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Lars Brausewetter, Stephan L. Thomsen, Johannes Trunzer

Authors

Lars Brausewetter
Halle Institute for Economic Research (IWH) – Member of the Leibniz Association, Department of Financial Markets
E-mail: lars.brausewetter@iwh-halle.de
Tel +49 345 7753 769

Stephan L. Thomsen
Corresponding author
Leibniz University Hannover, Institute of Economic Policy, IZA Bonn, and ZEW Mannheim
E-mail: thomsen@wipol.uni-hannover.de

Johannes Trunzer
Leibniz University Hannover, Institute of Economic Policy
E-mail: trunzer@wipol.uni-hannover.de

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Halle Institute for Economic Research (IWH) – Member of the Leibniz Association

Address: Kleine Maerkerstrasse 8
D-06108 Halle (Saale), Germany
Postal Address: P.O. Box 11 03 61
D-06017 Halle (Saale), Germany

Tel +49 345 7753 60
Fax +49 345 7753 820

www.iwh-halle.de

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Explaining Regional Disparities in Housing Prices Across German Districts*

Abstract

Over the last decade, German housing prices have increased unprecedentedly. Drawing on quality-adjusted housing price data at the district level, we document large and increasing regional disparities: Growth rates were higher in 1) the largest seven cities, 2) districts located in the south, and 3) districts with higher initial price levels. Indications of price bubbles are concentrated in the largest cities and in the purchasing market. Prices seem to be driven by the demand side: Increasing population density, higher shares of academically educated employees and increasing purchasing power explain our findings, while supply remained relatively constrained in the short term.

Keywords: Germany, housing market, regional disparities, rental prices

JEL classification: R23, R31

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1 Introduction

Around the globe, house prices rose considerably in the second half of the 20th century, with growth accelerating further after the turn of the millennium (Knoll et al., 2017). Within countries, there were large spatial disparities, as pointed out by scholars in the US (e.g., Anenberg and Kung, 2020; Mian and Sufi, 2011; Glaeser et al., 2012), Great Britain (e.g., Hilber and Vermeulen, 2016), and Germany (e.g., Belke and Keil, 2018; Kajuth et al., 2016; Kholodilin et al., 2018). As a result, inequalities in access to affordable housing and ultimately in wealth, consumption, and well-being can evolve (Dustmann et al., 2021), as a considerable part of income is spent on housing (19% across OECD countries in 2019; OECD, 2021). Moreover, disparities in housing prices can lead to an inefficient allocation of labor and capital across regions, diminishing long-term growth potential (Gorton and Ordoñez, 2020; Borio et al., 2015; Schularick and Taylor, 2012).

In Germany, the development of house prices remained moderate for a long time (Voigtländer, 2014). In terms of real house prices, it had one of the weakest long-term growth rates between 1870 and 2012 among advanced economies (Knoll et al., 2017). Since then, however, Germany has been experiencing unprecedented growth, as house prices increased by an average of approximately 50 percent across different price indicators between 2011 and 2017 (Baldenius et al., 2020), with much stronger growth occurring in large cities (Deutsche Bundesbank, 2021).

We investigate what caused this rapid and spatially diverging development of housing prices in Germany. We draw on quality-adjusted housing price data from the RWI-GEO-REDX price index provided by the FDZ Ruhr at the RWI – Leibniz Institute for Economic Research (RWI). These data allow us to map housing prices at the district level[1] and to distinguish between apartment rents, apartment purchase prices, and house purchase prices. We combine the price data with a large set of regional factors at the district level, covering the observation period from 2008 to 2019. This time period includes periods of moderate (~2008-2013) and strong price growth (~2014-2019).

Germany is a particularly interesting case to study. Apart from exhibiting atypical housing price development, Germany had the lowest homeownership rate (51%) among the EU-27 countries (70%) in 2019 (Eurostat, 2021). Therefore, the rental market is strongly connected to the real estate market. Due to high real wage growth, price increases in the housing market have

[1] German districts correspond to NUTS-3 regions at the European level and are comparable to US counties.

not weighed much on households' financial situation in recent years. In fact, less disposable household income was spent on housing in 2019 (26%) on average than in 2010 (28%) (Destatis, 2020). However, this masks the fact that burdens have developed very unequally for different groups of people and especially in different regions, thus exacerbating social inequality. For instance, for single individuals and the population at risk of poverty, the proportion of disposable net household income spent on housing increased slightly between 2010 and 2019. Finally, the settlement structure of Germany is decentralized, leading to relatively moderate urban-rural-disparities.[2]

Motivated by the related literature, we identify six categories of variables that influence housing prices at the regional level. Within these categories, we select variables that are the most relevant in multivariate correlations with housing price growth. As a robustness check, we employ a LASSO estimator for data-driven variable selection. In a second step, the selected variables are used as covariates in first difference models to account for unobserved heterogeneity in housing price development and to estimate the year-by-year effects of fundamentals. This procedure serves to identify and quantify factors that contributed to the observed regional disparities in price growth. Since we derive our variables from the literature on supply-side inelasticities and from spatial equilibrium models on the demand side, it seems plausible to assume that these variables are the most relevant explanatory factors and that there is no further omitted time-varying heterogeneity that would bias our results.

We have three main findings. First, we document stylized facts of housing price growth in Germany for 2008 to 2019: There are large and increasing spatial disparities, leading to a difference of 29 (apartment rents), 86 (apartment purchase prices), and 109 percentage points (house purchase prices) in quality-adjusted price growth between the top and bottom deciles of districts. The price increase was particularly high in the seven largest cities, but there is also great variation in price growth within less densely populated districts, depending on the affiliation with a certain labor market. Moreover, price growth was higher in districts located in the south. Finally, there is path dependency in price development. The price level (relative to the national mean) at the beginning of our observation period already explains more than half of the variation in total purchase price growth and slightly less than a third of total apartment rent growth from 2008 to 2019.

[2] In 2012, 64 percent of the German population lived in urban areas and only 32 percent resided in urban areas with above 1.5 million inhabitants compared to respective levels of 68 and 50 percent across OECD countries (OECD, 2012).

Second, in focusing on common indicators (residuals, the price-to-income gap, and the price-to-rent gap), we do not find conclusive evidence for widespread price bubbles. However, there are indications of excessive price increases in the largest cities, above all in Munich, and in the purchasing market for apartments, as the gap between apartment purchase price and rental price growth diverged for the majority of districts.

Third, we identify time-varying factors that are most relevant in explaining price growth at the district level. Regarding the total change from 2008 to 2019, we find that changes in population density and the share of academic qualifications alone can explain more than half of the variation in total price growth. This finding suggests a demand-driven increase in housing prices and is supported by year-by-year first difference models. Our estimation results reveal that population density, the share of academic qualifications, and household income increase housing prices in particular. A one standard deviation higher population density increases housing price growth rates by 29 percentage points (apartment rents), 84 percentage points (apartment purchase prices) and 106 percentage points (house purchase prices). For the share of academic qualifications, the effects range between eight and 21 percentage points, and for household income, they range between seven and 19 percentage points. Hence, this demand-driven increase in housing prices seems to be channeled through population growth (driven by immigration and a decline in mortality), the sorting of high-skilled labor, and increasing purchasing power. On the supply side, we find some evidence for building land prices as a moderate driver. Moreover, an increase in living area per capita appears to mitigate price growth but to a very slight and barely measurable extent. This confirms previous findings from the literature showing that small increases in housing supply do not significantly affect price growth in the short run.

This paper contributes to an extensive body of literature investigating the origins of regional disparities in housing prices. For instance, for the US, Glaeser et al. (2012) identify structural factors, such as the initial price level, population density, and educational level of citizens, that explain the majority of the variation in price growth across US metropolitan areas between 1996 and 2006. These findings are consistent with our results, implying very general mechanisms of regional housing price growth between the US and Germany for different periods. For Germany, there are numerous studies that derive a wide range of explanatory factors focusing on an earlier period of more limited price growth (see e.g., Belke and Keil, 2018; Kajuth et al., 2016; Hiller and Lerbs, 2016; Kholodilin et al., 2018). We extend and update these studies with recent housing price developments to 2019, exploit the whole universe of German districts and systematize the process of variable selection. Most closely related are Deutsche Bundesbank

(2020) which emphasizes, among other factors, housing stock, household income, and population density as relevant factors of price growth, and Kholodilin and Michelsen (2021), who find that housing prices, in relation to rental prices, are increasingly overvalued throughout Germany—most severely in the seven largest cities. In complementing their findings with other data, we highlight the role of skill sorting in driving prices even beyond the income effect, which by itself has not kept pace with house price growth in the largest cities.

The remainder of this paper is structured as follows: First, we discuss the related literature (Section 2). Then, we describe our data sources (Section 3) and document regional disparities in housing price growth (Section 4). Next, we explain these disparities through correlation analysis (Section 5) and panel regression analysis (Section 6). Section 7 concludes.

2 Related Literature

A first related strand of the literature stresses supply inelasticities as the primary driver of regional housing price disparities. Glaeser et al. (2008) estimate a supply-driven model based on US data linking regional supply elasticity and price bubbles. The authors find that large price increases are experienced predominantly in cities with inelastic housing supply. In a similar vein, Saiz (2010) finds that geographic land constraints explain housing price growth in the US, while Füss and Zietz (2016) document that these constraints also increase the elasticity of housing prices with respect to the Federal Funds Rate. Moreover, Anundsen and Heebøll (2016) show that not only tighter topographical but also regulatory constraints magnify boom-bust cycles in the US.

Closely related is a stream of literature that investigates the political economy contributing to supply inelasticities. Hilber and Vermeulen (2016) investigate regional elasticities between house prices and local housing demand in England from 1974 to 2008. The authors find that a lack of developable land only increases the price elasticity of housing demand in very urban areas, while the effect of more restrictive local planning authorities is quantitatively similar and becomes relevant in most regions due to the distribution of these constraints. Moreover, Murphy (2018) illustrates that procyclical building costs provide an incentive for landowners to time the market, while Ortalo-Magné and Prat (2014) demonstrate in an overlapping-generations framework a mechanism incentivizing the strategic blocking of construction activities to protect the value of housing investments, further reducing the elasticity of supply. Counterintuitively, increased building activities have often been found to be ineffective at decreasing prices: Zahirovich-Herbert and Gibler (2014) empirically demonstrate that the simple occurrence of new construction had no statistically significant effect on the prices of existing houses within a mile radius in Baton Rouge, Louisiana between 1984 and 2005. However, larger-than-average newly constructed houses exerted a price-increasing influence on smaller neighboring houses, while the price-decreasing effect measured for similarly sized houses was much smaller and barely statistically significant. Bahadir and Mykhaylova (2014) show in a theoretical setting that the delays present in the construction of housing asymmetrically dampen the response of prices to supply increases and amplify the response of prices to demand increases. Murray (2020) provides empirical evidence of housing developers strategically delaying the supply of new housing units to realize gains from sales price appreciation in Australia. For Germany, Deutsche Bundesbank (2020) finds that increased building activities, if anything, increased regional housing prices, mainly because the supply of available land was not expanded to a similar extent.

The majority of this literature, however, disregards the rental market and focuses entirely on house purchasing prices. As one of few exceptions, Kashiwagi (2014) builds a theoretical framework that integrates housing and rental markets into a singular model. According to this analysis, house purchase prices should be more responsive to increases in supply than rental prices in the short run. Furthermore, Anenberg and Kung (2020) simulate increases in supply in a rental market neighborhood choice model calibrated on US data from 2014 and find that marginal increases in the supply of rental units do not reduce prices, as they are in turn determined largely by local amenities.

A second focal point of the literature is the explanation of regional disparities with spatial equilibrium models. The seminal work of Roback (1982) demonstrates that amenities are capitalized into both wages and rents. Thus, spatial equilibrium models, particularly those of the Rosen-Roback framework, focus on wages (affected by productivity and labor skills), housing prices (or the cost of living) and amenities to explain regional disparities. Proost and Thisse (2019) posit in their review of the spatial economics literature that urbanization occurs as a result of the fundamental trade-off between increasing returns due to agglomeration and commuting costs. Founded in the idea that either skills and learning environments (Davis and Dingel, 2019), skills and population size (Behrens et al., 2014), or high and low levels of skills (Eeckhout et al., 2014) are complements (i.e., the agglomerating force), the regional sorting of labor skills further plays a major role in this context. This sorting should empirically result in observable domestic migration. Indeed, Diamond (2016) demonstrates that the increased sorting by labor skills that occurred in the US between 1980 and 2000 can be explained by differing local labor demand and amenities in an extended Rosen-Roback setting, thus determining the price of housing at the same time. Complementarities between cultural amenities and labor skills have also been demonstrated to empirically affect local economic growth in Germany

(Falck et al., 2011). In a spatial equilibrium setting, this complementarity would increase housing prices. Local amenities are also the focus of neighborhood sorting models: In taking house prices, household income, households' social characteristics and commuting opportunities as additional inputs, these models provide an opportunity to extract households' heterogeneous preferences according to their geographic sorting (see Kuminoff et al., 2013 for an overview).

Last, some authors stress the importance of speculative bubbles that decouple from fundamentals in boom periods. While house prices have been found to revert to their fundamentals over the medium term, path dependency has been observed: if house prices are above their fundamentals, they will likely continue to increase in the short term. This positive autocorrelation of house prices can be explained by concave demand (Guren, 2018), behavioral factors such as biases in the formation of price expectations (Glaeser and Nathanson, 2017), or social dynamics (such as herding) in housing investment (Bayer et al., 2021; Burnside et al., 2016).

3 Data

To empirically analyze how housing prices differ at the regional level and which factors can explain the observed disparities, we combine housing price data with administrative data from different sources at the district level. Based on these data, we construct a panel dataset for all 401 German districts covering the years 2008 to 2019. Appendix Table A-1 presents a detailed overview of the definitions of all included variables. Appendix Table A-2 displays a selection of summary statistics.

3.1 Housing Prices

For data on housing prices, we use the RWI-GEO-REDX price index provided by the FDZ Ruhr at the RWI (Klick et al., 2020).[3] This index is based on prices advertised on Germany's leading digital real estate platform *ImmoScout24* and therefore represents only price offers for advertised rentals or real estate purchases. To account for quality changes, the index is calculated as a hedonic price index, which expresses the price (per square meter) of a housing object as a function of its characteristics, such as the number of rooms and equipment. The RWI-GEO-REDX price index is available on a yearly basis for 2008 to 2019 at the district level. It comprises three different indicators: 1) apartment rents, 2) apartment purchase prices, and 3) house

[3] For a detailed description of the data source, see Klick and Schaffner (2020). The data are used, for instance, by Bauer et al. (2017) to estimate the effect of the Fukushima incident on the German housing market.

purchase prices. The price index we draw on is calculated as the region-year-fixed effect resulting from a regression of housing prices on housing characteristics.[4] It thus represents the growth in housing prices relative to the base year of 2008 for a certain region.

