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Research Report

FDZ data description: Regional real estate price indices for Germany (RWI-GEO-REDX)

RWI Projektberichte

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RWI – Leibniz-Institut für Wirtschaftsforschung, Essen

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RWI – Leibniz-Institut für Wirtschaftsforschung

**FDZ Data description:
Regional Real Estate Price Indices for Germany
(RWI-GEO-REDX)**

**Larissa Klick
Sandra Schaffner**

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1 Introduction

An important issue in the current German public and political discourse is the development of housing prices. Sharply increasing rents, shortage of living space in urban areas and rural exodus are some of the discussed problems. Despite its topicality, few data are available on the recent development of housing prices in Germany. To fill this gap, the RWI-GEO-REDX data¹ set quantifies regional differences in house purchase and apartment rent prices on the level of districts (*Kreise*, NUTS 3-level) and municipalities (*Gemeindeverband*, LAU 1-level).

Several methods are used to derive real estate indices. First, median sales prices are the easiest to construct and are used by the U.S. Census Bureau. However, they do not adjust for the quality of properties that are on the market (Ghysels et al. 2013). Case and Shiller (1987) propose a repeat-sales price index that is a constant-quality index and only uses information about homes that transact at least twice during the sample period. Very little data is needed for this index. However, those properties may not be representative of the population (Clapp/Giacotto 1998) and the index is based on the crucial assumption that quality does not change due to renovation or modernization. This second method is used for the HPI Index by the US Federal Housing Finance Agency.

Third, hedonic price indices are based on hedonic price regressions where the price is expressed as a function of characteristics. The quality, therefore, depends on the choice of characteristics. For all three index types it is essential that selling a property can be correlated with local economic conditions as more expensive homes will tend to be put on the market in expansionary times. Gatzlaff and Haurin (1998) take the selectivity of using only sold houses into account. Englund, Quigley and Redfearn (1998) combine the hedonic index with the repeat-sales index. Finally, there are stock-market based indices that are obtained by the trading of real estate investment trust stocks.

While a simple study on the regional mean price of apartment rents and house purchases is not sufficient for reliable statements on housing prices, the RWI-GEO-REDX is based on hedonic price regressions. The hedonic price regressions account for qualitative differences of residential offers, such as different facilities. Hedonic price regressions are a commonly used method for real estate pricing in Germany, e.g. in the *hedonic EPX* by the Europace AG (2018) which is a commercial online distributor of real estate financing, and the real estate price index by Verband deutscher Pfandbriefbanken e V. (vdp) (2018) handling transaction data from certain financial institutions. The real estate price index by bulwiengesa AG (2018) focuses on cities and larger towns but it does not contain coherent information on data structure and methodology, and it is available for commercial use only. The AK OGA, a cooperation of all German federal review committees on real estate topics, publishes housing price indices on different house types on a yearly basis and on federal and sub-district level. These price indices are partly obtained by median sales observation and hedonic price regressions. Furthermore, the IMX offer index is hedonic price index that is developed from placed offers from the online real estate *ImmobilienScout24* for house or apartment sales and rents.

The first two indices report the changes in housing prices on a national level, and they do not give further information for smaller regions. This study fills this gap by combining a comprehensive up-to-date dataset and a hedonic price regression; it offers regional price indices to the German mean capturing regional differences, the region-specific time trend as well as the national development over time. The analysis is based on a dataset of online real estate advertisements, the RWI-GEO-RED. This comprehensive data set is obtained from *ImmobilienScout24*. The data are updated regularly, allowing for the analysis of recent developments. Hence, it is possible to update the price

¹ Klick, Larissa; Schaffner, Sandra; RWI (2019): *Regional Real Estate Price Index. RWI-GEO-REDX. Version: 1. RWI – Leibniz-Institut für Wirtschaftsforschung. Dataset.* <http://doi.org/10.7807/immo:redx:V2>.

indices on a regular basis. Furthermore, the data set covers all of Germany, and thus price indices on district and municipality are available.

Here, we opt for a hedonic price regression for the price indices to capture various features of the sales and rent prices beyond the observation of the median. The repeat-sales approach is possibly not representative for the German real estate market, as Voigtländer (2017) mentions. Here, it also rules out due to the data limitation to connect two sales of the same object.

While, other published price indices are developed via financial data, the following analysis deals with seller-placed offers. This means that only apartments and houses that are for rent or for sale and offered on the listing website are available in the data set. Therefore, the analysis is based on advertising prices and not on transaction prices.

2 Data

We use the RWI-GEO-RED data of the FDZ Ruhr at RWI to generate the price indices. They are based on real estate offers published on the German listing website *ImmobilienScout24*. ImmobilienScout24 is the largest real estate listing website in Germany. It gives real estate owners and estate agents the opportunity to advertise their objects for a fee. All information is provided by the owner or the agent who sell or rent the object. While some information must be provided to place an advertisement online, most information is supplied at the discretion of the seller. However, more information on the object helps to present it adequately, and likely increases the chance of selling or renting.

The dataset entails information of real estate offerings on prices as well as on various characteristics that determine the value of a property. It is dealt with monthly data. Detailed information on the dataset can be found in Boelmann/Schaffner (2018). The present dataset covers January 2007 until October 2017. There are only little observations in 2007 we therefore restrict the data to the years 2008 to 2017 in the following.

The RWI-GEO-RED offers information on the 1km^2 grid², municipality, district and federal state of the building. Further, the data covers information on the size of the house or the apartment (e.g. living space, plot area, number of rooms), on its facilities (e.g. balcony, garden, bath rooms, level of facilities), financial aspects (e.g. price and additional costs) as well as information on energy consumption. Unfortunately, some variables are characterized by many missing values, which needs to be considered for the following analysis.

The selection of variables for the analysis is based on two considerations. First, we aim for coherence in the data set, to ensure comparability between properties. Second, the set of features used in the analysis needs to be comprehensive enough to capture the various characteristics of apartments and houses in Germany. Table 1 gives an overview of the characteristics that are included in the analysis.

