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Executive summary. This paper introduces new real estate price indices for 18 major German cities and their neighborhoods (*Stadtbezirke*) as well as a new composite indicator for the German housing market – the German Real Estate Index (GREIX). The series are constructed on the basis of long-run transaction level data from the *Gutachterausschüsse*. The novel data set marks a significant advancement in promoting transparency in the German real estate market and provides researchers with an unparalleled resource to study housing market dynamics in Germany. We highlight five core insights:

1. The new indices underscore the shortcomings of existing housing price indices that tend to be unsuited to capture price cycles at higher frequency. Only the transaction level data provide a reliable reading of housing market trends at high frequencies.

2. The neighborhood data, for the first time, allow to track substantial polarization of housing markets within and across cities over the past decades. The price gap between the most and least expensive neighborhoods in Germany has more than doubled over the past 30 years, while the price gap between the most and least expensive city in our sample has almost tripled over the same period.

3. Despite the current downturn, German home owners have witnessed considerably wealth gains during the decade-long housing boom. The best performing city since 2000 was Berlin with cumulative gains after inflation of 160%. In particular homeowners in Hamburg-Eppendorf, Munich-Maxvorstadt and Berlin-Kreuzberg registered real price increases of more than 180%. For a typical 100 square meter apartment in Berlin, the associated rise in real wealth amounts to approximately 300.000 Euros.

4. Since 2022, rising interest rates have triggered a pronounced correction in the German real estate market that is still under way. In inflation-adjusted terms, some cities have already seen price drops in the vicinity of 20%, for the country as a whole prices are down by close to 15% from peak in inflation-adjusted terms, and close to 8% in nominal terms.

5. We build a state-of-the-art dynamic factor prediction model to nowcast Q2 price developments on the basis of available data. The data point to further weakness ahead, but the pace of the decline appears to be moderating. Prices are likely to

decrease by additional 2% in nominal terms, bringing the decline from peak to 19% in inflation-adjusted terms for the country as a whole.

1 Introduction

This paper presents an ambitious project to construct a new long-run transaction-level data set covering the near universe of real estate transactions in Germany since the 1960s. The historical data come from the archives of Germany's *Gutachterausschüsse* which we combined with their more recent digital *Kaufpreissammlungen*. The result is a vast transaction-level data set that spans 18 major German cities, in some cases over more than half a century. The new data mark a major step towards more transparency in the German real estate market and provide researchers with an unprecedented resource to conduct a comprehensive analysis of the housing market in Germany.

Using the data, we introduce new indices for real estate prices in 18 major German cities and city-level neighborhoods as well as a composite indicator for the German housing market – the German Real Estate Index (GREIX). The composite GREIX, the underlying city-level and neigborhood-level indices are now available to researchers and the general public on the web at **www.greix.de**. All of these indices are hedonic price indices building on the latest models used in academic research, differentiating between market segments such as apartments, single-family, and multi-family properties. We also constructed indices at the neighborhood level, providing a more granular analysis of price changes and their socioeconomic repercussions within cities.

The new indices that rely on the high-quality GAA data accentuate the shortcomings of currently available housing price indices. Because of small sample sizes, other indices often fall short in their ability to reproduce price dynamics at a granular level, or inadequately capture changes and turning points at high frequencies, which is particularly important at this point in time.

The neighborhood data reveal a substantial polarization of housing markets within German cities over the past decades. The price gaps between the most and least expensive neighborhoods has more than doubled over the past 30 years. Among our 18 cities, nowadays the cheapest neighborhood is Chemnitz-Mitte-West, the most expensive is Munich-Schwabing.

German home owners in many cities have witnessed considerable wealth gains during the last cycle, the current correction not withstanding. The best performing city since the start of the century was Berlin with cumulative gains after inflation of close to 160%. Homeowners in Hamburg-Eppendorf, Munich-Maxvorstadt and Berlin-Kreuzberg registered price increases of more than 180%.

Housing prices rose strongly during the Covid-19 pandemic, but began to decline in 2022. We document that rising interest rates have already triggered a pronounced correction in the German real estate market that is still under way. In nominal and real terms, sales prices are dropping across all cities in our sample since the second half of 2022 and are still falling across all cities in our sample as of May 2023 according to our projections. In inflation-adjusted terms, some cities have seen price drops in the vicinity of 20%, for the country as a whole prices are around 8% from peak in nominal terms, and close to 15% in inflation-adjusted terms. In inflation-adjusted terms, certain cities have experienced price drops of approximately 20%. For the entire country, prices have decreased by about 8% from the peak in nominal terms, and nearly 15% in inflation-adjusted terms. It's not just prices that have been affected, but the number of transactions has also significantly declined. In cities like Hamburg and Berlin, the total number of transactions has decreased by over 50% between 2021 and 2022.

