlier and has remained constant since 2008. With a share of 23%, the proportion of employees in the low-wage sector is very high (Grabka/Schröder 2019: 249). This shift in income levels is further backed by observations of increasing socio-economic disparities, with the lower-middle class

⁹ BBSR INKAR is the spatial monitoring system of the Federal Institute for Research on Building, Urban Affairs and Spatial Development. It uses the number of benefit recipients as a key indicator for monitoring sustainable development goals. Available at <https://www.inkar.de> (01.08.2023).

¹⁰ The Regionalatlas is the publicly available interactive web mapping tool for spatial monitoring maintained by the German federal and state statistical offices. It uses the number of benefit recipients as an indicator under the ‘social’ monitoring heading; see <https://regionalatlas.statistikportal.de/> (01.08.2023).

¹¹ A comparison of the number of people qualifying for benefits can be understood as a proxy for spatial concentrations of material poverty. The benefits certainly also extend to non-material resources like the vocational training and re-integration of beneficiaries into the labour market. The material perspective, however, is at the core when it comes to the definition of basic subsistence resources (“Leistungen der Grundsicherung”) in negotiations of benefit levels.

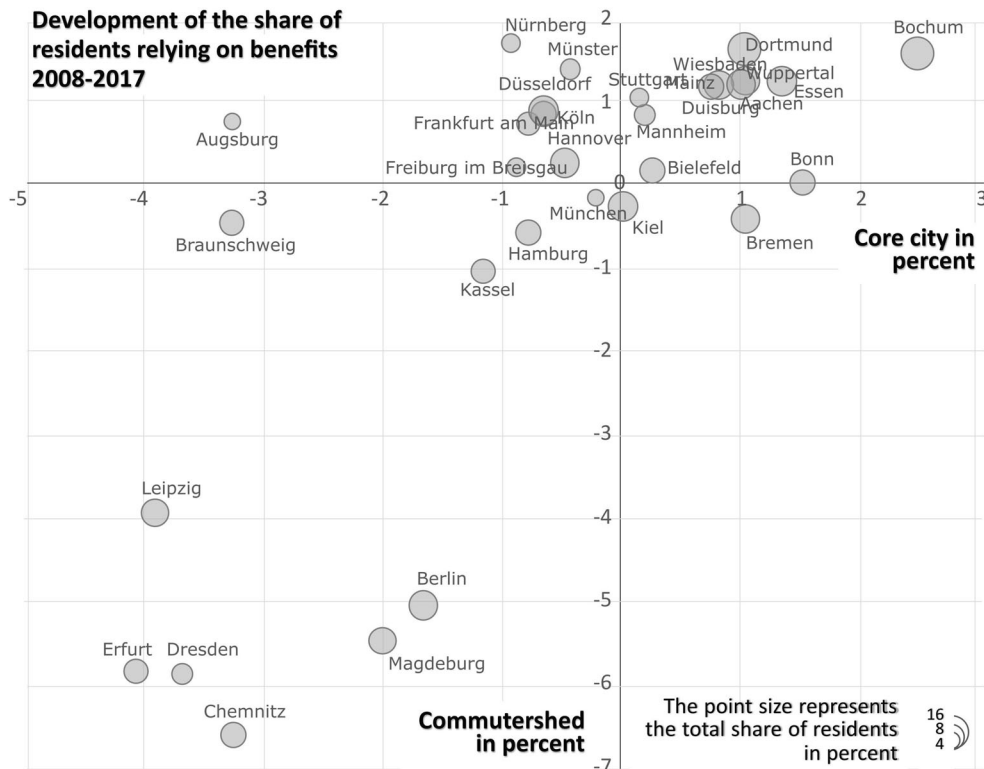


Figure 1 Average annual change in the number of residents dependent on benefits between core city (x-axis) and its commutershed (y-axis) in percent. Data: Federal Employment Agency. Source: Fina/Osterhage/Rönsch et al. (2020: 260)

increasingly exposed to rising living costs not compensated by higher wages.

The emerging ‘blind spot’ in the available data for this social group highlights the need to go one step further, looking for a method that includes the ‘working poor’ in the equation.

5 At-risk-of-poverty: new spatial concentrations of the ‘working poor’

The method found to achieve this aimed to map low-income household concentrations in selected German city regions (‘macro-analysis’) with the goal of equipping interviewers in the project team with initial results for discussion with local experts. Explorative data analysis used several possible indicators available for the whole of Germany from official datasets and research institutions and led to the choice of a 1x1 km grid dataset variable from the research data centre at the RWI – Leibniz Institute for Economic Research. This institute specializes in the publication of socio-economic variables, including aggregated micro-geographic data from

private data vendors.¹² This data can be licensed for research purposes on the basis of a cooperation agreement.