A limitation of the RWI-GEO-REDX price index is that it contains advertised rents and prices only, which (can) respectively diverge from actual transaction prices and asset values of existing lettings. Furthermore, the data may not be perfectly representative since they cover prices from a single online platform. For these reasons, our price data are probably upward biased, as online advertised prices, particularly for apartments, are usually higher than the average (Baldenius et al., 2020). This should nevertheless not impose a strong limitation. For instance, a study by Dinkel and Kurzrock (2012) of rural areas in the federal state of Rhineland-Palatinate finds that the deviations of transaction prices from advertised prices are independent of house or neighborhood characteristics.

3.2 Regional Characteristics

The majority of our data on regional characteristics stem from the Regional Database of the Federal Statistical Office (Destatis, 2021), augmented by data from the INKAR database (BBSR Bonn, 2021) and data obtained upon request from the Federal Employment Agency (BA, 2020a; BA, 2020b). Few missing values were imputed via linear inter- or extrapolation. This gives us a fully balanced panel for house purchase prices (N=4,812) and a slightly unbalanced panel for apartment rents (N=4,774) and apartment purchase prices (N=4,547), as some districts included in the RWI-GEO-REDX have less than 50 price observations; these cases do not allow for a reliable calculation of price indices.

4 Regional Disparities in Housing Price Growth

We start by analyzing housing price developments across 401 German districts between 2008 and 2019. Figure 1 shows the development of quality-adjusted apartment rents (Panel A), apartment purchase prices (Panel B), and house purchase prices (Panel C) relative to 2008 for the 10^{th}, 25^{th}, 50^{th}, 75^{th}, and 90^{th} percentiles of districts (see for maps Appendix Figure A-1). By 2019, rental prices increased by 25 percent at the median, while apartment and house purchase prices rose by 40 percent and 36 percent, respectively. Especially in the second half of the observation period, price growth accelerated considerably. Although the price increase on the

[4] See Equation (3) in Klick and Schaffner (2020): $\ln(y_{igt}) = \theta X_{igt} + \eta_{gt} + \varepsilon_{igt}$, where y_{igt} represents the sale or rent price per square meter of the single real estate advertisement *i* in region *g* in year *t*, vector X_{igt} denotes the characteristics of the property, and η_{gt} denotes year-region fixed effects. ε_{igt} is the error term.

housing market affected nearly the entire distribution of districts, there are large and increasing spatial disparities, especially for purchase prices. In 2019, the differences in price growth between the top and bottom deciles of districts were 29 (apartment rents), 86 (apartment purchase prices), and 109 (house purchase prices) percentage points (see Appendix Table A-3). In Munich, house purchase prices even quadrupled over the period considered (+304%).

[Insert Figure 1 here]

This leads us to document three main characteristics of regional disparities in housing price growth. First, there is a rural-urban-disparity. We group districts into four different categories according to the classification of the Federal Office for Building and Regional Planning (BBSR): (1) large urban districts, (2) urban districts, (3) rural districts with densification tendencies, and (4) sparsely populated rural districts. The main delineation criteria are population size and density. Following Deutsche Bundesbank (2020), however, we show the seven largest cities in Germany (Berlin, Hamburg, Munich, Cologne, Frankfurt am Main, Stuttgart, and Düsseldorf) as a stand-alone group ("Big7"). There is a ranking of mean housing price growth from sparsely to densely populated districts, although the differences between the first four groups are minor and mostly not statistically significant (see Figure 2).[5] The fifth group of the largest seven cities, however, stands out, displaying significantly higher price growth rates than the next group of urban districts, with approximately 36 (apartment rents), 91 (apartment purchase prices) and 96 (house purchase prices) percentage points higher growth rates.

[Insert Figure 2 here]

Apart from the distinction of the seven largest cities, the grouping by district type remains blurry to some extent, as price distributions overlap widely. This is probably due to spillover effects of housing price growth to adjacent districts (Mussa et al., 2017; Cohen et al., 2016) in combination with our investigation focusing on districts and not labor market regions[6]. For instance, the six districts with the highest housing price growth are part of the same labor market region of "Munich" but are grouped into two different district types. This clustering of price growth around the centers of large metropolitan areas, such as Munich, Frankfurt am Main, Stuttgart, Berlin, and Hamburg, is clear in Appendix Figure A-2.

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[5] For results of pairwise comparisons using Wilcoxon rank sum tests, see Appendix Table A-4.

[6] Labor market regions are defined according to the delineation of RWI (2018), which identifies 182 functional areal units from the universe of administrative districts mainly based on commuter links.

Second, we find a geographic sorting of housing price growth, revealing a south-north-west-east hierarchy (from the highest to lowest growth) (see Appendix Figure A-3). Particularly for apartment rents, the hierarchy is clear and mostly statistically significant, whereas for house and apartment purchase prices, differences between the east, west, and north are small, but the south stands out distinctly—particularly at the top of price growth. For apartment rents, 21 of the 25 districts with the highest price growths are in the south. For apartment and house purchase prices, it is 20 of 25. This geographic sorting may be driven by economic as well as sociodemographic differences, may reflect local amenities, and/or may be a result of large spillover effects from the two core centers Munich and Stuttgart (see above).

Third, we document path dependencies in housing price development. Regions with initially high price levels in 2008 also tended to experience higher growth rates (see Figure 3). This association holds in particular for house and apartment purchase prices, where 60 and 54 percent of the variation in price growth, respectively, can be explained by initial price levels (relative to the national mean). In the case of rents, the association is less pronounced, but 30 percent of the variation is still explained by the initial price effect.

[Insert Figure 3 here]

The evidence presented thus far suggests that the purchase price increases from 2008 to 2019 are a sign of a boom that decouples from fundamentals, where increasing prices make investments more attractive due to higher expectations of further price growth (Bayer et al., 2021; Arce and López-Salido, 2011; Murray, 2020). Altogether, the documented stylized facts—higher housing price growth in more densely populated areas and higher initial price levels, while varying geographically—are consistent with findings from Glaeser et al. (2012) for the US. However, these structural factors do not change over time, so they are unlikely to have contributed directly to the observed price growth; rather, they are indicative of unobserved third factors. Therefore, we now consider time-varying demand and supply factors to investigate the role of changes in fundamentals.

5 Identifying Relevant Factors

We seek to identify factors that best explain the observed regional disparities in the unprecedented German housing price growth. To avoid testing lagged (and lead) specifications of each variable but identify long-term patterns, we analyze a series of bivariate correlations between total price growth ($\Delta^{08-19}y_d$) across the whole observation period of 2008 to 2019 and total changes for a large set of regional characteristics across the same period ($\Delta^{08-19}x_d$) at the level of districts *d:*[7]

$$\Delta^{08-19}y_d = \Delta^{08-19}x_d\beta^{biv} + \varepsilon_d \quad (1)$$

Changes in variables measured in absolute values (e.g., GDP pc) are expressed as percentages; changes in variables measured in shares (e.g., unemployment rate) are expressed as percentage points. All variables are then standardized to allow for effect size comparisons. All bivariate correlation coefficients (β^{biv}) are shown in orange in Panel A in Figure 4.

As a second step, we include all variables from each of the six categories ($\boldsymbol{X'}_d$) (distinguished by rows in Panel A) into separate multivariate regressions (see for choice below). These multivariate blockwise regression coefficients (β^{block}) are shown in blue in Panel A. Panel B additionally presents the adjusted R-squared (see Appendix Table A-5 for detailed regression results).

$$\Delta^{08-19}y_d = \Delta^{08-19}\boldsymbol{X'}_d\beta^{block} + \varepsilon_d \quad (2)$$

5.1 Variables by Category

Motivated by the literature review in Section 2, we identify six broad categories that influence housing prices at the regional level. From the literature on supply inelasticities (e.g., Saiz, 2010; Glaeser et al., 2012), we use factors that capture the stock of *existing supply* (1) and the amount of *new*ly created *supply* (2). These factors comprise (1) living area per capita, the number of residential buildings per capita, the share of small apartments, the share of single and multiple family houses and (2) building permits per capita, completed apartments per capita, completed houses per capita, and average purchase prices for building land. The latter is used—despite its arguably endogenous character—as an explanatory factor in related studies, such as Deutsche Bundesbank (2020) and Kajuth (2021).[8]

From the literature on spatial equilibrium models (e.g., Roback, 1982; Proost and Thisse, 2019), we derive the four remaining categories on the demand side. *Labor market factors* (3) cover the state and dynamics of the local labor market, particularly with respect to wage setting and skill sorting. This includes labor market tightness, unemployment rate, vacancy rate, hiring

[7] In a sense, this represents a two-period first difference model.

[8] We do not consider regional deviations of (mortgage) interest rates here. Varying expectations of collateral price stability should be sufficiently captured by the regional-fixed effects (supply side) while systematic differences in credit-worthiness should be accounted for by labor market and sociodemographic variables (demand side).

rate, matching efficiency, employment share in the production industry, and the share of employees with academic qualifications. *Economic factors* (4) serve as proxies for the economic wealth and size of a region, including purchasing power and amenities that are hardly directly measurable and relatively time fixed. Therefore, we use household income per capita, GDP per capita, and population density as proxies. *Sociodemographic factors (5)* are used to represent households' social characteristics and thus capture their preferences by focusing on the mean population age, share of migrants, share of female population, student ratio, divorce rate, and debtor ratio. Finally, *migration and mobility* patterns (6) are the observable result of the spatial equilibrium framework. We consider them by including the domestic migration balance per 1,000 inhabitants, the external migration balance per 1,000 inhabitants, and the commuter balance per 100 employees. The remaining share of the variation that cannot be explained by these six categories should then reflect the influence of speculative bubbles that are decoupled from fundamentals (Geng, 2018), as indicated by the third strand of the related literature (e.g., Guren, 2018).

1) Existing Supply

Row (1) in Panel A in Figure 4 presents the coefficients for the existing supply stock. We find evidence for a modest correlation between changes in living area per capita and price growth (ρ = –0.46 to –0.53), which is very similar for changes in the number of residential buildings per capita. Moreover, an increase in the share of small apartments correlates significantly and positively with housing price growth. All housing structure indicators explain 36 to 40 percent of the variation and remain significant and stable in the blockwise case (Panel B).

[Insert Figure 4 here]

2) New Supply

Row (2) in Panel A presents the coefficients for the creation of new supply. We find that the change in the number of completed apartments per capita is positively correlated with price growth—to a small extent (ρ = +0.28 to +0.32). The same holds for the change in the number of building permits, albeit to an even lesser extent. Changes in the price for building land are also positively correlated with housing prices, particularly for house purchase prices (ρ = +0.40). In return, there is a weak indication that an increase in the number of completed houses per capita is associated with lower price growth. Altogether, building activities can explain 20 to 25 percent of the variation (Panel B), representing the lowest share of explained variation among all categories considered.

3) Labor Market Factors

Row (3) in Panel A presents the coefficients for labor market factors. For the share of academic qualifications, we find a strong and significant association with price growth—the second highest among all variables considered (ρ = +0.58 to +0.67). Furthermore, we find a significant negative correlation for changes in labor market tightness, while changes in its components (unemployment and vacancy rate) are respectively positively and negatively correlated with price changes. For the employment share in the production industry, there is only a very weak association; for the hiring rate and matching efficiency, there is no significant association. In the multivariate blockwise case, only the share of academic qualifications remains significant in all models. All labor market factors explain approximately one-third of the variation in price growth for purchase prices and up to 45 percent for rental prices (Panel B).

4) Economic Factors

Row (4) in Panel A presents the coefficients for economic factors. We find clear evidence for a strong positive association of price growth and changes in population density. The correlation coefficients range between +0.66 and +0.78—the highest values among all variables considered. In contrast, changes in household income per capita show a significant negative correlation with housing price growth. For changes in GDP per capita, we find results in the same direction, but they are barely significant. When controlling for the other economic factors, the change in the population density remains significant in all models, and household income remains significant in most models. Overall, the economic indicators explain between 44 and 52 percent of housing price growth (Panel B) and, hence, represent the most relevant category considered.

5) Sociodemographic Factors

Row (5) in Panel A presents the coefficients for sociodemographic factors. We find a significant negative relationship between price growth and a change in the average population age (ρ = –0.38 to –0.52). Furthermore, for changes in the share of migrants, the student ratio, and the share of females, we also find significant bivariate correlations with all three price indicators. However, in the blockwise case, only the effect of the change in the mean population age remains significant across all specifications. Taken together, sociodemographic characteristics explain between 21 and 33 percent of the variation (Panel B).

6) Migration and Mobility

Row (6) in Panel A presents the coefficients for migration and mobility. There is evidence that an increase in the domestic migration balance relative to the population is associated with decreasing housing price growth. The correlation coefficients range between –0.44 and –0.49.[9] The size of the coefficients even increases once we control for the other two mobility factors. In contrast, a change in the external migration balance relative to the population correlates positively with price growth in the bivariate case but negatively in the blockwise case. Finally, the change in the commuter balance shows a negative correlation with price growth but is insignificant in the blockwise case. All three mobility variables explain between 22 and 28 percent of the variation (Panel B).

5.2 Variable Selection

Most of the considered variables correlate significantly with price growth, confirming their theoretically presumed relevance. However, it would not be appropriate to include all variables in one model due to high multicollinearity. Therefore, we choose only the most relevant factors from each category ($\boldsymbol{X'}_d$) based on significance and effect size in the blockwise regressions.[10]

$$\Delta^{08-19} y_d = \Delta^{08-19} \boldsymbol{X'}_d \beta^{mult} + \varepsilon_d \qquad (3)$$

This procedure addresses the fact that we have found strong within-categorical correlations and that each category should be relevant for price growth from a theoretical point of view. Figure 4 shows the coefficients resulting from this approach (β^{mult}) in green (“multivariate”). Taken together, all considered variables explain up to sixty percent of the variation in price growth (Panel B). *Ceteris paribus*, we find that total house price growth from 2008 to 2019 is higher for regions where population density and the share of academic qualifications increased more across the same period. Changes in the living area per capita, the mean population age, the share of small apartments, purchase prices for building land and the domestic migration balance are further significant for at least one price indicator (for detailed regression results, see Appendix Table A-6).

[9] This could indicate a negative time trend in the relative share of the domestic migration balance in districts with high price growth. In return, once we use the cumulative sum of the domestic migration balance across the entire period instead, the correlation coefficients clearly turn positive.

[10] These variables include living area per capita, the share of small apartments, completed apartments per capita, land prices, the share of academic qualifications, labor market tightness, population density, household income per capita, the mean population age, and domestic migration balance.