Finally, to obtain real-time readings of latest markets developments, we build a state-of-the-art dynamic factor model to nowcast price developments. The latest results suggest that further weakness likely lies ahead in the current quarter, but that the pace of the decline is subsiding. With the data at hand, prices are expected to decrease slightly by another 2% relative to previous quarter in nominal terms, which is approximately a decline of 4% in real term, increasing the decline from peak to 19% in inflation-adjusted terms.

2 Sources and data set construction

Since 1960, notaries in Germany have been required by the law stated in section 195 'Purchasing Price Data' of the Federal Bulding Code to report purchase details for every real estate transaction to the "Gutachterausschuss" (GAA), which is comprised of real estate experts organized on a regional basis. Initially, every municipality had their own GAA, but in recent years the numbers are declining as municipalities are merging their GAAs.[1] The GAAs store transaction price information along with house characteristics and compile annual statistics on transaction volumes and price trends, which are used to calculate benchmark land prices ("Bodenrichtwerte") and form the basis for the assessment of real estate values for bank loans and insurance contracts.

[1] In 2018, there were approximately 900 GAAs in existence. However, by 2021, this number had experienced a substantial decline, reducing to around 250. For more details on the regional distribution see Figure 26 in Appendix A.

The archives of the GAAs contain micro transaction data covering the universe of real estate transactions in (West-) Germany over the past 60 years. Most of the data is only available in digital format since the 1990s, with older transaction registries kept in analog format. In a major co-operation between the MacroFinance Lab at the University of Bonn, the ECONtribute Excellence Cluster and the GAAs, we digitized about one million analog records with the help of professional optical-character-recognition (OCR). The type of documents were varying not only across GAAs but also within a GAA depending on the time-span and market segment. Information on the documents were extracted by localisation of keywords. Eventually, the newly compiled data sets were merged with the existing digital data. The result is the first long-term micro-level data set on residential property transactions in Germany that can be used for research purposes.

In total, we digitized around one million transactions from ten different cities. In some cities, the archives no longer exist, were already digitized or, as is the case with former East German cities, there were simply no real estate market transactions before the 1990s. In those cases, we built on the already digitized data directly from the GAA. For these cities, the data typically starts in the 1990s.

An overview of the cities and time periods for which we have collected data can be found in Table 1, in which the cities are ordered by population size in 2020. Cities are grouped according to a common classification for German cities. A-cities include the largest seven cities in Germany which are of an international significance: Berlin, Hamburg, Munich, Cologne, Frankfurt, Stuttgart and Dusseldorf. The group of B-cities consists of cities which have an important national but particular large regional significance. The cities of groups C and D usually only have a strong regional relevance. Table 1 further illustrates the variations in data coverage within a city for the three distinct market segments: apartments, single-family houses, and multi-family houses. These discrepancies may stem from various factors, including the absence of recorded transactions for certain market segments, insufficient information to accurately identify the segment, or the unavailability of historical records.

The GAAs typically record the price, address, and date for each transaction, along with detailed information about the property, such as its size, age, and the type of transaction. This includes whether it was an arm's-length transaction or not, meaning whether there is reason to believe that the price reflects a market transaction price. For example, the sale took place between relatives or was a foreclosure. In most cases, additional information about the property, such as whether the property has a garage or not, is collected directly with questionnaires from the buyers and sellers. Owing to the diverse nature of documents in analog data found both within and between cities, as well as the evolving software systems employed to gather digital data, the collected attributes of transactions can exhibit heterogeneity along these two dimensions. The essential characteristics required to construct indices will be elaborated upon in the subsequent chapter. [2]

Table 1: *City and data coverage*

	Time coverage				
City	**Apartments**	**Single-Family**	**Multi-Family**	**Format**	**Category**
Berlin	1984 - 2023	1965 - 2023	1965 - 2023	digital	A
Hamburg	1964 - 2023	1964 - 2023	1964 - 2023	analog & digital	A
Munich	1971 - 2023	-	-	analog & digital	A
Cologne	1981 - 2023	1966 - 2023	1989 - 2023	analog & digital	A
Frankfurt	1983 - 2023	1982 - 2023	1982 - 2023	analog & digital	A
Stuttgart	1984 - 2023	1984 - 2023	1984 - 2023	analog & digital	A
Duesseldorf	1980 - 2023	1980 - 2023	1980 - 2023	analog & digital	A
Leipzig	2014 - 2022	2014 - 2022	2014 - 2022	digital	B
Dortmund	1971 - 2023	1975 - 2023	1975 - 2023	analog & digital	B
Dresden	1991 - 2023	1991 - 2023	1991 - 2023	digital	B
Duisburg	1972 - 2023	1978 - 2023	1978 - 2023	analog & digital	B
Bonn	1993 - 2023	1994 - 2023	1994 - 2023	digital	B
Muenster	1986 - 2022	1986 - 2022	1986 - 2022	digital	B
Wiesbaden	1992 - 2022	1975 - 2022	1975 - 2022	analog & digital	B
Chemnitz	1992 - 2023	1994 - 2023	1993 - 2023	digital	C-D
Luebeck	1993 - 2023	1993 - 2023	1993 - 2023	analog & digital	C-D
Erfurt	1991 - 2023	1991 - 2023	1991 - 2023	digital	C-D
Potsdam	1995 - 2022	1994 - 2022	1994 - 2022	digital	C-D

Note: This table shows the list of cities in our sample alongside their data coverage and the original format of the underlying transaction information, ordered by population size in 2020.