From the investigated variables (and their potential combinations), we ended up choosing the concept of household purchasing power as the most suitable proxy for relative poverty in comparison to the local and city-regional averages. We prefer this procedure over the usage of a fixed income threshold value since income levels are highly diverse across German city regions. In this context, purchasing power is a most conclusive proxy for the affordability of housing where local deviations (‘cold spots’) hint at relative concentrations of low-income and poorer households. It is defined as net household income from labour, interest payments, rents and leases. It is further adjusted for social transfers. Expenses such as taxes or social security contributions are deducted. Social benefits such as unemployment benefit, family allowances and pensions are added where

¹² The aggregation procedure summarizes street address data to the 1x1 km grid complying with the General Data Protection Regulation (i.e., counts less than 5 are blacked out).

applicable.¹³ Expenditure on such basic needs as housing is not deducted (Breidenbach/Eilers 2018: 613).

It is important to note that this data source is based on aggregated street-level data modelled by the market research institute Michael Bauer Research GmbH in cooperation with the data vendor microm. Coming from the Federal Statistics Office, their input data represents purchasing power at municipality level. This is then disaggregated to street level using explanatory variables for local differentiation (e.g., typology, age, status, car variables). The results are validated by a sampling strategy that allows a comparison with the socio-economic survey panel (SOEP) and other survey information. RWI researchers check the validity of the data and their application for socio-economic spatial analysis (Budde/Eilers 2014; Breidenbach/Eilers 2018).

Based on the selection of purchasing power as an easily communicated indicator, the macro-analysis identifies spatial concentrations of low-income and poor households in German urban regions. The analysis can be performed by spatial geostatistical analysis packages that use the Getis-Ord G_i^* algorithm, aka ‘hotspot analysis’. It is available in commercial software packages like ArcGIS Desktop or ArcGIS Pro or open-source alternatives like GeoDa or the R statistical software package. In the macro-analysis, the Getis-Ord G_i^* method compares the value of a cell with the average of all cells of a city region, moderated by a distance decay function. This means that cells neighbouring the purchasing power cell in question have a greater influence on the weighting algorithm than cells farther away. The Getis-Ord G_i^* algorithm uses parameters to specify neighbourhood size (‘zone of indifference’) as well as a linear function for distance decay. We used a neighbourhood size of two kilometres, i.e., two cells, and Euclidian distance to weight the influence of neighbouring cells on the result of a selected cell (Getis/Ord 2010).

The output of this ‘hotspot’ analysis also includes so-called cold spots, places where the local purchasing power deviates negatively from the surrounding area and the city-regional average. Figure 2 shows an example for the city region of Augsburg where red and blue cells are colour-shaded based on the level of significance (99%, 95% and 90% significance). High values express a high statistical robustness of the deviation from the average purchasing power of the whole city region. Blue cells of high significance are visible in the core city and the nearby suburbs. Peripheral concentrations of low-income households are located in western and north-eastern municipalities, as well as in the far south of the city region (in smaller numbers and

with lower significance). Hot spots are located in western and eastern suburbs of the core city, in the northern town of Donauwörth and towards the east where the Augsburg city region overlaps with Munich’s comparatively affluent suburbs.

Interactive maps for all results can be accessed online.¹⁴ The web page contains the analysis results for the 33 largest German city regions as single layers in alphabetical order that can be displayed in greater detail with zoom-in functions and the selection of background maps (e.g., topography, satellite images).

The cold-spot maps were complemented by factsheets from the city regions and their municipal administrations, as well as by socio-economic statistics presented in Tables S1 to S6 in the supplements. Based on the interpretation of these results, the project team selected case study regions for stakeholder interviews from their interpretation of the results presented in the supplementary material.