We exclude luxury apartments from the analysis. To this end, apartment with rents exclusive utilities above 5 000 Euro per month are omitted from the analysis. The living area is restricted to 15 to 400 sqm and not more than 7 rooms per apartment. These restrictions still cover a very large range of rent prices and living space, but it discards the extremely small or exclusive apartments from the portfolio: 5.2 percent of the observations from the original sample are dropped for rental apartments

² INSPIRE (*Infrastructure for Spatial Information in Europe*) regulation.

It is likely that the luxury apartment market is not fully integrated with average rental market, making any comparison over regions across the markets difficult. We further set a bottom limit of 15 sqm living space to include only self-efficient apartments and to exclude typing errors.

House purchases are restricted in a similar fashion; the living area ranges from 50 to 600 sqm and the house price varies up to 5 Million Euro. The number of rooms is restricted to 15. The aim, here, is to ensure self-efficiency but rule out possibly faulted and extremely luxurious objects as above. The focus of the analysis of house purchases lies on single-family homes, thus, apartment buildings are excluded. Furthermore, holiday homes are excluded if declared explicitly so by the seller. The data is reduced by 5.4 percent after imposing these restrictions and excluding incomplete observations.

About 12 percent of the observations in house purchases and almost 5 percent of the rental apartment offers are weakly georeferenced. This phenomenon is more profound to observations between 2011 and 2013 due to publishing regulations on the listing website. The weakly georeferenced data points are not included to secure coherence and prevent wrong allocations.

When placing the advertisement online, the user decides which information to publish on the advertised real estate. Working with these self-declared information leads to many missing values in most variables that need to be handled with care. For the binary variables a missing is accounted for as a zero, so the offer does not meet the feature in question. This seems reasonable the extent that the user tends to publish benefits of the real estate to attract searchers with certain preferences. Furthermore, in some years many characteristics are collected using checkboxes which means that there is no difference between “no” and “no answer”. Examples are especially positive characteristics of the object, such as a balcony or guest toilet. In the analysis, we deal with missing values as a separate category for categorical variables. In the considered metric variable, number of rooms, missing values are given as “zero rooms”.

We compute the price indices for districts and municipalities based on the regional definitions of 2015. In 2015, there were 402 districts of different area and population size in Germany. Further, there were 4,542 municipalities (*Verbandsgemeinden*).

Regional Real Estate Price Indices for Germany (RWI-GEO-REDX)

Table 1
Explanatory Variables in Analysis of House and Rent Prices

| Variable | Description | house- sale | apart- ment- rent | Restrictions |
|-----------------------------|---|----------------|-------------------------|---|
| Metric variable | | | | |
| number of rooms | number of rooms in apartment | x | x | restricted to 15 (houses) and 7 rooms (apartments), respectively |
| Categorical variables | | | | |
| year of construction | 1:=missing | x | | |
| | 2:=before 1900 | | | |
| | 3:=1900-1945 | | | |
| | 4:=1946-1959 | | | |
| | 5:=1960-1969 | | | |
| | 6:=1970-1979 | | | |
| | 7:=1980-1989 | | | |
| | 8:=1990-1999 | | | |
| | 9:=2000-2009 | | | |
| | 10:=after 2009 | | | |
| plot area | 7 categories [in sqm] | x | | |
| | 0:=missing | | | |
| | 1:=(0-200] | | | |
| | 2:=(200-400], | | | |
| | 3:=(400-600] | | | restricted to 2 500 sqm due to possible agricultural use ³ |
| | 4:=(600-800] | | | |
| | 5:=(800-1 200] | | | |
| equipment | 6:=(1 200-2 500] | | | |
| | 0:=missing | x | x | |
| | 1:=Simple | | | |
| | 2:=Normal | | | |
| | 3:=Sophisticated | | | |
| 4:=Exclusive | | | | |
| Binary variables | | | | |
| first occupancy | 1 if new owner or renter move in as first occupancy | x | x | |
| detached house | 1 if house is detached | x | | |

³ In the report on the property market of the federal state of North Rhine-Westphalia (Der Obere Gutachterausschuss für Grundstückswerte im Land Nordrhein-Westfalen 2017) the referees do not count sales of undeveloped rural plot area under 2 500 sqm in their statistics of farmland sales. This is also the case in the report on the property market for the scarcely populated state of Saxony-Anhalt (Gutachterausschuss für Grundstückswerte in Sachsen-Anhalt 2017). This gives a notion that plot areas above the margin of 2 500 sqm can be of interest for agricultural and not only residential purpose. To focus on house sales for living purposes without further commercial use, only plot areas smaller than 2 500 sqm are included in the following.

| | | | |
|----------------------------|--|---|---|
| semi-detached house | 1 if house is semi-detached | x | |
| terraced house | 1 if house is a terrace house | x | |
| exclusive house | 1 if property is declared as a mansion or castle | x | |
| other house type | 1 if house is categorized differently | x | |
| balcony | 1 if property has a balcony | | x |
| garden | 1 if apartment has access to a private garden | | x |
| guest toilet | 1 if object includes a guest toilet | x | x |
| fitted kitchen | 1 if object comes with a fitted kitchen | | x |
| cellar | 1 if a cellar room is available | | x |
| granny flat | 1 if property contains a separate "granny flat" or secondary suite | x | |

3 Methodology

Regional price indices should account for characteristics of the facility as well as for regional and time differences. Hence, we first develop a hedonic price regression which takes into account characteristics of the real estate advertisements. The regression is comparable to common hedonic price regressions (e.g. Sirmans 1996) as applied for Germany in Bauer et al. (2013), for example.

As the dependent variable the purchase price per square meter is used for house purchases and the exclusive rent price (*Kaltniete*) per square meter for rental apartments. The endogenous variable is thus given independently from the size of the apartment or house. Other features that determine the rental or purchase price are included in the hedonic price regression as exogenous variables. We include the year of construction and an indicator for first occupancy, the plot area for sales and garden and balcony access for flats, the equipment of the property, the house type and an indicator for additional granny flat for houses, guest room indicator, and the existence of a fitted kitchen for flats (cf. Table 1).