To check the robustness of our variable selection, we also use the Least Absolute Shrinkage and Selection Operator (LASSO), a machine-learning tool that selects the most predictive variables via regularization. We use the full set of variables considered in the bivariate correlations as inputs and choose the penalty level, as is common, by 10-fold cross validation to minimize the mean squared error. Appendix Figure A-4 presents all LASSO paths for the three price indicators. We find strong support for using the share of academic qualifications and population density as the most important explanatory variables (see Appendix Figure A-5).

5.3 Price Bubble Indicators

After explaining approximately sixty percent of the variation in housing price growth with changing fundamentals, we now investigate the likely role of a potential price bubble. Following Geng (2018), we focus on three indicators: 1) residuals of the multivariate regression specified in Equation (3) representing the valuation gap, 2) the price-to-income gap, and 3) the price-to-rent gap. Since we are not aware of any conventional thresholds, we standardize these indicators to a mean of zero and a standard deviation of one and define values above two standard deviations as indications of excessive price booms. Our results for residuals are plotted in Figure 5. To assess the absolute deviations of predicted from actual growth rates, the underlying nonstandardized values are displayed in Appendix Figure A-6.

Interestingly, we find no indication of widespread price bubbles, as the absolute deviations are rather small for the majority of districts. However, our model tends to underfit housing prices, particularly for districts belonging to the labor market of Munich and especially for purchase prices. A few other regions also show specific overvaluation in the rental market, such as Stuttgart, Lörrach (border region of Basel (CH)) and the greater metropolitan area of Nuremberg. With respect to apartment purchase prices, the district containing the high-price island Sylt is distinct in the north. In contrast, housing price growth is substantially overfitted in some cities in East Germany, such as Potsdam, Leipzig or Chemnitz, as well as in some peripheral areas, indicating that price growth is lower than expected from changing fundamentals.

[Insert Figure 5 here]

An analysis of the price-to-income gap (Appendix Figure A-7 and Figure A-8) supports a similar absence of widespread price bubbles. However, in addition to Munich and Stuttgart and their surroundings, other major cities, such as Berlin, Hamburg, Frankfurt and Düsseldorf, show excessively high price-to-income gaps for rental and purchasing prices. This indicates that in the largest cities, households' purchasing power gains have not kept pace with house price growth.

Turning to the gap between apartment purchase prices and rents (see Figure 6), we find very similar results as those for the price-to-income gap, supporting our view of a price bubble that exists mainly in the largest German cities, particularly in the area of Munich. Nevertheless, the nonstandardized values show that the gap between apartment purchase price and rental price growth diverged for the majority of districts, making it more expensive to buy than to rent a property (see Appendix Figure A-9).

[Insert Figure 6 here]

In conclusion, we do not find evidence in support of widespread price bubbles. Excessive price increases are concentrated in the largest cities and in the purchasing market for apartments. The latter is however insignificantly small outside of urban areas.

6 Panel Regression Analysis

Having assessed the relevant explanatory variables, we now turn to a quantitative estimation of year-by-year (and thus short-term) effects of fundamentals on housing prices. To exploit the panel structure of our full dataset, we estimate a first difference model specified as follows:

$$\Delta y_{d,t} = \Delta \boldsymbol{X}'_{d,t}\beta + \Delta\varepsilon_{d,t} \tag{4}$$

where $\Delta y_{d,t}$ is the change in the selected price indicator (apartment rents, apartment purchase prices, or house purchase prices) to the previous period in district *d* and year *t*. This corresponds well to the nature of the price index measured as a growth rate relative to the base year 2008. Thus, the first differencing yields yearly growth rates. $\Delta \boldsymbol{X}'_{d,t}$ is the change in the set of selected covariates. $\Delta\varepsilon_{d,t}$ is the first differenced error term. Robust standard errors are clustered at the district level. Note that we do not include a constant in the main specification, as the price indicators are calculated as region-year fixed effects from hedonic price regression (see Section 3). Thus, a common time trend has already been eliminated. The first difference model further eliminates all unobserved *time-fixed* factors, such as cultural norms (urban lifestyles, individualism, etc.) that may determine both housing demand and fundamentals such as the level of immigration. The β-coefficients can then be interpreted as causal effects if there is no further *time-varying* unobserved heterogeneity. Although we do not claim this assumption to hold strictly, our selection of variable categories from theory makes it at least likely that there are no relevant omitted time-varying factors.

Table 1 presents the first difference estimates based on the variables assessed as relevant in the correlation analysis. Column (1) shows the estimates for explaining rental price growth, Column (2) shows those for apartment purchase price growth, and Column (3) shows those for house purchase price growth compared to the previous year. Since all independent variables are standardized, effect sizes can be compared directly and represent the effect of a one standard deviation change in the respective variable on price growth in percentage points.

[Insert Table 1 here]

In terms of supply factors, we estimate that an increase in living area per capita by one standard deviation significantly reduces price growth by 1.6 to 4.0 percentage points. However, since an increase in living area per capita by one standard deviation approximately represents the average increase in living area per capita across the entire observation period, the immediate mitigating effect of increasing supply seems to be very weak and hardly measurable. Given that the association is particularly strong in urban areas, these results strengthen the importance of structural supply constraints (Glaeser et al., 2008; Anundsen and Heebøll, 2016; Füss and Zietz, 2016). Likewise, housing prices seem to be fueled by an increasing share of small apartments and increasing prices for building land. Moreover, we estimate that the number of completed apartments per capita correlates significantly and positively with housing price growth in the same year, which stands in contrast to the results for the living area. This may indicate a reverse causality mechanism where building activities react to strong price changes with a certain time lag, consistent with findings from Bahadir and Mykhaylova (2014).

On the demand side, we find that the coefficient for population density is significant in all models and by far the largest. We estimate that an increase in population density by one standard deviation increases price growth by 29 percentage points (apartment rents), 84 percentage points (apartment purchase prices), and 106 percentage points (house purchase prices). Despite its large size, the estimated effect seems plausible. A one standard deviation increase in population density equates to an increase of 686 inhabitants per square kilometer, which is more than double at the mean. Thus, we find strong evidence that increasing population density is an immediate driver of price growth in the housing market, particularly for purchasing prices. However, for the domestic migration balance per 1,000 inhabitants, we find insignificant effects for purchase prices and opposing (although very weak) negative effects for rental prices, which is counterintuitive at first sight.[11] The insignificant effects suggest that there is no additional price driving effect of a larger share of domestic migrants, keeping the population constant. We support this by showing that the total change in population density across our observation period is driven by changes in deaths per capita (which explains most of the variation) as well as by domestic and external immigration—all with similar elasticity (see Appendix Table A-7 and Figure A-10). The negative effect on apartment rents, however, might be indicative of a reverse causality mechanism, where individuals move away from districts with strong price growth, which may be especially true for the second half of the observation period and for urban areas. This is also supported by Henger and Oberst (2019), who find that large German cities have experienced negative domestic migration balances in recent years. The identified pattern still holds once we consider specific age groups, such as 18- to 25-year-old, 25- to 30-year-old, and 30- to 50-year-old individuals. However, when we focus on the skill composition of the population, we find a large positive effect of the share of academic qualifications on housing price growth (+8.4 to +20.6 percentage points). Thus, particularly the sorting of high-skilled labor seems to fuel price growth. Given that we simultaneously control for household income, this finding seemingly suggests that a higher share of academic qualifications drives prices through additional channels. Academically educated individuals tend to not only have higher homeownership rates in general (Andrews and Sánchez, 2011)[12] but also a greater willingness to pay for housing due to higher utility gains from amenities (Diamond, 2016). Additionally, more productive human capital also implies higher productive potential in the future, which results in further elevated labor demand (Diamond, 2016) and income paths (Tamborini et al., 2015). These mechanisms are supported by, first, larger effects for purchase prices (see Table 1); second, a positive correlation between a change in the share of academic qualifications and local property taxes (as a proxy for real estate purchases) (see Appendix Table A-8); and, third, the fact that skill sorting is higher for more densely populated districts (see Appendix Figure A-11). However, since our analysis focuses on the macro level, it is beyond the scope of this paper to isolate the direct housing demand effect of high-skilled workers from an indirect effect of endogenously induced labor demand through higher productivity (Falck et al., 2011).

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[11] Both the effect of population density and the domestic migration balance remain stable once we exclude the other.

[12] Apart from higher current income and financial resources, this is particularly explained by higher upward wage mobility expected by banks, facilitating mortgage access (Bayrakdar et al., 2019).

The coefficient for the mean population age is also significant in the model for rental and house purchase prices. We estimate that an increase of one standard deviation increases apartment rent growth by 2.9 and reduces house purchase price growth by 10.6 percentage points. At the mean, this represents a four percent increase in the average population age. Two underlying mechanisms may explain this finding. On the one hand, the demographic change *per se* seems to relax purchase prices considerably. Older persons have generally higher ownership rates than younger persons and are less mobile. In the case of apartment rents, the mechanism seems to be reversed, as with increasing age, the willingness and ability to pay for higher rents may first increase. This could also point to increased demand for living area per capita after a certain age due to the death or movement of household members. Both findings (a positive association between aging and rent growth and a negative association between aging and purchase price growth) have already been established in the literature for Germany by Hiller and Lerbs (2016).

Moreover, in contrast to the correlation analysis, there is evidence for the expected positive effect of purchasing power. A one standard deviation increase in household income per capita (approximately 15 percent at the mean) increases price growth by 6.5 (apartment rents), 14.8 (apartment purchase prices), and 19.5 percentage points (house purchase prices). Labor market tightness also shows significant effects, but they are small compared to the previous factors. These estimates point toward the effect of favorable labor market conditions, as reflected in wage growth.

To further investigate the cause of unprecedented housing price growth in Germany, we divide our observation period in half and investigate the periods of 2008-2013 and 2014-2019 separately (see Appendix Table A-9 and Table A-10). Indeed, the drivers of housing prices seem to shift over time: While population density maintained the largest comparative effect size, its effect nearly tripled for purchasing prices in later years. Similarly, the share of academic qualifications turned positive in the later period while simultaneously exhibiting the largest difference in effect size among all variables. This indicates that population density and the share of academic qualifications were the driving forces behind the unprecedented housing price growth in Germany. Furthermore, the effect of small apartment shares increased considerably, and land prices became significant in the later period, indicating that increased demand met supply constraints that were unmitigated by the construction of new apartments. The effect of household income remained relatively unchanged and significant throughout both periods.

To check the robustness of our results, we run alternative model specifications and estimate the effects at the level of labor market regions. Using a fixed effects estimator (see Appendix Table A-11) as well as a fixed effects estimator in log specification (see Appendix Table A-12) strongly supports our findings. Although some of the effect sizes change, the identified patterns remain robust. Once we estimate the effects at the level of labor market regions (see Appendix Table A-13), the effect of population density is considerably reduced. This could be explained by the fact that much of the population-changing migration behavior takes place within (the) homogeneous labor market regions. However, most of the coefficients are predominantly stable and support the interpretation of our main results. The stable effect of the share of academic qualifications removes concerns about a potential bias due to a separation of home and workplace in the district-level specification.

7 Conclusion

We have documented regional disparities in housing price growth in Germany between 2008 and 2019 by drawing on the RWI-GEO-REDX, which provides quality-adjusted price data at the district level. Although increases in apartment rents, apartment purchase prices, and house purchase prices affected almost the entire distribution of districts, the gap between the upper and lower tail has widened substantially over time, especially for purchase prices. Price growth was especially pronounced in the seven largest cities and in districts located in the south. We further illustrate path dependency that is well documented in the literature on housing bubbles. However, excessive price increases seem to be concentrated in the largest cities and to a lesser degree in the purchasing market for apartments; thus, similar to Kholodilin and Michelsen (2021), we do not find evidence supporting widespread price bubbles.

We identify time-varying factors that best explain the observed regional disparities by conducting correlation analyses using long-term changes and estimating a year-by-year first difference model. Our results confirm the empirical relevance of housing price fundamentals emphasized in the theoretical literature. House price increases in Germany were primarily driven by the demand side. We find that population density and the share of academic qualifications (Glaeser et al., 2012) as well as household income per capita are the most relevant factors. Housing price increases are thus best explained by population growth (due to immigration and a reduction of death rates), sorting of high-skilled labor and rising purchasing power. We interpret the qualification effect as a sign of a greater willingness to pay and the better mortgage access of high-skilled households coupled with higher regional income, productivity and growth paths. Prices for building land also seem to play a moderate role in driving regional disparities. Concurrent with the literature, increased building activity does not seem to mitigate price increases in the short term. However, our correlation analysis demonstrates that changes in housing supply and building activities explain a sizable part of price growth across the entire observation period, indicating a role for supply constraints in the medium and longer terms.

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Tables and Figures

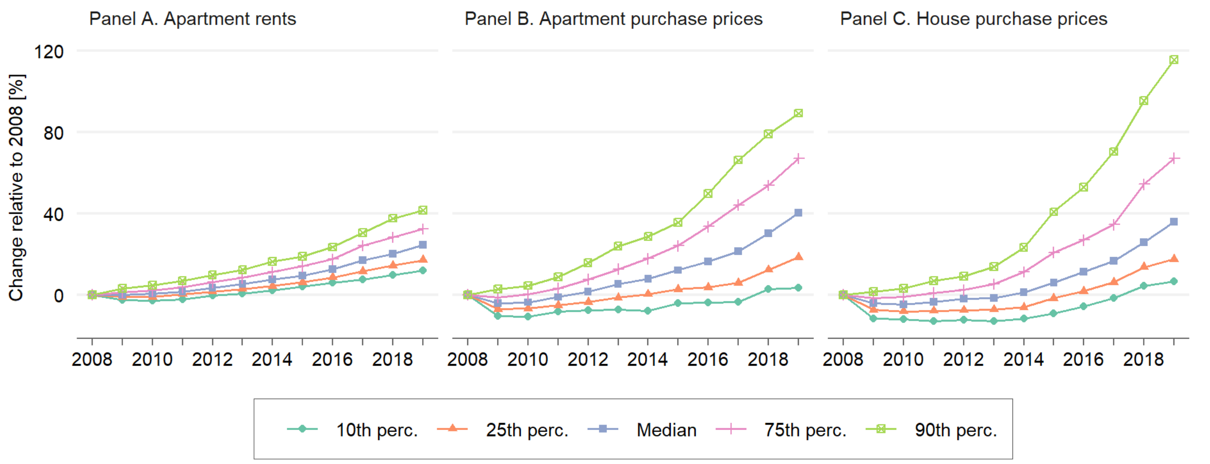

Figure 1: Change in apartment rents (Panel A), apartment purchase prices (Panel B), and house purchase prices (Panel C) compared to the base year 2008 by quantiles of districts. Housing price data are drawn from the RWI-GEO-REDX (Klick et al., 2020).