6 Neighbourhood deprivation: a lack of resources and exposure to environmental pressures

The ‘micro-analysis’ approach to measuring poverty concentrations is based on an understanding of poverty beyond the material and income perspectives of absolute and relative poverty. Alongside income, the state of the local environment in terms of socio-economic opportunities and environmental pressure is also analysed. The sample concept for a data-driven implementation in the project context of this paper is illustrated in Figure 3. Data was purchased for selected municipalities where cold spot selection served as input for the stakeholder interviews, with variable selection based on an initial synthesis of multiple deprivation approaches in the literature (see, for example, the selection presented in Fairburn/Maier/Braubach 2016 and references to our own preliminary research in Section 2 of this paper). For the purpose of our research project, we identified three dimensions to systemize determinants of deprivation: (1) socio-economic household characteristics and housing costs, (2) public services and accessibility of the city-regional transport network, and (3) environmental pressures and resources. The indicators listed below the maps show potential candidates for measuring the dimensions before weighting is used to arrive at a combined index of disadvantaged neighbourhoods (the map on the right). The differing geometric representations of input data (e.g., point locations

¹³ <https://fdz.rwi-essen.de/doi-detail/id-107807micromkaufkraftv7.html> (18.08.2023).

¹⁴ <https://ils-geomonitoring.de/maps/505/view/> (16.08.2023).

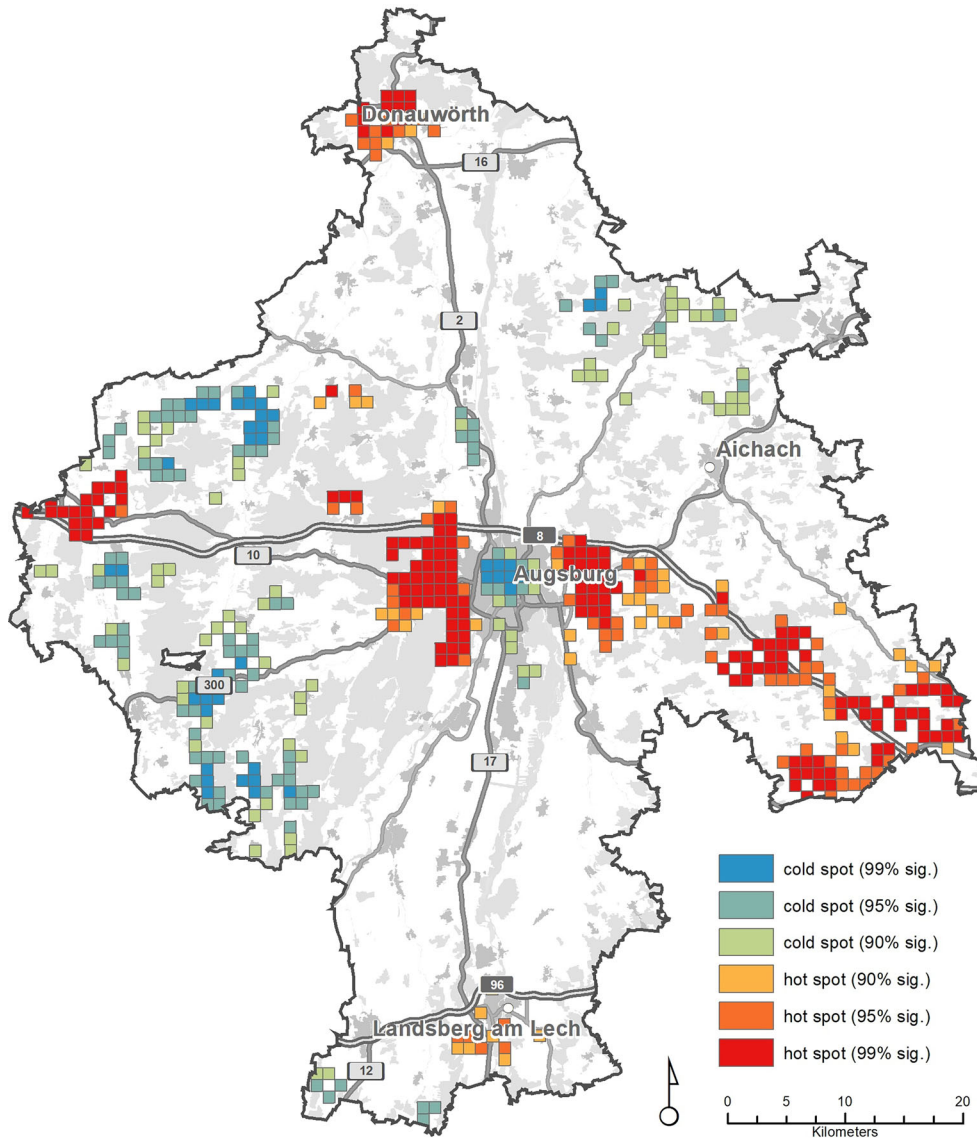


Figure 2 Print example of the interactive maps for the Getis-Ord G_i^* hot and cold spot analysis Source: <https://ils-geomonitoring.de/maps/505/view#/> (16.08.2023)

for amenities and housing costs vs. areal representations of accessibility isochrones or noise bands) require rules-based transformations into target geometries like grid cells. Such procedures are readily available in GIS software packages. Ideally, the spatial granularity of results is sufficiently detailed to represent local variations between individual plots of land and city blocks.