The aim of the indices is to show the time development of housing prices for Germany, their regional differences as well as the regional time development. For estimation of these three types of indices different models are needed. First, we apply the following model to estimate price indices for the overall time development in Germany:

$$\ln(y_{igt}) = \beta X_{igt} + u_g + \delta_t + \varepsilon_{igt}, \quad (1)$$

with the dependent variable y representing the sale or rent price per sqm of the single real estate advertisement i in region g (districts or municipality) in year t . The characteristics of the property are included in vector X .

This first model comprises a time-independent price index u_g for region g (fixed effect). Furthermore, year fixed effects δ_t are included. The time development in Germany is described by the development of δ_t for each year $t = \{2008, \dots, 2017\}$. Since all regions and years are studied jointly, it is assumed that the characteristics are valued in the same way for all years and all regions. The error term ε_{igt} is assumed to be normally distributed with mean 0.

The second regression describes a yearly cross-sectional approach with a regional price index u_{gt_0} for a specific year t_0 :

$$\ln(y_{igt_0}) = \gamma x_{igt_0} + u_{gt_0} + \varepsilon_{igt_0} \quad (2)$$

In this approach, it is assumed that characteristics are valued the same way in all regions during the respective year t_0 . The price index u_{gt_0} , therefore, indicates the price differences between the regions in a given year if all characteristics of housing are identical.

The first approach gives insights into the overall time development while the second gives insights into year-specific time differences. However, besides differences in the absolute price also different regional developments over time are of interest for research and political discussion. We, therefore, apply a third approach to measure the respective time development of regions g via the year-region fixed effects η_{gt} :

$$\ln(y_{igt}) = \theta x_{igt} + \eta_{gt} + \varepsilon_{igt} \quad (3)$$

The specific time development in region g between year t_0 and t_1 can be derived by $\eta_{gt_1} - \eta_{gt_0}$. The main assumptions in this analysis are similar to the ones in equation 2 that characteristics are valued the same in every region and across years. Additionally, the time development can differ between regions.

4 Results

The result section is separated into three parts that present the price indices available in the data set RWI-GEO-REDX. First, we present the time development of housing prices in overall Germany. Second, cross-sectional regional price indices are presented. Finally, we present the region-specific time trends.

The overall price development in Germany is captured by the time effects δ_t in equation 1. The estimated values for offered houses for sale in regression 1 decrease sharply during the financial crisis. The prices are almost 5% lower in the years 2009 to 2011 compared to 2008. From 2012 on the prices recover to the value of 2008 while they significantly increase in the following years. In 2017 house prices are 19% higher than in the year 2008. However, these are nominal values. During the same time period the overall inflation was almost 11%. Compared to the year 2012 the house prices increased by 22% with only 5% inflation between 2012 and 2017.

Table 2
Changes in the Time Effect δ_t on District Level
 Reference Year 2008

| | House Purchase Change in δ_t in Percentage Points | Rental Apartment Change in δ_t in Percentage Points | Consumer Price Index (2008=100) |
|------|--|--|------------------------------------|
| 2008 | 0 | 0 | 100 |
| 2009 | -4.48* | 0.98* | 100.30 |
| 2010 | -4.52* | 2.45* | 101.42 |
| 2011 | -3.94* | 5.11* | 103.55 |
| 2012 | -3.04* | 8.23* | 105.58 |
| 2013 | -1.61 | 11.33* | 107.20 |
| 2014 | 1.01 | 15.08* | 108.11 |
| 2015 | 6.45* | 17.71* | 108.42 |
| 2016 | 13.27* | 21.91* | 108.92 |
| 2017 | 19.00* | 28.33* | 110.85 |

Source: Destatis [2018] for Consumer Price Index. Time effects based on fixed effects in regression 1.

* indicates that the estimated coefficient is significantly different from 0 (reference year 2008) on the 5%-confidence level.

In contrast to house prices, apartment rent prices increase monotonically between 2008 and 2017. During this period rents increase by more than 28 percent with the sharpest rise between 2016 and 2017. Overall, price increases for apartment rents are higher than for house sales, and higher than the increase in the consumer price index. However, as the analysis is based on advertisements for new rental contracts, it is likely that price increases are much smaller for current tenants staying in the same apartment.

Cross-sectional differences between regions are covered by u_{gt_0} in equation 2. As regions we implement districts and municipalities. When comparing the house sale and apartment rental price indices on district level for 2017 in Figure 2 the metropolitan areas of Hamburg, Berlin, Frankfurt, Munich, Stuttgart and partly the Rhine-Ruhr metropolitan region have both high sales and rental prices⁴. Generally, higher sale and rental price indices are observed in Bavaria and Baden-Wuerttemberg. In East Germany - apart from Berlin and its surroundings-, the North of Hesse and the East of the states North Rhine-Westphalia, Lower Saxony and Bavaria prices are comparably low. Besides some urban districts (some are towns with universities), the district of North Frisia, which embodies the touristic island of Sylt, has exceptionally high prices compared to its vicinity.

Compared to rental prices the difference between districts are much more pronounced for sale prices. The range of the 1% and the 99% percentile in 2017 on district level is almost 280 percentage points which displays the severe regional disparities in house prices. The distribution on price indices is additionally visualized as a histogram in Figure 1. The mass center on house purchase in 2017 lies in the lightly negative number range. That opposes the high positive outliers representing metropolitan regions on the other end of the price indices scale. Further, it can be seen in Figure 5 that the regional differences are quite stable over time as the structure of expensive and less expensive regions are mainly the same in the year 2008. Besides districts, it is also possible to generate municipality-specific price indices, displayed in Figure 3 for 2017 and Figure 4 in a combination of 2016