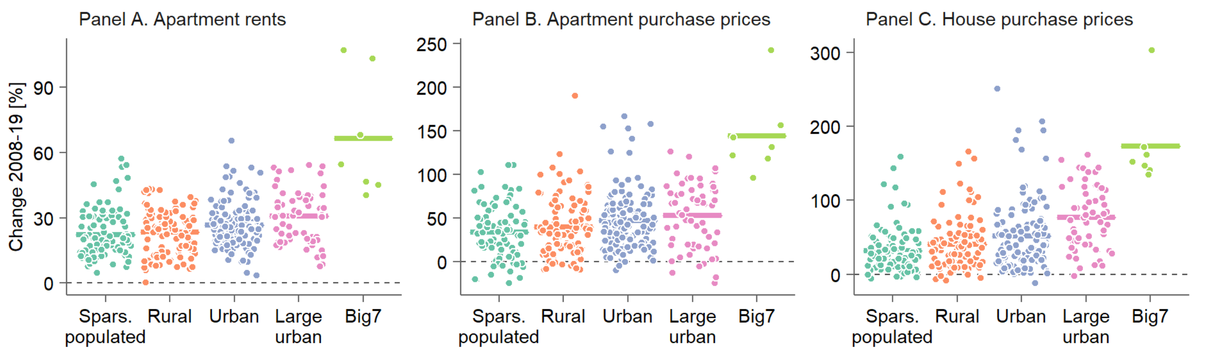

Figure 2: Change in apartment rents (Panel A), apartment purchase prices (Panel B), and house purchase prices (Panel C) from 2008 to 2019 by type of district according to the BBSR classification. The seven largest cities are shown as a stand-alone group ("Big7"). Housing price data are drawn from the RWI-GEO-REDX (Klick et al., 2020).

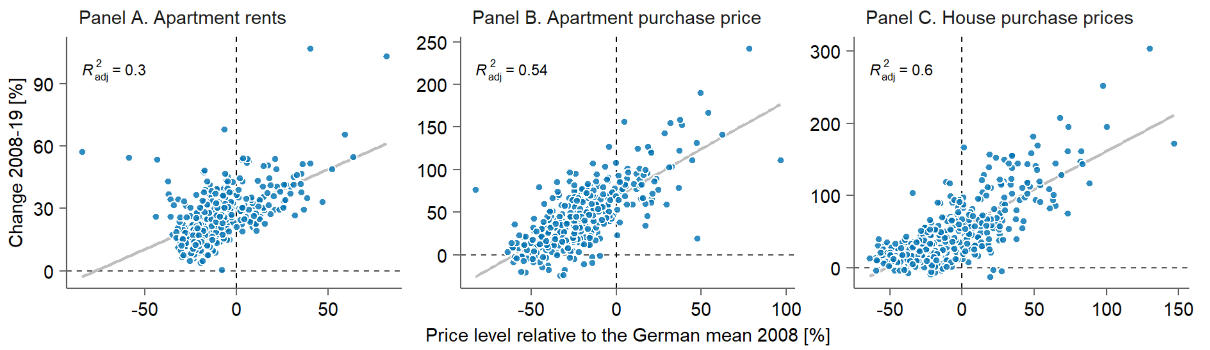

Figure 3: Association between initial price level (relative to the German mean) and price growth between 2008 and 2019 for apartment rents (Panel A), apartment purchase prices (Panel B), and house purchase prices (Panel C). Housing price data are drawn from the RWI-GEO-REDX (Klick et al., 2020).

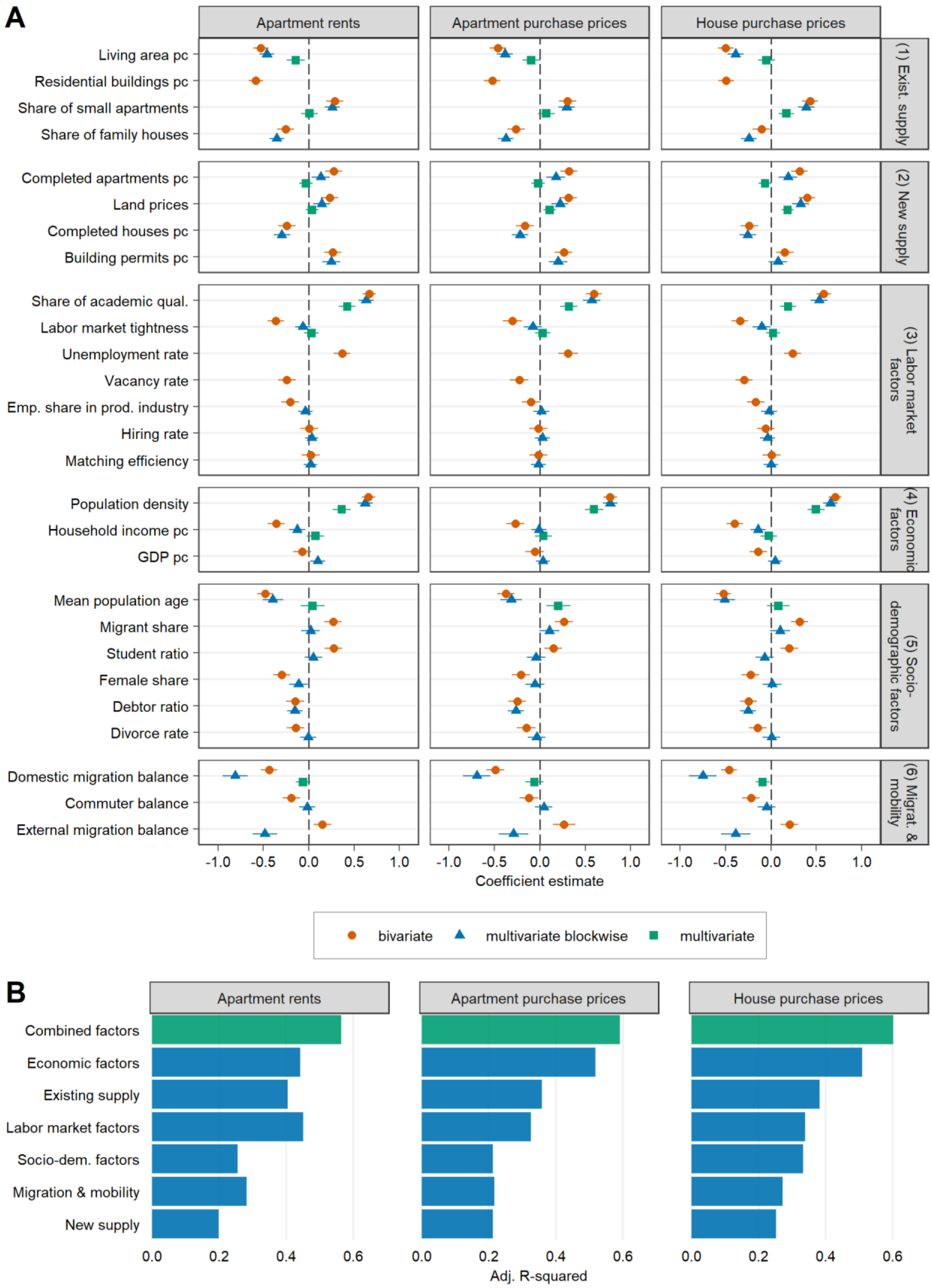

Figure 4: Panel A shows bivariate correlation coefficients from estimating equation (1) ("bivariate" in orange), multivariate blockwise correlation coefficients from equation (2) ("multivariate blockwise" in blue), and multivariate correlation coefficients for selected variables from equation (3) ("multivariate" in green), separately for all three housing price indicators. Covariates are grouped into six categories (see text for details). All variables are expressed as the total change during the observation period 2008 to 2019 and have been standardized to mean zero and standard deviation one. 95 percent confidence intervals shown. Panel B plots the Adj. R-squared resulting from the multivariate blockwise regressions (equation (2); blue) and from the multivariate regression with selected variables (equation (3); green).

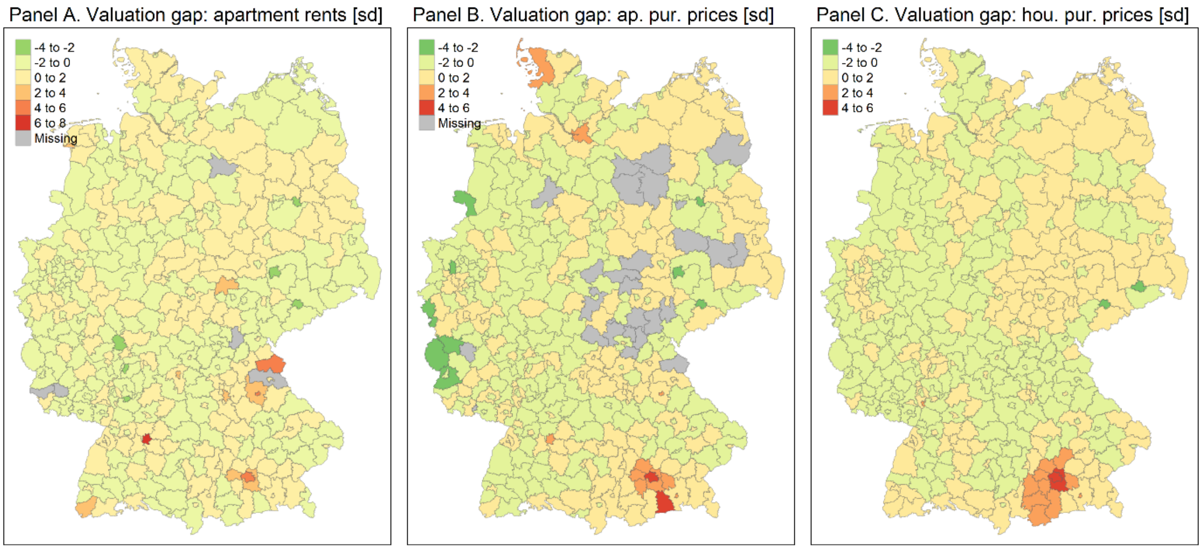

Figure 5: Standardized overvaluation gap of housing price growth from 2008 to 2019 across German districts. The overvaluation gap is calculated as the percentage point difference between actual growth rates and predicted growth rates according to the multivariate regression in equation (3) (see Section 5.2) over the entire observation period and is then standardized to mean zero and standard deviation one. Housing price data are drawn from the RWI-GEO-REDX (Klick et al., 2020); geodata from GeoBasis-DE/BKG (2018).

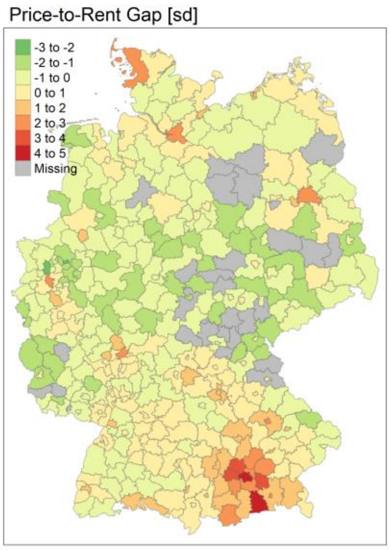

Figure 6: Standardized price-to rent gap across German districts. The price-to-rent gap is calculated as the percentage point difference between growth rates in apartment purchase prices and growth rates in apartment rents from 2008 to 2019 and is then standardized to mean zero and standard deviation one. Housing price data are drawn from the RWI-GEO-REDX (Klick et al., 2020); geodata from GeoBasis-DE/BKG (2018).

Table 1: First difference estimates

	Apartment rents (1)	Apartment purchase prices (2)	House purchase prices (3)
Living area pc	-1.554***	-2.387***	-4.047***
	(0.319)	(0.851)	(1.041)
Share of small apartments	1.068***	2.516***	2.413***
	(0.245)	(0.564)	(0.744)
Completed apartments pc	0.282***	0.580***	0.801**
	(0.095)	(0.190)	(0.340)
Building land prices	0.894***	1.553***	1.427
	(0.215)	(0.381)	(1.009)
Share of academic qual.	8.350***	12.658***	20.640***
	(0.872)	(1.683)	(2.586)
Labor market tightness	0.690***	1.440***	2.051***
	(0.195)	(0.558)	(0.777)
Population density	29.245***	84.427***	106.150***
	(5.145)	(10.257)	(20.189)
Household income pc	6.546***	14.828***	19.500***
	(0.688)	(1.905)	(2.523)
Mean population age	2.887***	-2.170	-10.578***
	(0.614)	(1.734)	(2.062)
Dom. migration balance	-0.135**	-0.117	-0.239
	(0.062)	(0.131)	(0.194)
Constant	No	No	No
Observations	4,375	4,164	4,410
R^2	0.054	0.077	0.127
Adjusted R^2	0.052	0.075	0.126

Notes: The table shows results from estimating separate first difference models for apartment rents (1), apartment purchase prices (2), and house purchase prices (3) at the district level, as specified in equation (4). All independent variables are standardized to enable comparisons. The coefficients represent the effect of a one standard deviation change in the respective covariate on the change in the respective price indicator in percentage points. Robust standard errors are clustered at the district level and shown in parentheses. Significance level: *p<0.1; **p<0.05; ***p<0.01.

Appendix –

Explaining Regional Disparities in Housing Prices across German Districts

Lars Brausewetter[1], *Stephan L. Thomsen*[2], *and Johannes Trunzer*[3]

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[1] Halle Institute for Economic Research (IWH), Kleine Maerkerstrasse 8, 06017 Halle (Saale), Germany. E-mail: lars.brausewetter@iwh-halle.de.

[2] Corresponding author. Leibniz University Hannover, Institute of Economic Policy, Königsworther Platz 1, 30167 Hannover, Germany; IZA Bonn, and ZEW Mannheim. E-mail: thomsen@wipol.uni-hannover.de.

[3] Leibniz University Hannover, Institute of Economic Policy, Königsworther Platz 1, 30167 Hannover, Germany. E-mail: trunzer@wipol.uni-hannover.de.