Implementation of such concepts, however, involves a range of challenges to spatial analysis, particularly on a local neighbourhood scale. Thus data protection laws in Germany prohibit the release of information allowing individuals to be identified and located. A further constraint is that the retrieval of aggregated information is highly

dependent on the goodwill of cooperation partners and individuals backing the idea of establishing such research data infrastructures within city administrations. Even where this is the case, cooperation partners may decline consent to publish their figures. The supplementary material of this paper shows Düsseldorf as an example where a cluster analysis mapping the spatial variation of locational advantages and disadvantages was successfully completed and published. Endeavours to extend such cooperation projects to suburban communities in the Ruhr region have failed through not all cities seeing the need and/or having the capacity to support the research.

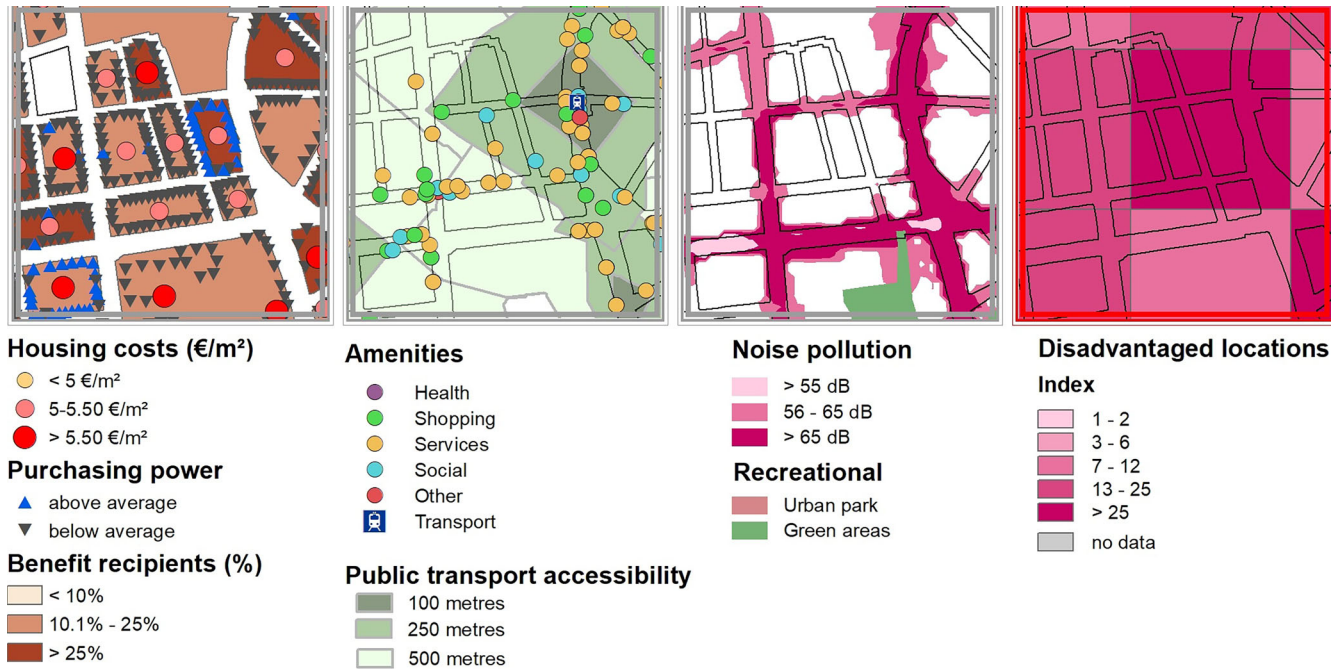


Figure 3 Micro-analysis concept to characterize deprived neighbourhoods

Alternatives such as small-area statistics available from private data vendors are mainly designed to support businesses with location-based information on customer potentials (Herter 2018). Their use for scientific purposes is theoretically possible but subject to cost constraints and acceptance of the fact that the methods used to produce the datasets are not fully disclosed. The RWI's release of its purchasing power dataset, which we used for our cold spot analysis, represents a way to publish this data, but many prerequisites have to be met. Moreover, grid size is limited to 1x1 km. The use of such data remains problematic when wanting to maintain the highest scientific standards and have reliable base data for a continuous and consistent monitoring of neighbourhood deprivation.