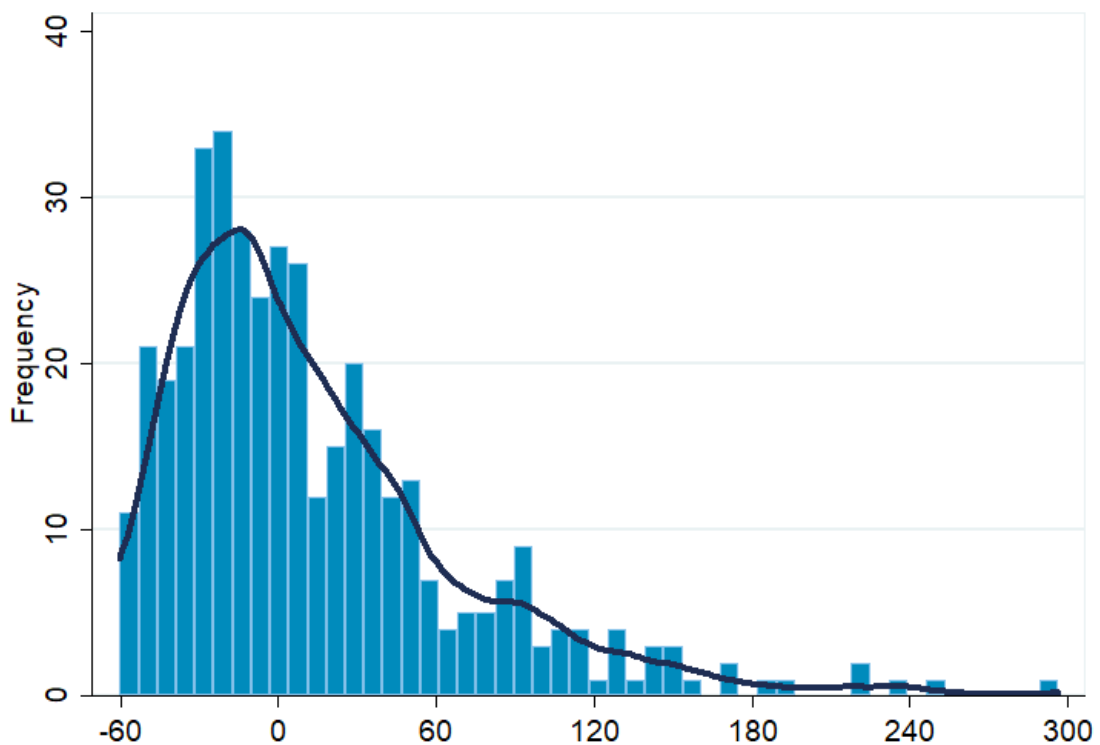
⁴ The colouring of the regions follows the percentile structure of the represented price indices.

Regional Real Estate Price Indices for Germany (RWI-GEO-REDX)

and 2017. As only municipalities and districts with at least 50 observations are published, the combination of two years is given in Figure 4. It demonstrates the option to gather more regional information if accepting a reduction on time accuracy. On the municipality level, large price effects can be observed in the surroundings of the big cities. The closer a municipality the more expensive becomes housing. This is particularly pronounced for Berlin that is surrounded by relatively large districts.

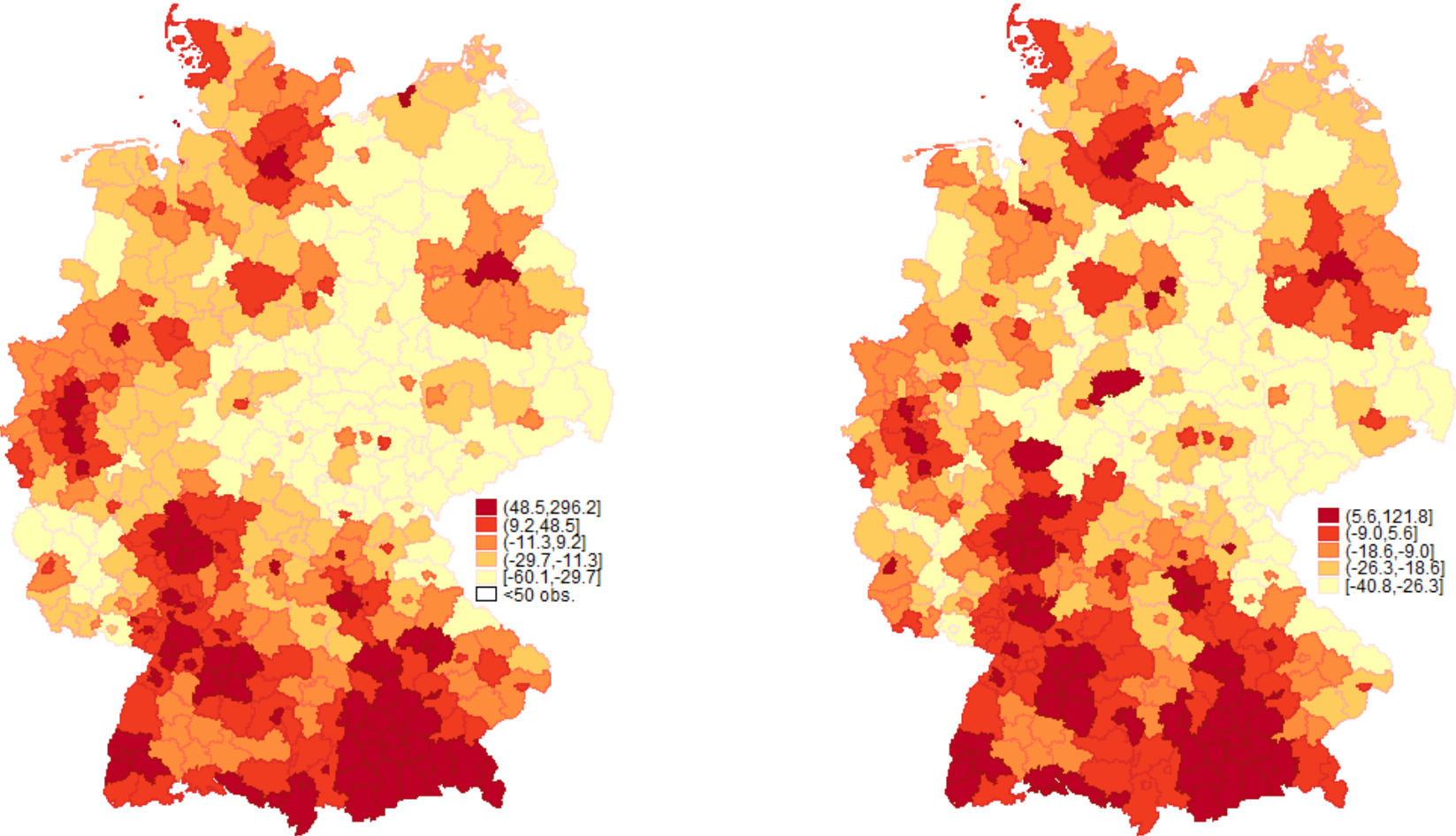
The cross-sectional indices indicate large regional differences in Germany which are larger in 2017 than in 2008. Furthermore, the overall time trend is positive. However, this information does not directly give insights into the regional price development. We, therefore, analyze the regional price effect by comparing η_{gt} from equation 3 over different years t . In Figures 6 and 7 the differences to the base year 2008 are presented in percentage points on district and municipality level. For the latter, it was opted for a representation comparing the changes between two-year regional price indices, in this case between 2008/2009 and 2016/2017 to acquire more regional information for municipalities.