Table A-1: Definition and sources of variables used

Variable	Description	Unit	Source
Apartment rents	Change in the regional price index for apartment rents at the district level relative to 2008 (regression 3)	%	Klick et al. (2020)
Apartment purchase prices	Change in the regional price index for apartment purchase prices at the district level relative to 2008 (regression 3)	%	Klick et al. (2020)
House purchase prices	Change in the regional price index for house purchase prices at the district level relative to 2008 (regression 3)	%	Klick et al. (2020)
GDP per capita	Nominal GDP per capita	In 1,000€ per capita	Destatis (2021)
Household income per capita	Average household income per capita	In 1,000€ per capita	Destatis (2021)
Debtor ratio	Private debtors per 100 inhabitants aged 18 years and older	Ratio	BBSR Bonn (2021)
Employment share in the production industry	Percentage of persons in employment in the production industry (incl. construction), classified according to Destatis (2008), per total persons in employment	Ratio	Destatis (2021)
Unemployment rate	Share of unemployed persons per total labor force	Ratio	BA (2020a)
Vacancy rate	Vacancies per total labor force	Ratio	BA (2020a)
Hiring rate	Hires at the place of work per total labor force	Ratio	BA (2020a)
Labor market tightness	Number of vacancies per number of unemployed persons	Ratio	BA (2020b)
Matching efficiency	Log(number of hires) $-$ $\alpha \times$ log(number of vacancies) $-$ $\beta \times$ log(number of unemployed); $\alpha = \beta = 0.5$	$[0;\infty]$	BA (2020a)
Share of academic qualifications	Share of employees subject to social security contributions with academic qualification at place of work	Ratio	Destatis (2021)
Population density	Number of inhabitants per km²	Ratio	Destatis (2021)
Population age	Average age of the population at the place of residence	In years	BBSR Bonn (2021)
Birth rate	Live births per 1,000 inhabitants	Ratio	BBSR Bonn (2021)
Death rate	Deaths per 1,000 inhabitants	Ratio	BBSR Bonn (2021)
Migrant share	Share of migrants per total population at the place of residence	%	BBSR Bonn (2021)
Female share	Share of female persons per total population at the place of residence	%	Destatis (2021)
Student ratio	Number of students per 100 inhabitants at the place of residence	Ratio	BBSR Bonn (2021)
Divorce rate	Divorces per 1,000 inhabitants aged 18 years and older	Ratio	BBSR Bonn (2021)
Marriage rate	Marriages per 1,000 inhabitants aged 18 years and older	Ratio	BBSR Bonn (2021)
Commuter balance	Commuting balance per 100 employees subject to social security contributions at place of work	Ratio	BBSR Bonn (2021)
Total migration balance	Total migration balance per 1,000 inhabitants	Ratio	BBSR Bonn (2021)
Domestic migration balance	Total domestic migration balance per 1,000 inhabitants	Ratio	BBSR Bonn (2021)

Education migration	Domestic migration balance of population aged 18 to under 25 years per 100 inhabitants aged 18 to under 25 years	Ratio	BBSR Bonn (2021)
Job entry migration	Domestic migration balance of population aged 25 to under 30 years per 100 inhabitants aged 25 to under 30 years	Ratio	BBSR Bonn (2021)
Work migration	Domestic migration balance of population aged 30 to under 50 years per 100 inhabitants aged 30 to under 50 years	Ratio	BBSR Bonn (2021)
External migration balance	Total external migration balance per 1,000 inhabitants	Ratio	BBSR Bonn (2021)
Residential buildings per capita	Total number of residential buildings per 100 inhabitants	Ratio	Destatis (2021)
Living area per capita	Living area per capita	In m^2	Destatis (2021)
Share of small apartments	Share of apartments with 1 and 2 rooms per total apartments in residential and non-residential buildings	Ratio	Destatis (2021)
Share of big apartments	Share of apartments with 5 or more rooms per total apartments in residential and non-residential buildings	Ratio	Destatis (2021)
Share of family houses	Share of residential buildings with 1 and 2 apartments per total residential buildings	Ratio	Destatis (2021)
Building permits per capita	Building permits for new apartments in residential buildings per 1,000 inhabitants	Ratio	Destatis (2021)
Completed houses per capita	Completed apartments in residential buildings with 1 or 2 apartments per 1,000 inhabitants	Ratio	Destatis (2021)
Completed apartments per capita	Completed apartments in residential buildings with 3 or more apartments per 1,000 inhabitants	Ratio	Destatis (2021)
Land prices	Average purchase price for building land	In € per m^2	Destatis (2021)
Property taxes per capita	Actual revenue of property tax	In 1,000€ per capita	Destatis (2021)

Notes: Own illustration.

Table A-2: Summary statistics of variables used

Variable	N	Mean	SD	Min	Pctl(25)	Pctl(75)	Max
Apartment rents	4,774	9.555	11.488	-12.97	0.799	14.920	108.180
Apartment purchase prices	4,547	12.978	25.271	-58.2	-2.142	20.926	242.431
House purchase prices	4,812	11.485	29.744	-83	-4.2	16.2	304
GDP pc	4,812	33.364	15.074	12.141	24.331	36.907	188.453
Household income pc	4,812	20.556	3.031	14.289	18.420	22.331	42.555
Debtor ratio	4,812	9.423	2.662	3.670	7.460	10.790	21.670
Emp. share in prod. industry	4,812	27.646	9.037	6.171	20.743	34.340	54.936
Unemployment rate	4,812	6.228	3.066	1.250	3.842	7.933	19.225
Vacancy rate	4,812	1.257	0.601	0.153	0.817	1.575	5.029
Hiring rate	4,812	5.338	2.218	1.893	3.973	5.880	25.401
Labor market tightness	4,812	0.259	0.188	0.011	0.124	0.338	1.396
Matching efficiency	4,812	0.695	0.307	-0.201	0.475	0.897	2.231
Share of academic qual.	4,812	11.125	4.891	4.040	7.911	12.820	35.686
Population density	4,812	524.348	685.838	35.612	115.161	662.222	4,777.039
Mean population age	4,812	44.070	1.901	38.460	42.730	45.152	50.530
Birth rate	4,812	8.432	1.129	5.100	7.610	9.140	13.040
Death rate	4,812	11.345	1.790	6.840	10.010	12.490	17.930
Migrant share	4,812	8.277	5.019	0.660	4.478	11.105	36.560
Female share	4,812	50.808	0.685	48.349	50.344	51.199	53.552
Student ratio	4,812	26.388	50.473	0.000	0.000	28.235	452.960
Divorce rate	4,812	2.483	0.524	0.230	2.120	2.793	6.330
Commuter balance	4,812	-11.080	31.062	-148.9	-27.648	6.333	66.810
Total migration balance	4,812	4.023	6.042	-40.58	0.220	7.330	59.310
Domestic migration balance	4,812	-1.412	91.092	-2,017	-19.745	33.432	359.420
External migration balance	4,812	42.155	96.487	-140.6	6.150	49.505	2,610.0
Education migration	4,812	0.235	1,074.8	-9,818	-376.4	62.3	12,213.8
Job entry migration	4,812	0.117	596.2	-7,762	-100.9	62.3	7,701.0
Work migration	4,812	-0.050	798.8	-10,032	-72.5	290.6	5,042.5
Residential buildings pc	4,812	25.069	6.078	8.968	21.295	29.371	39.730
Living area pc	4,812	45.552	4.496	34.655	42.409	48.504	67.815
Share of small apartments	4,811	9.646	5.090	2.362	5.989	11.810	31.928
Share of big apartments	4,812	45.558	13.425	13.277	34.842	56.355	74.079
Share of family houses	4,812	83.088	10.803	46.935	78.208	91.009	96.743
Building permits pc	4,812	2.818	1.744	0.194	1.524	3.727	15.569
Completed houses pc	4,812	1.340	0.815	0.020	0.713	1.762	5.736
Completed apartments pc	4,812	1.035	1.079	0.000	0.310	1.417	10.352
Land prices	4,812	124.494	160.188	1.740	42.320	151.300	2,861.340
Property taxes pc	4,812	132.387	42.200	63.736	99.427	155.004	366.085

Notes: The table shows summary statistics for all variables used, including the number of observations (N), the mean, the standard deviation (SD), the minimum value, the 25th percentile, the 75th percentile, and the maximum value.

Table A-3: Distribution of housing price indicators by years

Year	10th perc.	25th perc.	Median	75th perc.	90th perc.	Mean	Standard Dev.
Panel A. Change in apartment rents relative to 2008 [%]							
2008	0	0	0	0	0	0	0
2009	-2.66	-1.16	0.04	1.34	3.22	0.42	4.18
2010	-3.05	-1.05	0.53	2.04	4.63	0.93	4.81
2011	-2.14	0.33	1.58	3.67	6.82	2.35	5.02
2012	-0.53	1.55	3.38	6.12	9.65	4.3	5.49
2013	0.71	2.91	5.19	8.4	12.33	6.16	5.91
2014	2.18	4.35	7.49	11.21	16.29	8.65	6.77
2015	3.95	6.22	9.49	13.97	18.97	10.85	6.94
2016	5.95	8.6	12.55	17.51	23.44	13.73	7.54
2017	7.41	11.48	17.02	24.25	30.59	18.82	10.42
2018	9.73	14.34	20.17	28.3	37.62	22.58	12.14
2019	12.03	17.12	24.62	32.4	41.45	25.96	12.82
Panel B. Change in apartment purchase prices relative to 2008 [%]							
2008	0	0	0	0	0	0	0
2009	-10.36	-6.98	-4.28	-1.37	2.82	-4.04	5.94
2010	-10.66	-6.79	-3.7	0.12	4.49	-3.19	7.1
2011	-8.32	-5.15	-1.16	3.17	8.79	-0.65	8.11
2012	-7.5	-3.56	1.41	7.58	15.66	2.67	10.69
2013	-7.28	-1.33	5.29	12.7	23.89	6.7	12.49
2014	-7.83	0.28	7.85	17.82	28.56	10.05	15.58
2015	-4.2	2.8	12.08	24.16	35.46	15.16	17.42
2016	-3.95	3.74	16.22	33.58	49.77	20.44	23.25
2017	-3.47	5.9	21.47	44.18	66.32	27.86	29.32
2018	2.75	12.31	30.29	53.84	79.05	36.89	31.92
2019	3.29	18.43	40.35	67.11	89.34	45.15	37.34
Panel C. Change in house purchase prices relative to 2008 [%]							
2008	0	0	0	0	0	0	0
2009	-11.85	-7.39	-4.24	-1.52	1.62	-4.59	6.91
2010	-11.9	-8.17	-4.92	-0.91	3.19	-4.4	6.97
2011	-12.93	-7.89	-3.53	0.94	6.84	-3.21	10.25
2012	-12.3	-7.6	-1.99	2.37	9.08	-1.49	11.22
2013	-13.11	-7.28	-1.53	5.28	13.7	0.1	14.18
2014	-11.83	-6.06	1.13	11.3	23.36	4.22	17.4
2015	-9.24	-1.66	6.04	20.8	40.78	11.84	23.09
2016	-5.89	1.77	11.3	26.91	52.83	18.67	26.89
2017	-1.69	6.25	16.68	34.58	70.43	27.18	33.6
2018	4.5	13.61	25.81	54.36	95.53	39.78	39.69
2019	6.58	17.55	35.97	67.21	115.58	49.72	45.5

Notes: The table shows the distribution of housing price indicators across German districts by years. Panel A refers to the change in apartment rents, Panel B to the change in apartment purchase prices and Panel C to the change in house purchase prices relative to 2008. Data source is the RWI-GEO-REDX (Klick et al., 2020).

Table A-4: Results of Wilcoxon rank sum tests

H_0	p-Value
Panel A. Change in apartment rents 2008-19	
Big7 = large urban	0.00183
Big7 = urban	0.00034
Big7 = rural	0.00015
Big7 = sparsely populated	0.00031
Large urban = urban	0.24117
Large urban = rural	0.00439
Large urban = sparsely populated	8.6e-05
Urban = rural	0.80701
Urban = sparsely populated	0.00479
Rural = sparsely populated	1.00000
East = West	1.1e-08
East = North	5.3e-09
East = South	< 2e-16
West = North	0.16
West = South	< 2e-16
North = South	3.7e-08
Panel B. Change in apartment purchase prices 2008-19	
Big7 = large urban	0.00040
Big7 = urban	0.00038
Big7 = rural	0.00024
Big7 = sparsely populated	0.00016
Large urban = urban	0.86230
Large urban = rural	0.12815
Large urban = sparsely populated	0.02321
Urban = rural	0.82101
Urban = sparsely populated	0.14958
Rural = sparsely populated	1.00000
East = West	0.580
East = North	0.005
East = South	7.8e-15
West = North	0.171
West = South	< 2e-16
North = South	1.1e-08
Panel C. Change house purchase prices 2008-19	
Big7 = large urban	0.00094
Big7 = urban	0.00048
Big7 = rural	0.00021
Big7 = sparsely populated	0.00015
Large urban = urban	0.00032
Large urban = rural	1.8e-06
Large urban = sparsely populated	2.1e-10
Urban = rural	0.50096
Urban = sparsely populated	0.00089
Rural = sparsely populated	0.64213
East = West	1.00
East = North	0.15
East = South	3.2e-09
West = North	0.26
West = South	1.8e-09
North = South	7.0e-05

Notes: The table shows the results of Wilcoxon rank sum tests for group wise comparisons of mean housing price growth between 2008 and 2019. The first column shows the null hypothesis, the second column the corresponding p-value.

Table A-5: Blockwise regressions of total housing price growth on long-term changes in fundamentals

	Apartment rents	Apartment purchase prices	House purchase prices
	(1)	(2)	(3)
Panel A. Existing supply			
Living area pc	-0.460***	-0.383***	-0.389***
	(0.041)	(0.045)	(0.041)
Share of small apartments	0.258***	0.296***	0.388***
	(0.043)	(0.046)	(0.044)
Share of family houses	-0.352***	-0.375***	-0.243***
	(0.041)	(0.043)	(0.042)
Observations	396	374	401
R^2	0.409	0.363	0.387
Adjusted R^2	0.405	0.358	0.382
Panel B. New supply			
Completed apartments pc	0.133**	0.176***	0.188***
	(0.052)	(0.052)	(0.049)
Land prices	0.144***	0.223***	0.325***
	(0.047)	(0.048)	(0.045)
Completed houses pc	-0.296***	-0.217***	-0.256***
	(0.046)	(0.047)	(0.044)
Building permits pc	0.248***	0.202***	0.076
	(0.051)	(0.052)	(0.049)
Observations	396	374	401
R^2	0.207	0.220	0.261
Adjusted R^2	0.199	0.212	0.253
Panel C. Labor market factors			
Share of academic qual.	0.632***	0.571***	0.529***
	(0.042)	(0.048)	(0.046)
Labor market tightness	-0.064	-0.079	-0.101**
	(0.043)	(0.051)	(0.047)
Emp. share in prod. industry	-0.036	0.017	-0.019
	(0.040)	(0.045)	(0.043)
Hiring rate	0.033	0.027	-0.036
	(0.037)	(0.042)	(0.041)
Matching efficiency	0.020	-0.016	-0.00002
	(0.037)	(0.041)	(0.041)
Observations	396	374	401
R^2	0.458	0.335	0.347
Adjusted R^2	0.451	0.326	0.339
Panel D. Economic factors			
Population density	0.621***	0.775***	0.655***
	(0.042)	(0.042)	(0.039)
Household income pc	-0.126***	-0.011	-0.141***
	(0.046)	(0.042)	(0.042)
GDP pc	0.101**	0.034	0.045
	(0.042)	(0.040)	(0.039)
Observations	396	374	401
R^2	0.446	0.522	0.513
Adjusted R^2	0.442	0.518	0.509
Panel E. Socio-demographic factors			
Mean population age	-0.396***	-0.316***	-0.513***
	(0.058)	(0.060)	(0.054)

Migrant share	0.020	0.107*	0.099**
	(0.053)	(0.056)	(0.050)
Student ratio	0.050	-0.041	-0.071
	(0.049)	(0.051)	(0.047)
Female share	-0.113**	-0.055	0.012
	(0.052)	(0.054)	(0.049)
Debtor ratio	-0.152***	-0.263***	-0.253***
	(0.044)	(0.045)	(0.041)
Divorce rate	-0.005	-0.035	0.006
	(0.045)	(0.049)	(0.043)
Observations	396	374	401
R^2	0.267	0.225	0.343
Adjusted R^2	0.255	0.212	0.333
Panel F. Migration and mobility			
Dom. migration balance	-0.809***	-0.695***	-0.750***
	(0.071)	(0.077)	(0.071)
Commuter balance	-0.015	0.044	-0.048
	(0.046)	(0.049)	(0.045)
Ext. migration balance	-0.483***	-0.289***	-0.390***
	(0.068)	(0.083)	(0.069)
Observations	396	374	401
R^2	0.287	0.223	0.278
Adjusted R^2	0.281	0.216	0.272

Notes: The table shows estimates from regressing the total change in the respective housing price indicator from 2008 to 2019 separately on six different sets of covariates (Panel A-F), as specified in equation (2). All variables are measured as the change across the entire observation period from 2008 to 2019 and are standardized to mean zero and standard deviation one. See text for details. Standard errors in parentheses. $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$.