Mapping out data-driven concepts of deprivation potentially stigmatizes locations exposed to such socio-economic pressures. Critical geographers point to social constructivism theory, which indicates that results should be handled with care so as not to interfere with the research subject. This extends to cartography where mapping requires sensitive handling and sometimes a conscious decision not to publish results where a potential negative impact on an area's image may fuel deprivation dynamics (Kühne 2021). At the same time, performing such analyses for social policy action requires exchanges among scholars on data potentials and methods (Martínez/Pfeffer/Baud 2016).

Against this background, neighbourhood deprivation analyses ('micro-analyses') could only be performed in an

explorative manner for selected cold spots in the case study regions where a budget for purchasing data was provided by the project-funding party (in our case, the German Research Foundation). The author team has agreed not to publish location-based results for case studies in selected cold spots to avoid the neighbourhoods in question being stigmatized as deprived. Instead, Figure S1 in the supplementary material shows the sample implementation for Düsseldorf mentioned above.

7 Summary and discussion

The methods discussed in this paper to spatially analyse poverty concentrations are based on three main strands of poverty concepts. The material poverty perspective focuses on households and people unable to cover basic material needs with their income or savings. In the German context, they therefore qualify for social benefits including either the provision of social housing or financial support for housing on the free market. Methods to operationalize this concept are limited to the spatial analysis of benefit recipient concentrations at city and municipal levels. This approach is frequently used due to the ready availability of data. Results are therefore frequently reproduced in political debates on social policy and the governance of social and territorial disparities. However, the resulting information is not sufficiently representative for research questions aimed at

analysing the displacement and relocation pressures affecting low-income households. Recipients of benefits are by and large shielded from gentrification dynamics within city limits in German city regions, making it unlikely that they will be forced to relocate to suburban areas where housing is cheaper, at least not in larger numbers. Instead, stakeholder interviews in the case study regions and scholars invited to discuss these results point to segregation pressures where local pockets of poverty emerge with no clear locational pattern along the core-to-suburban continuum.¹⁵

This observation prompts a need for additional analysis methods targeting low-income households with incomes just above the thresholds for receiving benefits. In public debates on poverty and spatial justice, awareness is growing that the dynamics of socio-economic disparities are putting the ‘working poor’ at risk of poverty. They are the ones especially vulnerable to gentrification in the face of rising costs of living, with housing costs frequently the dominant cost factor. Locational concentrations of this group can be pinpointed through mapping purchasing power cold spots at the city-regional level. Together with auxiliary data on housing costs, such mapping can be used to identify concentrations of households at risk of poverty and establish a baseline for future monitoring. An additional advantage of this approach is the higher data granularity of 1x1 km cells compared to the limitations of aggregated city and municipal data normally used for spatially analysing the receipt of benefits.

Finally, the neighbourhood deprivation concept zooms in further when analysing selected cold spots. For the areas in question, a multi-criteria framework of neighbourhood resources and pressures is used to compute an index of disadvantage in 100x100 metre cells. This approach is very demanding in terms of data availability. Data providers able to supply such data only exist in larger cities, meaning that suburban communities are rarely covered. Moreover, the data is subject to data protection laws prohibiting researcher access to data where individuals can potentially be identified. The approach can therefore only be used for small-area estimates, with auxiliary data sourced from private data vendors at high cost.¹⁶

The combination of these methods represents a comprehensive chain for analysing concentrations of low-income households in German city regions. The main contribution of this paper is the exploration of data-driven implementation options for the poverty concepts that we cover in this

paper. As a methodological building block, they contribute to a wider research project extending to research questions on the monitoring of displacement trends internationally known as ‘suburbanization of poverty’. Despite the findings presented in this paper, limitations remain. First, the question guiding the research was whether there is pressure to relocate from attractive inner-city locations to the suburban fringe in Germany, similar to that observed in the United States and the United Kingdom in the aftermath of the financial crisis. The data-driven methods presented in this paper only allow poverty concentrations to be analysed, but not movements across the administrative borders of cities and suburban municipalities.