Figure 1
Distribution of the Regional Price Index for House Purchases
based on regression 2 in 2017 on district level



A representation of the kernel density estimator based on Epanechnikov kernel is displayed additionally to the histogram of the regional price index.

Figure 2
Regional price indices in 2017 on district level
Deviation in % from the German mean



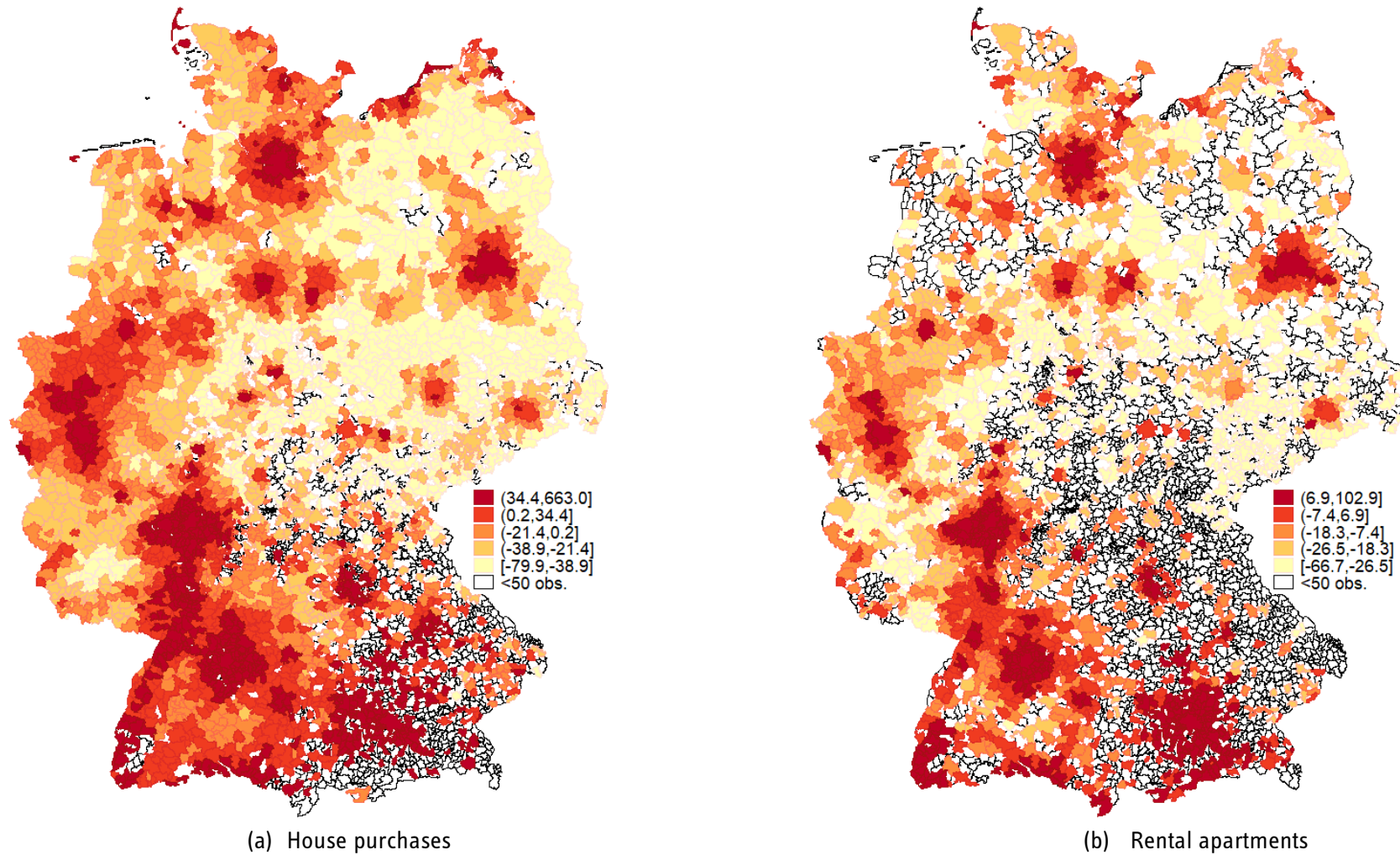
(a) House purchases

(b) Rental apartments

One district has less than 50 observations for house purchases and has been excluded. Indices based on cross-sectional regressions based on equation 2.