Table A-6: Multivariate regressions of total housing price growth on long-term changes in fundamentals

	Apartment rents	Apartment purchase prices	House purchase prices
	(1)	(2)	(3)
Living area pc	-0.143***	-0.094*	-0.050
	(0.051)	(0.051)	(0.048)
Share of small apartments	0.009	0.070	0.170***
	(0.046)	(0.048)	(0.044)
Completed apartments pc	-0.031	-0.018	-0.064*
	(0.039)	(0.038)	(0.037)
Building land prices	0.037	0.109***	0.183***
	(0.036)	(0.036)	(0.035)
Share of academic qual.	0.424***	0.321***	0.189***
	(0.047)	(0.047)	(0.044)
Labor market tightness	0.031	0.030	0.024
	(0.042)	(0.043)	(0.040)
Population density	0.365***	0.597***	0.496***
	(0.051)	(0.052)	(0.048)
Household income pc	0.073	0.038	-0.023
	(0.050)	(0.047)	(0.045)
Mean population age	0.043	0.203***	0.082
	(0.068)	(0.067)	(0.063)
Domestic migration balance	-0.064	-0.061	-0.092**
	(0.041)	(0.050)	(0.040)
Observations	396	374	401
R^2	0.575	0.602	0.611
Adjusted R^2	0.564	0.591	0.601

Notes: The table shows estimates from regressing the total change in the respective housing price indicator from 2008 to 2019 on our selected set of covariates, as specified in equation (3). All variables are measured as the change across the entire observation period from 2008 to 2019 and are standardized to mean zero and standard deviation one. See text for details. Standard errors in parentheses. *p<0.1; **p<0.05; ***p<0.01.

Table A-7: Explaining changes in the population density

	Population density				
	(1)	(2)	(3)	(4)	(5)
Birth rate	2.042***				0.014
	(0.366)				(0.159)
Death rate		-3.775***			-1.052***
		(0.219)			(0.144)
Domestic migration balance			0.189***		1.171***
			(0.041)		(0.037)
External migration balance				0.231***	1.170***
				(0.039)	(0.036)
Observations	401	401	401	401	401
R^2	0.072	0.427	0.051	0.081	0.850
Adjusted R^2	0.070	0.425	0.049	0.079	0.849

Notes: The table shows estimates from regressing the total change in the population density between 2008 and 2019 on changes in several demographic indicators across the same period. Thus, the coefficients can be interpreted as the effect of a unit increase in the respective variable (i.e., one birth/death per 1,000 inhabitants; one migrant per 100 inhabitants) on the change in the population density in percent. See text for details. Standard errors in parentheses. *p<0.1; **p<0.05; ***p<0.01.

Table A-8: First difference estimates for local property taxes

	Local property taxes pc
	(1)
Share of academic qual.	0.100***
	(0.025)
Living area pc	0.072***
	(0.018)
Share of small apartments	0.068***
	(0.016)
Completed apartments pc	0.005
	(0.003)
Building land prices	0.019
	(0.012)
Labor market tightness	0.002
	(0.007)
Population density	0.141
	(0.330)
Household income pc	0.141***
	(0.025)
Mean population age	0.246***
	(0.029)
Dom. migration balance	0.0002
	(0.002)
Constant	No
Observations	4,410
R^2	0.005
Adjusted R^2	0.003

Notes: The table shows results from estimating a first difference model for local property taxes at the district level. All variables are standardized to enable comparisons. The coefficients represent the effect of a one standard deviation change in the respective covariate on the change in local property taxes in standard deviations. Robust standard errors are clustered at the district level and shown in parentheses. Significance level: *p<0.1; **p<0.05; ***p<0.01.

Table A-9: First difference estimates for 2008-2013

	Apartment rents	Apartment purchase prices	House purchase prices
	(1)	(2)	(3)
Living area pc	-0.127	-0.076	-1.149
	(0.259)	(0.779)	(0.939)
Share of small apartments	1.376***	2.786***	2.840***
	(0.198)	(0.490)	(0.722)
Completed apartments pc	0.258**	1.079***	0.755
	(0.121)	(0.246)	(0.472)
Land prices	0.033	-0.279	-0.845
	(0.208)	(0.567)	(1.055)
Share of academic qual.	-3.189***	-14.037***	-13.147***
	(0.588)	(1.915)	(1.882)
Labor market tightness	-0.394*	1.406**	1.688***
	(0.224)	(0.553)	(0.609)
Population density	11.706***	36.507***	41.898**
	(2.698)	(8.812)	(20.239)
Household income pc	3.100***	6.477***	8.850***
	(0.658)	(1.676)	(1.485)
Mean population age	2.853***	-1.892	-10.191***
	(0.607)	(1.308)	(1.615)
Domestic migration balance	-0.033	-0.924**	-2.051***
	(0.185)	(0.459)	(0.532)
Constant	No	No	No
Observations	1,989	1,901	2,004
R^2	0.007	0.100	0.120
Adjusted R^2	0.003	0.096	0.116

Notes: The table shows results from estimating separate first difference models for apartment rents (1), apartment purchase prices (2), and house purchase prices (3) at the district level for the period 2008 to 2013. All independent variables are standardized to enable comparisons. The coefficients represent the effect of a one standard deviation change in the respective covariate on the change in the respective price indicator in percentage points. Robust standard errors are clustered at the district level and shown in parentheses. Significance level: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$.

Table A-10: First differences estimates for 2014-2019

	Apartment rents	Apartment purchase prices	House purchase prices
	(1)	(2)	(3)
Living area pc	2.230	-5.040	0.866
	(2.537)	(5.705)	(7.552)
Share of small apartments	12.046**	48.993***	50.049***
	(4.816)	(10.966)	(11.087)
Completed apartments pc	-0.035	-0.407*	0.064
	(0.125)	(0.247)	(0.428)
Land prices	0.800***	1.130***	1.066
	(0.183)	(0.329)	(1.011)
Share of academic qual.	22.042***	43.234***	58.745***
	(2.526)	(3.352)	(5.370)
Labor market tightness	0.837***	-0.749	-0.278
	(0.211)	(0.581)	(0.889)
Population density	8.406	89.587***	149.776***
	(17.873)	(20.471)	(31.336)
Household income pc	3.432***	7.700***	10.475***
	(0.871)	(1.919)	(3.304)
Mean population age	2.710	16.497***	7.118
	(3.116)	(5.666)	(6.749)
Domestic migration balance	-0.125**	-0.175	-0.226
	(0.061)	(0.153)	(0.215)
Constant	No	No	No
Observations	1,988	1,880	2,005
R^2	0.087	0.110	0.121
Adjusted R^2	0.083	0.105	0.117

Notes: The table shows results from estimating separate first difference models for apartment rents (1), apartment purchase prices (2), and house purchase prices (3) at the district level for the period 2014 to 2019. All independent variables are standardized to enable comparisons. The coefficients represent the effect of a one standard deviation change in the respective covariate on the change in the respective price indicator in percentage points. Robust standard errors are clustered at the district level and shown in parentheses. Significance level: *p<0.1; **p<0.05; ***p<0.01.

Table A-11: Fixed effects estimates

	Apartment rent growth	Apartment purchase price growth	House purchase price growth
	(1)	(2)	(3)
Living area pc	-3.076***	-6.759***	-9.487***
	(0.587)	(1.557)	(1.901)
Share of small apartments	1.621***	2.681***	3.775***
	(0.413)	(1.033)	(1.174)
Completed apartments pc	0.930***	2.677***	1.884***
	(0.199)	(0.465)	(0.561)
Land prices	2.525***	8.171***	11.204***
	(0.589)	(1.550)	(2.312)
Share of academic qual.	11.390***	18.166***	23.807***
	(1.050)	(2.525)	(3.491)
Labor market tightness	1.389***	3.320***	3.358***
	(0.305)	(1.022)	(1.083)
Population density	29.131***	83.847***	123.083***
	(6.459)	(14.326)	(21.076)
Household income pc	9.279***	16.951***	21.999***
	(0.826)	(2.433)	(2.415)
Mean population age	0.644	-3.013	-11.246***
	(0.956)	(2.415)	(2.700)
Domestic migration balance	-0.171	-0.439	-0.453
	(0.116)	(0.268)	(0.290)
District FE	Yes	Yes	Yes
Time FE	No	No	No
Observations	4,773	4,547	4,811
R^2	0.835	0.729	0.731
Adjusted R^2	0.819	0.704	0.706

Notes: The table shows results from estimating separate fixed effects models for growth in apartment rents (1), apartment purchase prices (2), and house purchase prices (3) at the district level for the period 2008 to 2013. All independent variables are standardized to enable comparisons. The coefficients represent the effect of a one standard deviation change in the respective covariate on the change in the respective price indicator in percentage points. Robust standard errors are clustered at the district level and shown in parentheses. Significance level: *p<0.1; **p<0.05; ***p<0.01.

Table A-12: Fixed effects estimates in log specification

	Log apartment rents	Log apartment purchase prices	Log house purchase prices
	(1)	(2)	(3)
Log living area pc	-0.121**	0.214	-0.094
	(0.056)	(0.137)	(0.182)
Share of small apartments	0.004***	0.006***	0.007***
	(0.001)	(0.002)	(0.002)
Completed apartments pc	0.004***	0.010***	0.005
	(0.001)	(0.003)	(0.004)
Log land prices	0.007***	0.017***	0.036***
	(0.003)	(0.006)	(0.007)
Share of academic qual.	0.020***	0.029***	0.036***
	(0.002)	(0.003)	(0.004)
Labor market tightness	0.039***	0.063*	0.081**
	(0.011)	(0.034)	(0.033)
Log population density	0.893***	3.015***	2.834***
	(0.065)	(0.177)	(0.219)
Log household income pc	0.520***	0.595***	1.104***
	(0.033)	(0.101)	(0.099)
Log mean population age	0.426**	0.535	-1.905***
	(0.180)	(0.419)	(0.484)
Domestic migration balance	-0.0002	-0.0002	-0.0002
	(0.0001)	(0.0002)	(0.0003)
District FE	Yes	Yes	Yes
Time FE	No	No	No
Observations	4,773	4,547	4,811
R^2	0.850	0.749	0.729
Adjusted R^2	0.836	0.726	0.703

Notes: The table shows results from estimating separate fixed effects models for apartment rents (1), apartment purchase prices (2), and house purchase prices (3) at the district level for the period 2008 to 2013. The dependent as well as selected independent variables are specified in logs. The coefficients in logs represent the effect of a one percent change in the respective covariate on the percent change in the respective price indicator. The coefficients not in logs represent the effect of a one-percentage point change in the respective covariate on the percent change in the respective price indicator. Robust standard errors are clustered at the district level and shown in parentheses. Significance level: *p<0.1; **p<0.05; ***p<0.01.

Table A-13: First differences estimates at the level of labor market regions

	Apartment rents	Apartment purchase prices	House purchase prices
	(1)	(2)	(3)
Living area pc	-1.758***	-2.361	-4.218***
	(0.661)	(1.523)	(1.322)
Share of small apartments	0.512	1.663**	0.977
	(0.328)	(0.790)	(0.599)
Completed apartments pc	0.267**	0.670**	0.261
	(0.113)	(0.300)	(0.356)
Land prices	0.487**	1.448*	2.563***
	(0.217)	(0.805)	(0.622)
Share of academic qual.	5.776***	4.509***	10.325***
	(0.757)	(1.683)	(1.831)
Labor market tightness	0.096	-0.505	0.561
	(0.257)	(0.683)	(0.651)
Population density	25.836*	67.025*	30.499
	(14.903)	(36.103)	(31.066)
Household income pc	7.276***	19.792***	20.755***
	(0.645)	(2.024)	(1.464)
Mean population age	2.440***	-11.045***	-16.913***
	(0.920)	(2.100)	(1.829)
Domestic migration balance	-0.119*	-0.131	0.012
	(0.070)	(0.226)	(0.215)
Constant	No	No	No
LMR level	Yes	Yes	Yes
Observations	1,989	1,836	2,001
R^2	0.052	0.091	0.159
Adjusted R^2	0.048	0.086	0.155

Notes: The table shows results from estimating separate first difference models for apartment rents (1), apartment purchase prices (2), and house purchase prices (3) at the level of labor market regions. Labor market regions are defined according to the delineation of RWI (2018), which identifies 182 areal units from the universe of administrative districts. All independent variables are standardized to enable comparisons. The coefficients represent the effect of a one standard deviation change in the respective covariate on the change in the respective price indicator in percentage points. Robust standard errors are clustered at the level of regional labor markets and shown in parentheses. Significance level: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$.