In this respect, the interviews conducted with stakeholders and housing experts in the case study regions support the finding that households on benefits are shielded from relocation pressures within city limits. Even if gentrification is leading to rising housing costs, thus squeezing out low-income households, city administrations are still by and large successful in providing housing alternatives within their jurisdiction, at least for households on benefits. However, the material poverty method has little to say about the displacement pressures faced by the working poor.

This methodological deficit cannot currently be overcome by the presented cold-spot analysis (i.e., the relative poverty method) either. Despite its general suitability for detecting poverty concentrations and their spatial variations over time, it is not suitable for attributing new poverty concentrations to displacement or relocation pressures. When presented with the maps, interviewed stakeholders unanimously argued that, while the cold spots were remarkably accurate for detecting poverty concentrations, most of these concentrations had emerged in situ. Reasons mentioned point to the declining socio-economic situations of older residents in increasingly derelict housing estates and to image-related neighbourhood disadvantages. The role of displaced new arrivals was seen as marginal.

This finding is not surprising if one acknowledges that data-driven spatial observation cannot be expected to identify causal relationships between poverty concentrations and the forces driving the displacement and relocation of low-income households. It is exactly for this reason that the authors favoured a mixed-methods approach within an interdisciplinary research project, including expert workshops and stakeholder interviews, from project outset. The information gained from the respondents was not only used to validate the results of the cold-spot analysis, but also to guide the selection of indicators and the dimensions used in the micro-analysis conceptually presented in this paper.

We encourage readers to consult detailed project publications that draw on expert advice and stakeholder feedback on the factors explaining disadvantaged neighbourhoods

¹⁵ See also the detailed reports on interview results of the project in Pfaffenbach/Dobusch/Weck et al. (2023).

¹⁶ In the project context, data was obtained for three municipal case studies at a total cost of approximately 16,000 euros.

and the related poverty concentrations (Weck/Dobusch/Pfaffenbach et al. 2023, Pfaffenbach/Dobusch/Weck et al. 2023).

8 Conclusion

This paper presents data-driven methods from Germany aimed at examining a common trend in Global North countries where housing in attractive inner city areas can increasingly only be afforded by affluent sections of society. The hypothesis of a ‘suburbanization of poverty’ originates from observations in the United States and the United Kingdom where persisting urbanization has led to new concentrations of lower-income households in suburban communities. Especially after the financial crisis in the late 2000s, the majority of these households apparently relocated from modernized inner city neighbourhoods to locations in the suburbs where housing remained affordable. The lack of neighbourhood resources and exposure to locational disadvantages in the suburbs potentially reinforces disparities between inner cities and the suburbs.

Based on a project funded by the German Research Foundation, spatial planners and human geographers combined forces to analyse whether this trend was to be seen in German city regions. The findings of this paper are a building block in this research. Three methods were found to be worthwhile examining, each representing a different conceptualization of poverty. One method that is very prominent in the German context operationalizes the concept of material poverty through a spatial analysis of households on benefits. A second one identifies purchasing power ‘cold spots’, with the results showing where ‘working poor’ neighbourhoods are relatively poorer than nearby neighbourhoods and the city-regional average. The last method conceptualizes neighbourhood deprivation as a lack of resources and opportunities as well as exposure to environmental and social pressures.

Selected results were discussed in expert groups and presented to local stakeholders in the city administrations of the case study regions. The respondents unanimously endorsed the ‘cold spot’ method as suitable for monitoring poverty concentrations. However, the experts could not agree on the ‘suburbanization of poverty’ trend being the cause of new poverty concentrations, instead observing increasing segregation forces within their jurisdictions. Housing markets seem to play a dominant role in reshaping territorial disparities in this respect. However, further research is needed to test whether such observations are biased towards the situation of households on benefits. This might be the case when stakeholders focus on the concerns of benefit recipients as the ‘clients’ of their daily work. It is also possi-

ble that respondents were not able or willing to speculate on future risks in their current assessment. In this context, current economic crises and the predicted shortage of affordable housing in German city regions are likely to exert increasing pressure on low-income households to relocate to affordable locations. One can therefore not rule out that the factors driving the suburbanization of poverty are yet to prevail.

For this reason, it seems prudent for the spatial sciences to establish monitoring concepts tailored to the observation of poverty concentrations and the related socio-economic disparities. The analysis chain presented in this paper, accompanied by dedicated surveys and interviews, is thus considered as contributing new methodological knowledge in this respect.

Competing Interests The authors declare no competing interests.

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