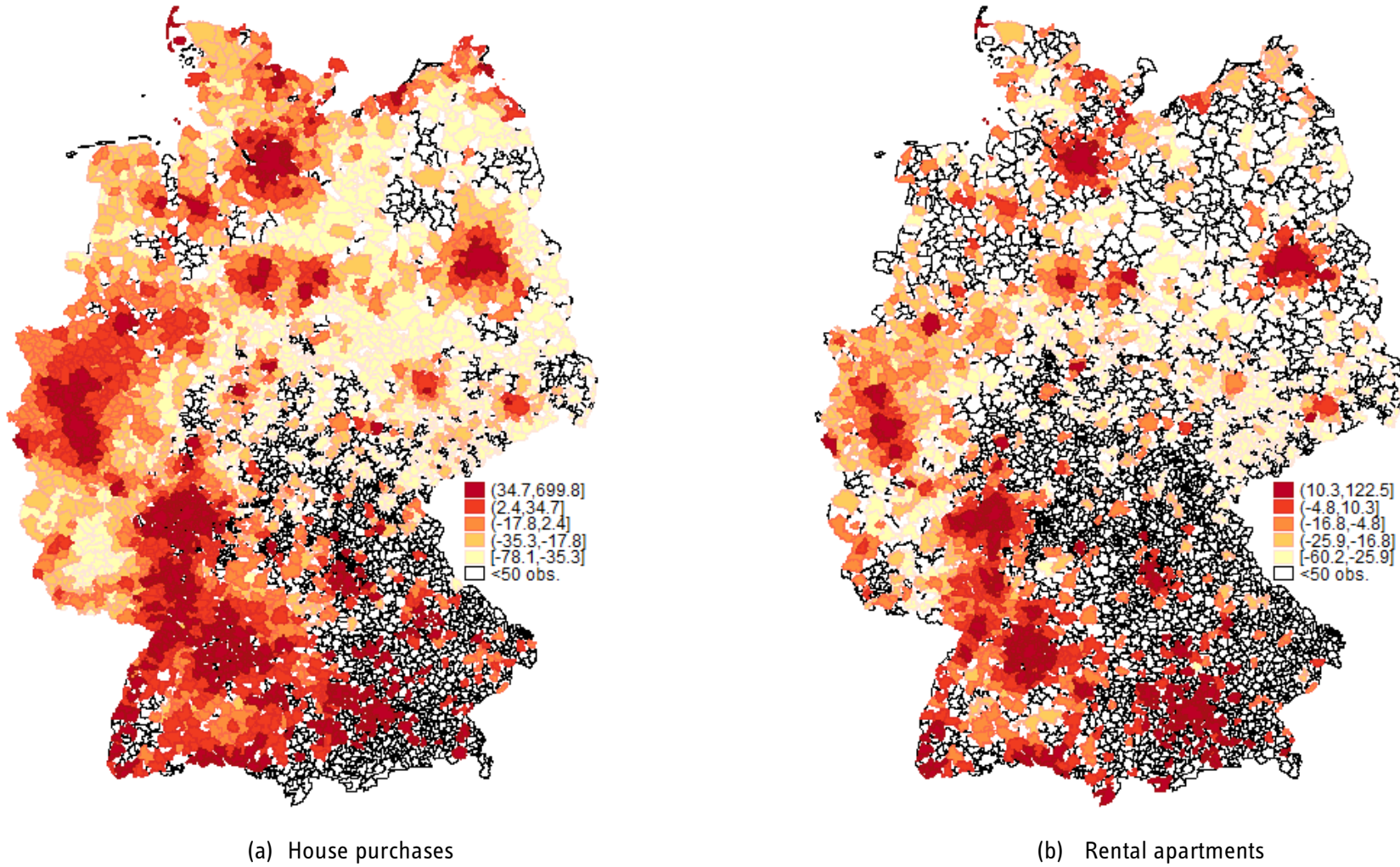
Regional Real Estate Price Indices for Germany (RWI-GEO-REDX)

Figure 3
Regional price indices in 2016/2017 on municipality level
Deviation in % from the German mean



Only municipalities with at least 50 observations, added up in 2016 and 2017, are displayed. Indices based on cross-sectional regressions based on equation 2.

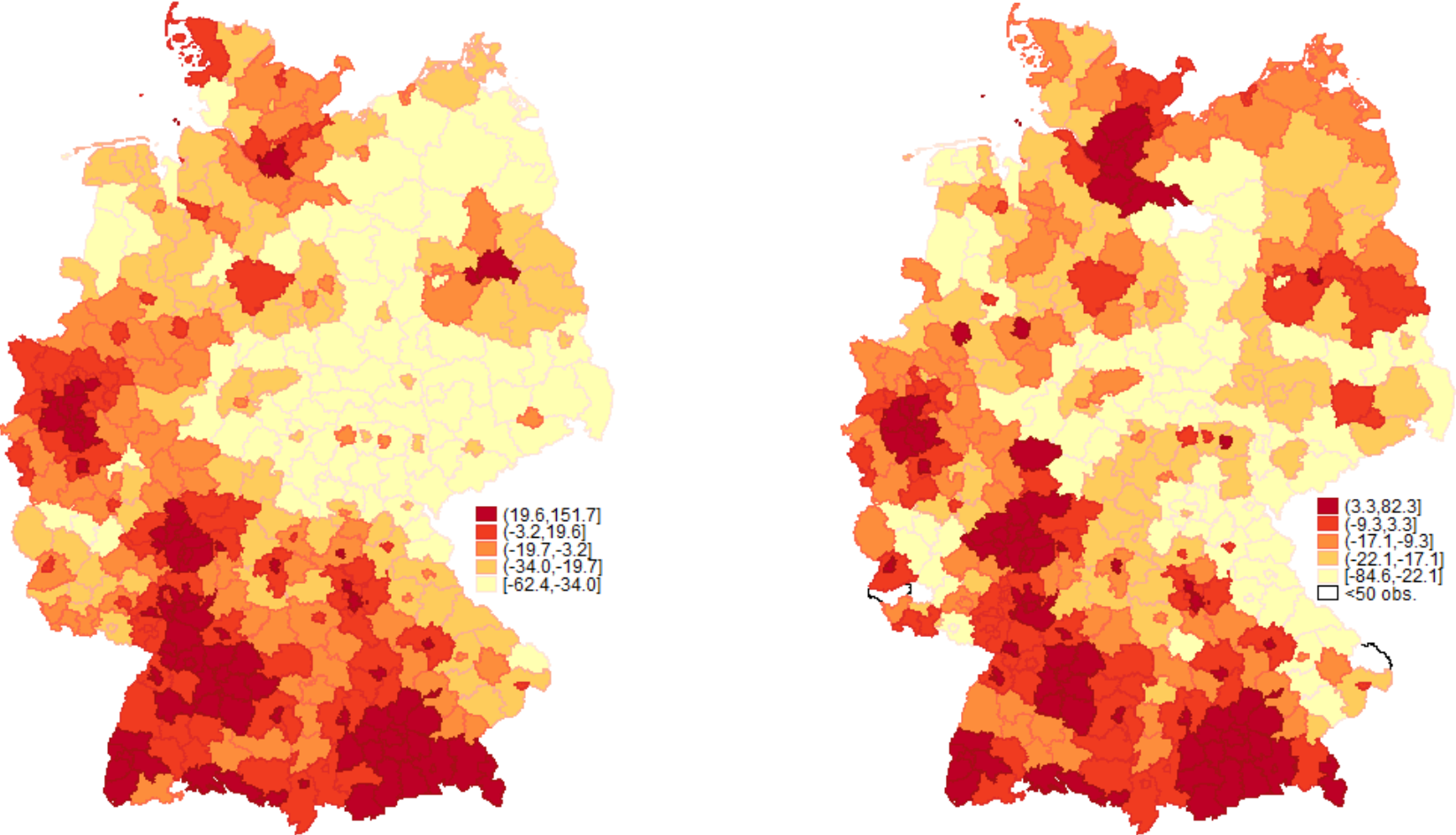
Figure 4
Regional price indices in 2017 on municipality level
 Deviation in % from the German mean