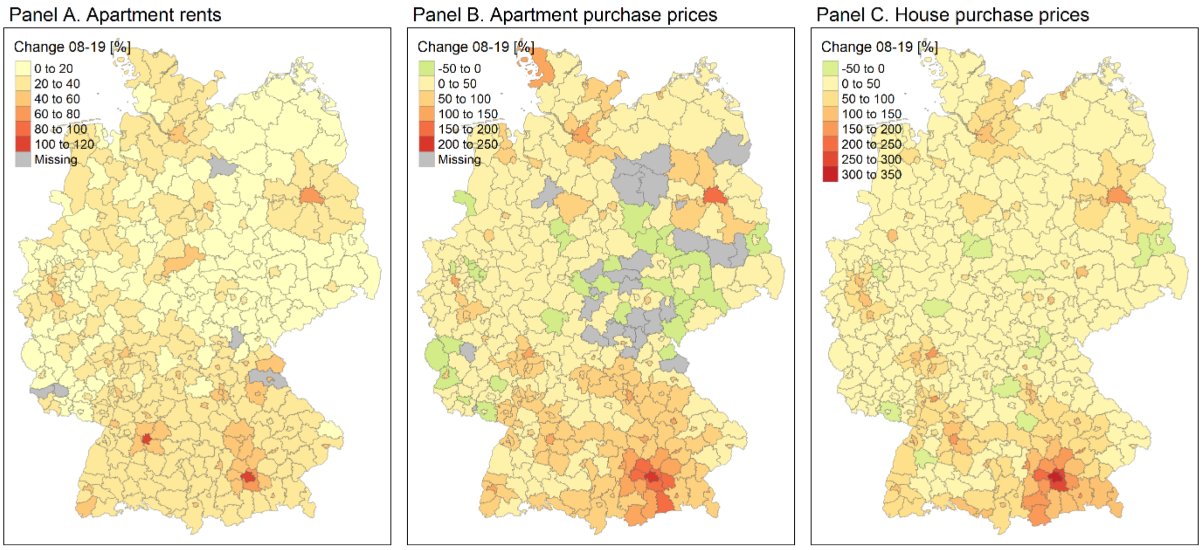

Figure A-1: Change in apartment rents (Panel A), apartment purchase prices (Panel B), and house purchase prices (Panel C) from 2008 to 2019 across districts. Districts with missing price information depicted in gray. Housing price data are drawn from the RWI-GEO-REDX (Klick et al., 2020); geodata from GeoBasis-DE/BKG (2018).

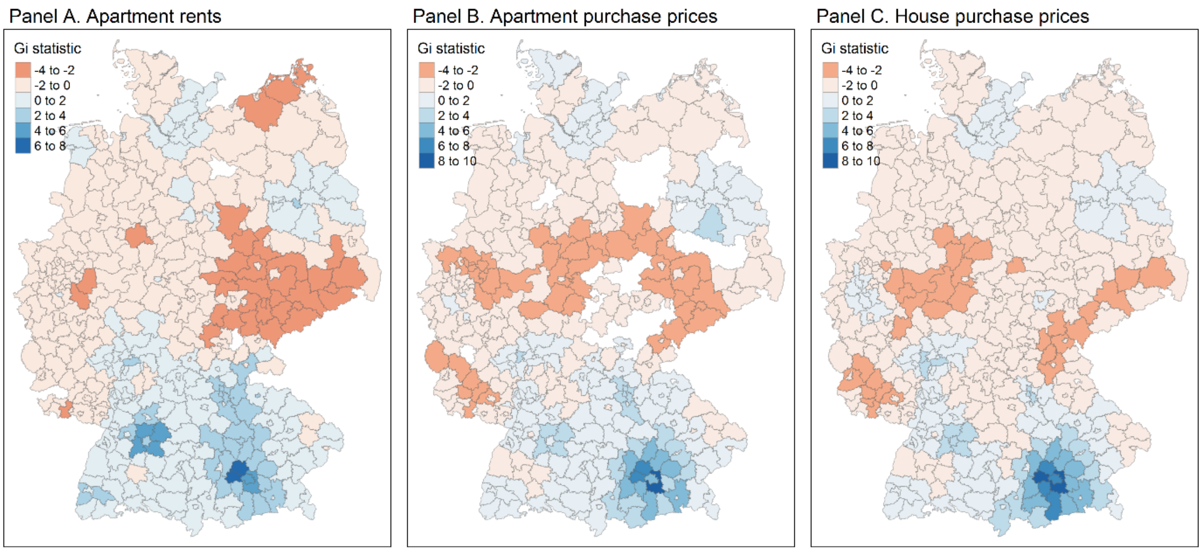

Figure A-2: Getis-Ord Gi Statistic represented as a Z-score for the total change in apartment rents (Panel A), apartment purchase prices (Panel B), and house purchase prices (Panel C) from 2008 to 2019 across districts. The Getis-Ord GI Statistic is a measure for the spatial autocorrelation of a variable, i.e., the tendency of high or low values to cluster spatially. Larger values represent a greater intensity of clustering and the direction (positive or negative) indicates clusters of high or low price growth. Districts with missing price information depicted in white. Housing price data are drawn from the RWI-GEO-REDX (Klick et al., 2020); geodata from GeoBasis-DE/BKG (2018).

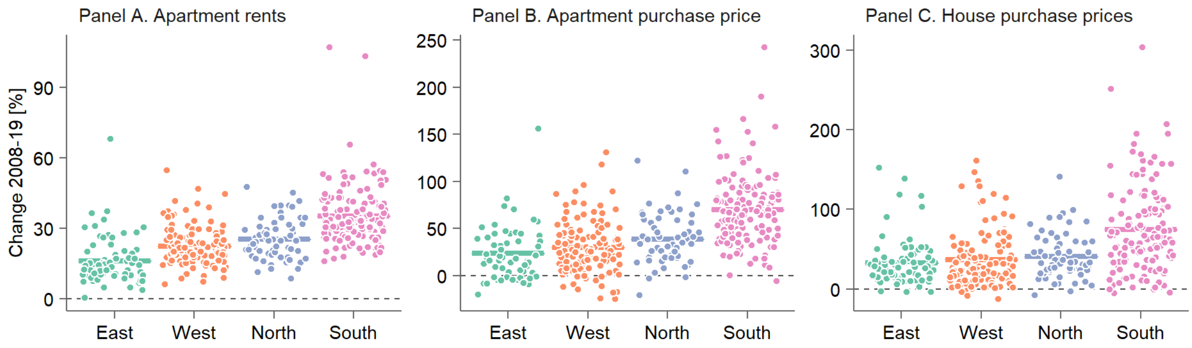

Figure A-3: Total change in apartment rents (Panel A), apartment purchase prices (Panel B), and house purchase prices (Panel C) from 2008 to 2019 by four broad geographic areas. East is defined as all districts located in East Germany, West as districts located in North Rhine-Westphalia, Rhineland-Palatine, Hesse, and Saarland, North as districts located in Schleswig-Holstein, Bremen, Hamburg, and Lower Saxony, South as districts located in Baden-Wurttemberg and Bavaria. Housing price data are drawn from the RWI-GEO-REDX (Klick et al., 2020).

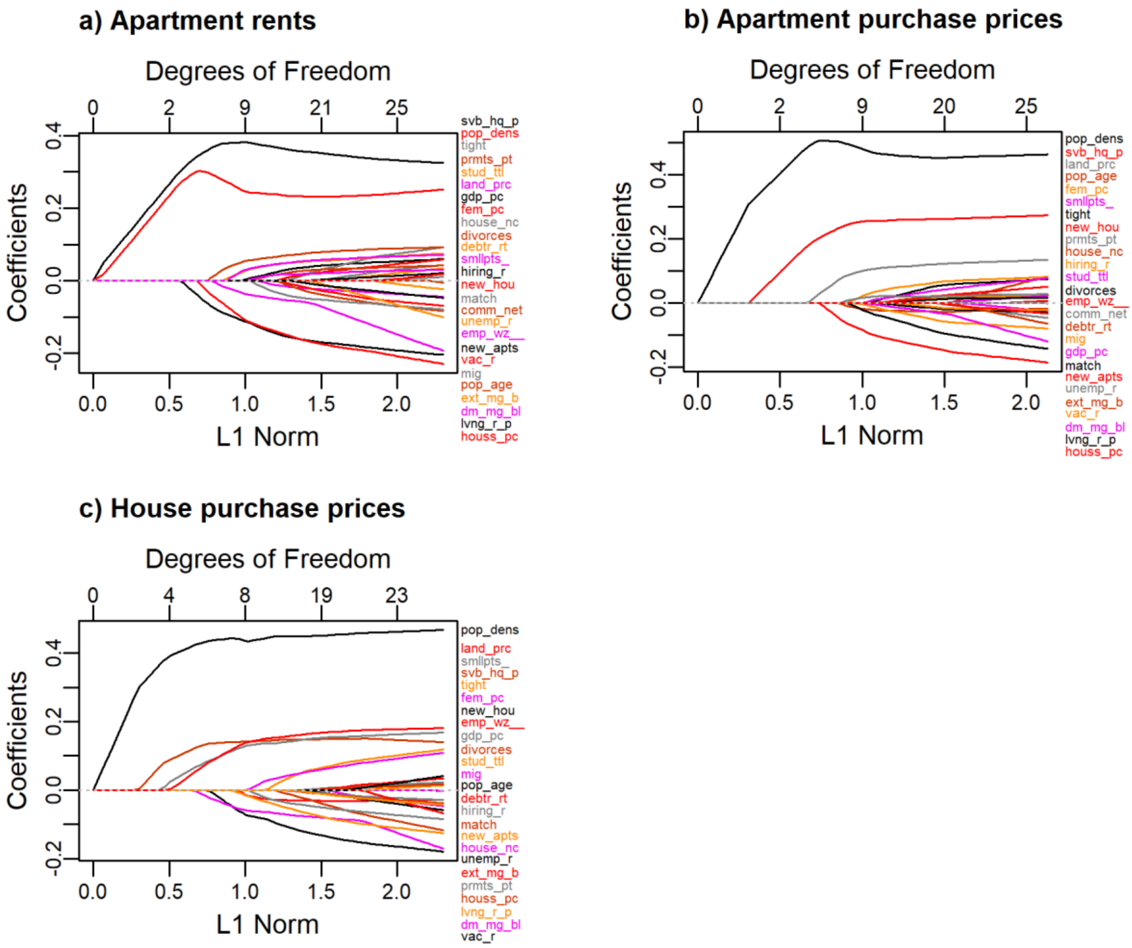

Figure A-4: LASSO estimate path plots for explaining the total change in a) apartment rents, b) apartment purchase prices, and c) house purchase price from 2008 to 2019. Each line corresponds to a variable and shows the path of its coefficient against the L1-norm of the whole coefficient vector as λ varies. The axis above indicates the number of nonzero coefficients at the respective λ, which is the effective degrees of freedom. All 26 variables from the bivariate correlations, excluding residential buildings pc, used as inputs (see Figure 4). The abbreviations stand for: svb_hq_p = share of academic qualifications; pop_dens = population density; tight = labor market tightness; prmts_pt = building permits per capita; stud_ttl = student ratio; land_prc = land prices; gdp_pc = GDP per capita; fem_pc = female share; house_nc = household income per capita; divorces = divorce rate; debtr_rt = debtor ratio; smllpts_ = share of small apartments; hiring_r = hiring rate; new_hou = completed houses per capita; match = matching efficiency; comm_net = commuter balance; unemp_r = unemployment rate; emp_wz__ = employment share in production industry; new_apts = completed apartments per capita; vac_r = vacancy rate; mig = share of migrants; pop_age = mean population age; ext_mig_b = external migration balance; dm_mg_bl = domestic migration balance; lvng_r_p = living area per capita; houss_pc = share of family houses.

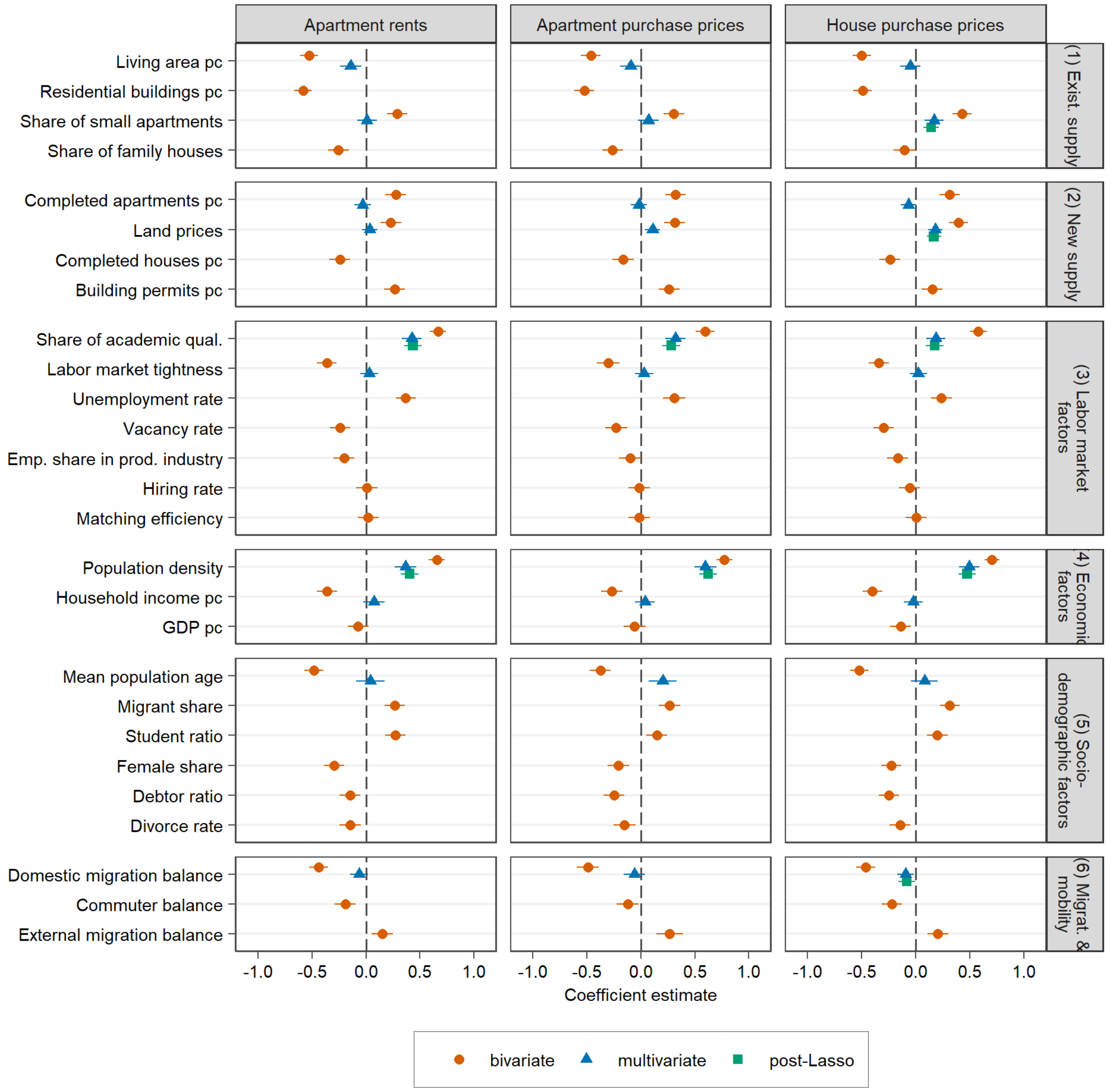

Figure A-5: The figure shows bivariate correlation coefficients from estimating equation (1) ("bivariate" in orange), multivariate correlation coefficients for selected variables from equation (3) ("multivariate" in blue), and coefficients for variables selected by LASSO ("post-LASSO" in green), separately for all three housing price indicators. Covariates are grouped into six categories (see text for details). All variables are expressed as the total change during the observation period 2008 to 2019 and have been standardized to mean zero and standard deviation one. 95 percent confidence intervals shown.