Only municipalities with at least 50 observations are displayed. Indices based on cross-sectional regressions based on equation 2.

Regional Real Estate Price Indices for Germany (RWI-GEO-REDX)

Figure 5
Regional price indices in 2008 on district level
Deviation in % from the German mean

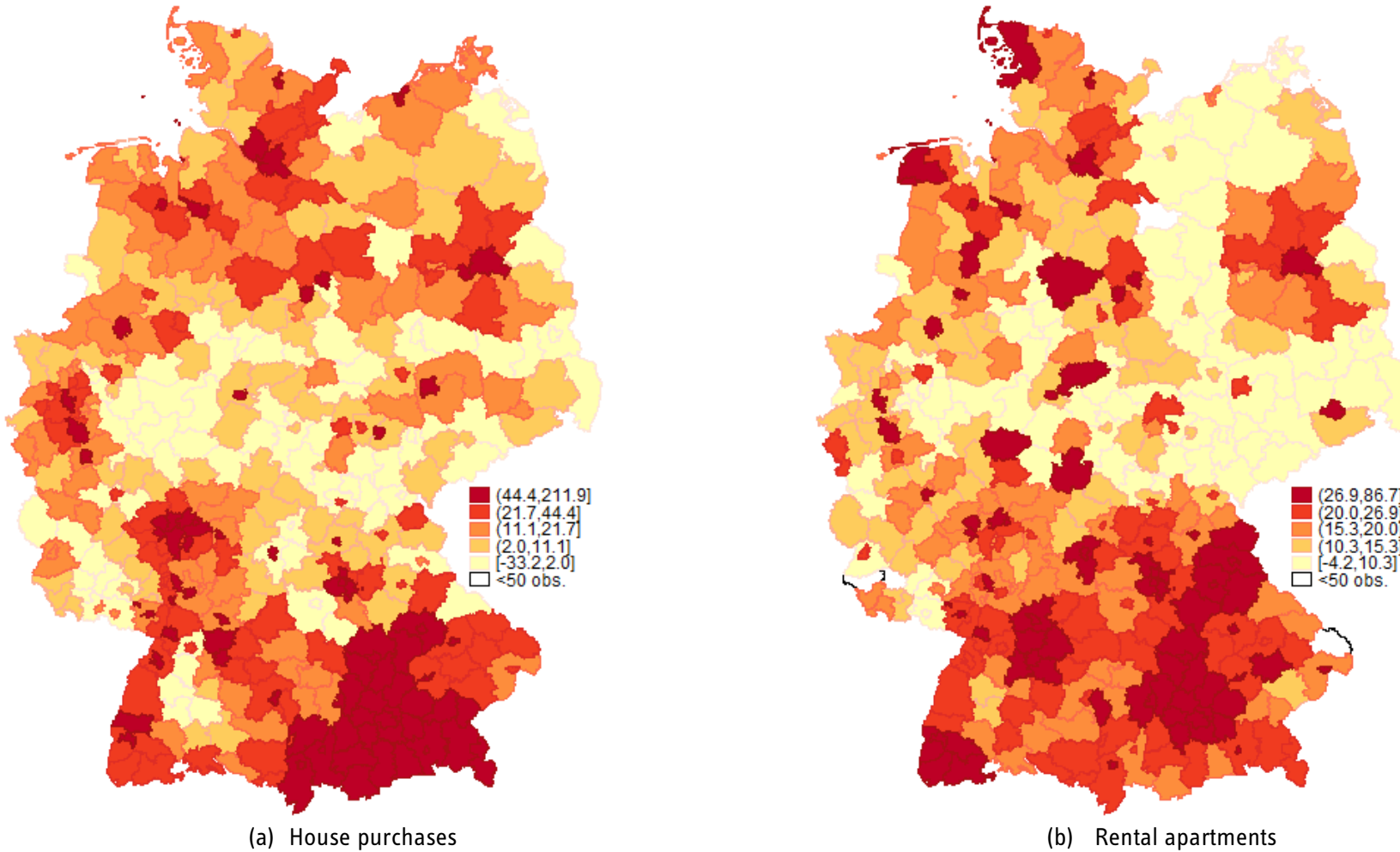


(a) House purchases

(b) Rental apartments

One district for house purchases and four districts for rental apartments have less than 50 observations in one of the compared years and have been excluded. Indices from cross-sectional and time variation following equation 3.

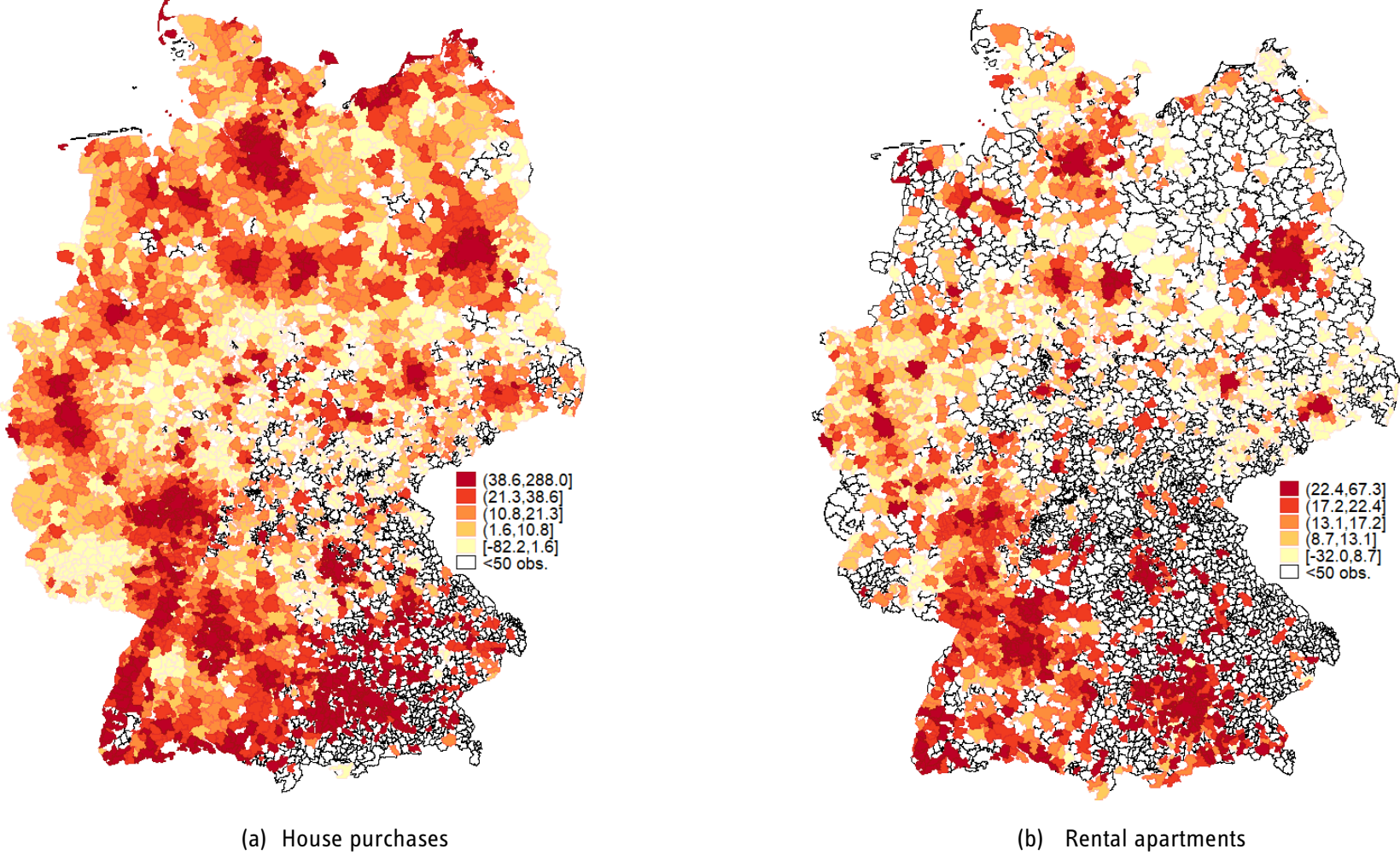
Figure 6
Change in regional price indices between 2008 and 2017 on district level
 Change in percentage points



Four districts have less than 50 observations for rental apartments and have been excluded. Indices based on cross-sectional regressions based on equation 2.

Regional Real Estate Price Indices for Germany (RWI-GEO-REDX)

Figure 7
Change in regional price indices between 2008/2009 and 2016/2017 on municipality level
Change in percentage points



Only municipalities with at least 50 observations in both time spans are displayed. Indices from cross-sectional and time variation following equation 3.

The results indicate that prices rise most strongly in urbanized areas for both sale prices as well as rental prices. Sale prices in the metropolitan area around Munich show an exception in house price increases since the whole region – including more rural areas – experiences large increases. In other regions, the urbanized independent cities show the highest changes. One can detect partially higher changes in areas with generally low house prices, especially in the Eastern Federal States, which possibly suggest a slow catch-up to West German sales prices. On the contrary, especially the Eastern part of North Rhine-Westphalia seems to lag far behind in the observed house price change and even shows decreases in the development since 2008.

When it comes to changes in rental prices, the South of Germany experienced strong positive changes which cluster immensely around Munich and further South, as well as adjacent to Frankfurt and Stuttgart. In East Germany, rental prices increase less compared to house prices, except for the districts around Berlin and other large cities like Leipzig and Dresden.

The range of change is much higher for sale prices than for rental prices. While regional differences for apartment rents are already smaller than for house sales prices, this pattern seems to become more pronounced. Some urban centers face house sales price that are disproportionately larger than their rental price increase, and some rural areas experience a fall in house prices which is larger than their fall in rental prices.

5 Data Access

The data can be obtained as a Public Use File by the FDZ Ruhr at RWI. The FDZ Ruhr is the research data centre at the RWI – Leibniz-Institute for Economic Research. The data is open for public use. The data set only covers indices that rely on the district level or on municipalities with at least 50 observations per year. We also provide the indices that base on less than 50 observations as Scientific Use File upon request. However, we assume that the observations are too small for estimating reliable values. Since the RWI-GEO-REDX subsumes aggregated information it does not contain information with restricted use due to data security. The presented indices can be obtained as a Stata® dataset (.dta), Excel (.xlsx) sheet or .csv file.

Data access does not require a data use agreement, but users need to register for data access. Interested users should register via email to fdz@rwi.essen.de. The email needs to include information on the applying department or person as well as the desired data format. The users are requested to cite the source correctly and to inform the FDZ Ruhr about publications with the data.

When using the data set RWI-GEO-REDX, please cite the data as Klick, Larissa; Schaffner, Sandra; RWI (2019): Regional Real Estate Price Index. *RWI-GEO-REDX*. Version:1. RWI – Leibniz-Institut für Wirtschaftsforschung. Dataset. <http://doi.org/10.7807/immo:redx:v2> Further, we recommend citing this data description.

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