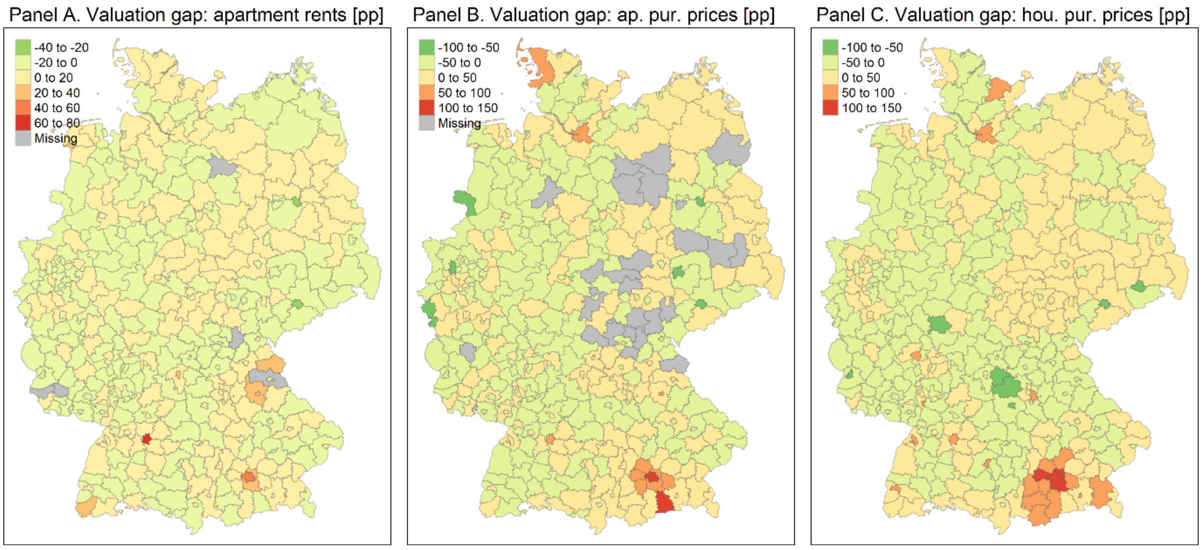

Figure A-6: Overvaluation gap of housing price growth from 2008 to 2019 across German districts. The overvaluation gap is calculated as the percentage point difference between actual growth rates and predicted growth rates according to the multivariate regression in equation (3) (see Section 5.2) over the entire observation period. Housing price data are drawn from the RWI-GEO-REDX (Klick et al., 2020); geodata from GeoBasis-DE/BKG (2018).

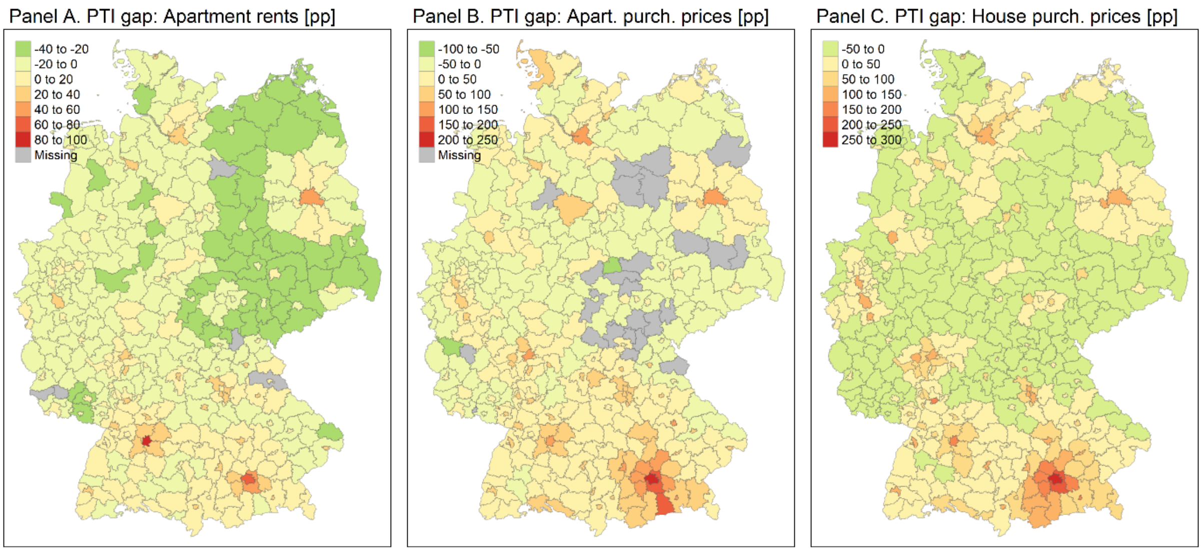

Figure A-7: Price-to-income (PTI) gap of housing price growth from 2008 to 2019 across German districts. The PTI gap is calculated as the percentage point difference between growth rates in housing prices and growth rates in household income per capita over the entire observation period. Housing price data are drawn from the RWI-GEO-REDX (Klick et al., 2020); geodata from GeoBasis-DE/BKG (2018).

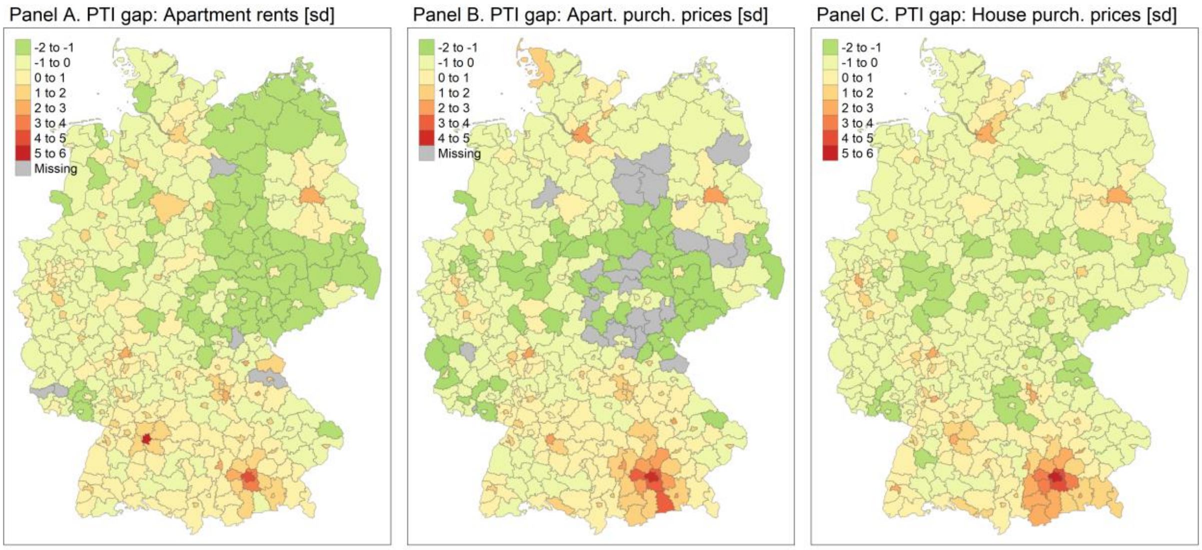

Figure A-8: Standardized price-to-income (PTI) gap of housing price growth from 2008 to 2019 across German districts. The PTI gap is calculated as the percentage point difference between growth rates in housing prices and growth rates in household income per capita over the entire observation period and is then standardized to mean zero and standard deviation one. Housing price data are drawn from the RWI-GEO-REDX (Klick et al., 2020); geodata from GeoBasis-DE/BKG (2018).

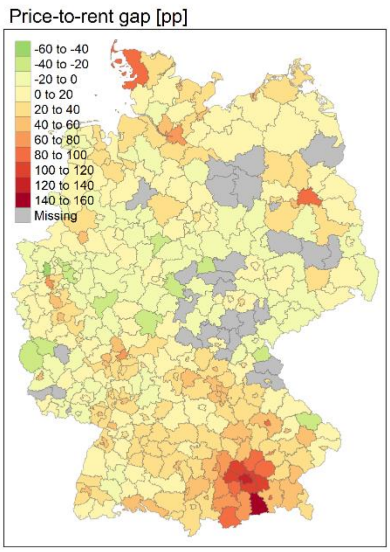

Figure A-9: Price-to rent gap across German districts. The price-to-rent gap is calculated as the percentage point difference between growth rates in apartment purchase prices and growth rates in apartment rents from 2008 to 2019. Housing price data are drawn from the RWI-GEO-REDX (Klick et al., 2020); geodata from GeoBasis-DE/BKG (2018).

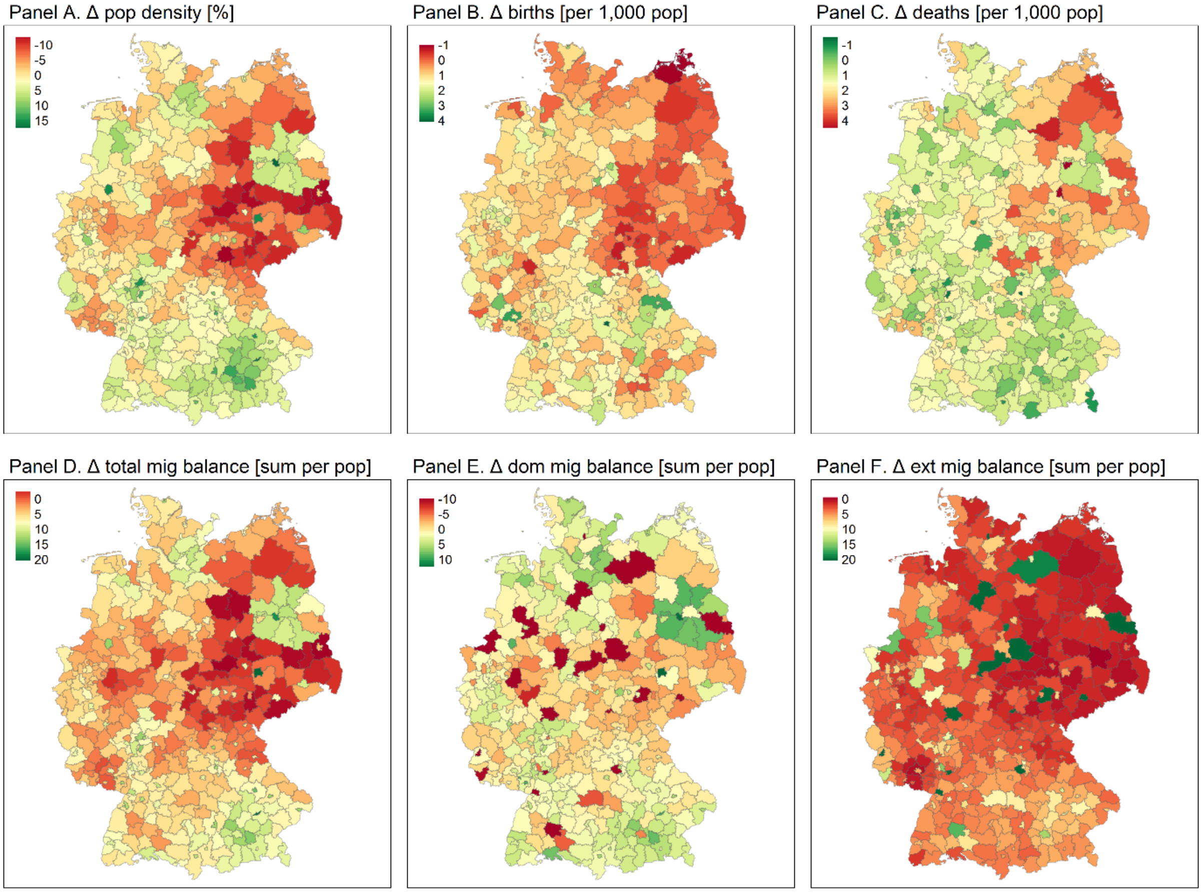

Figure A-10: Several indicators of population growth across German districts. All indicators are measured as the total change across the entire observation period from 2008 to 2019. Districts with missing price information depicted in gray. For presentation reasons maximum value for the sum of the external migration balance is set to 20 and the minimum value for the sum of the domestic migration balance to -10. Geodata are drawn from GeoBasis-DE/BKG (2018).

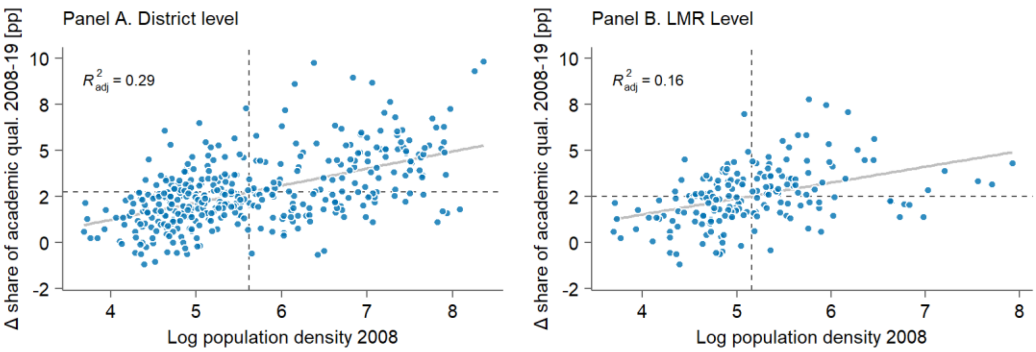

Figure A-11: Association between the log population density in 2008 (x-axis) and the total percentage point change in the share of academic qualifications from 2008 to 2019 (y-axis) at the district level (Panel A) and at the labor market region (LMR) level (Panel B). The gray solid line represents a trend line resulting from a linear fit; dashed lines represent the respective means.

Halle Institute for Economic Research –
Member of the Leibniz Association

Kleine Maerkerstrasse 8
D-06108 Halle (Saale), Germany

Postal Adress: P.O. Box 11 03 61
D-06017 Halle (Saale), Germany

Tel +49 345 7753 60
Fax +49 345 7753 820

www.iwh-halle.de

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