Summary statistics. Table 2 presents a comprehensive overview of the summary statistics for all cities in our sample, broken down by the three distinct market segments. One notable observation is that apartments constitute the market segment with the highest number of transactions in German cities, in opposite to US cities where single-family houses are predominant. As one might expect, larger cities tend

[2] For a more comprehensive understanding of the data acquisition process and the specific characteristics used for each city, please refer to the documentation available at greix.de.

to exhibit not only the highest number of transactions but also a general trend toward higher average prices within the apartment segment. In contrast, the pattern for single-family houses is less consistent. Smaller cities such as Lübeck and Münster have a considerable number of transactions, while some larger cities like Frankfurt and Düsseldorf report relatively fewer transactions. When examining average prices for single-family houses, it is evident that they are consistently higher in every city within our sample when compared to apartments. Multi-family houses exhibit a similar pattern as apartments, with a greater number of transactions occurring in larger cities. Additionally, the average prices for multi-family houses are unsurprisingly the highest among all three market segments across all cities. Despite single-family and multi-family houses accounting for a relatively smaller share of total transactions, due to their higher prices they contribute significantly to the overall transaction volume.

Table 2: *Summary statistics by city and market segment*

	Condos			Single-Family			Multi-Family		
City	Observations per year	Total observations	Mean price (1000€)	Observations per year	Total observations	Mean price (1000€)	Observations per year	Total observations	Mean price (1000€)
Berlin	7119	284760	159	1437	84811	270	751	44306	1301
Munich	3395	176545	218						
Hamburg	2413	149606	161	1617	103480	266	337	20904	1058
Cologne	3002	129081	149	943	31110	349	298	9818	856
Frankfurt	2375	97391	222	339	21340	297	217	13869	903
Stuttgart	2679	96441	196	150	5267	514	96	3347	936
Duesseldorf	1728	76053	176	343	20553	372	333	19954	663
Dresden	2025	66838	144	305	9758	241	286	9439	887
Leipzig	3985	39854	187	335	3346	331	337	3368	361
Bonn	1210	37523	150	623	18691	315	119	3567	696
Dortmund	695	36828	94	508	30496	203	154	9259	290
Chemnitz	920	29454	93	133	4128	164	153	4729	339
Muenster	807	29044	139	444	16425	301	63	2322	942
Wiesbaden	747	23153	173	261	8083	411	112	3479	1267
Duisburg	541	18922	88	528	24826	167	335	15387	259
Erfurt	562	17999	136	163	5210	201			
Potsdam	555	15526	204	159	4601	332	42	1047	1528
Luebeck	325	10062	154	423	13119	213	95	2857	502
GREIX	35084	1335080	158	8710	405244	291	3726	167652	799

Note: Table reports summary statistics for all sales after cleaning. The statistics are calculated over the full sample for each city. For precise information on the periods covered please check Table 1.

3 Constructing city-level indices

The ideal housing price index would capture the price appreciation of a representative, unchanged property that is sold every period. Unfortunately, houses are sold infrequently and are very heterogeneous. This means that the sample of transacted houses changes substantially from period to period. In order to approximate the ideal price index described above, we need to control for the heterogeneity and infrequent sales of properties. The current literature has identified two main methods to achieve this goal (Balk et al., 2014). The first is the so-called repeat-sales method. The idea underlying this method is to use the price evolution of the same property over time to build a price index. This method is naturally restricted to properties that are sold more than once and has thus proved to be very popular in liquid real estate markets, such as in the U.S., but it is mostly infeasible in very illiquid markets, such as in Germany. The second method employs so-called hedonic regressions to construct a housing price index. The key idea is to control the transaction price for a set of property and transaction characteristics and estimate a quality-adjusted price index over time.

Rolling window time-dummy hedonic regression. Due to the low turnover of properties in Germany and the high level of property detail available in the dataset, we decided to use hedonic regression methods to construct the city-level indices. These indices are referred to as GREIXX (German Real Estate Indices).[3] In particular, we employed time-dummy rolling window hedonic regressions based on a log-linear specification. In our baseline specification, we regress the log sales price of property i on a set of property characteristics (x_i) and a time dummy (D_τ) using a log-linear specification:

$$ln(P_t^i) = \beta^0 + \sum_{\tau=0}^{T} \gamma_\tau D_\tau^i + \sum_{k=1}^{K} (\beta^k * x^{k,i}) + \epsilon_t, \qquad (1)$$

where ϵ_t is the error term.

The time dummy parameter allows us to assess the influence of "time" on the price, while controlling for property characteristics. Our set of controls, denoted by x_i, exhibit variation across market segments, cities, and subperiods.[4] However, there exist certain attributes for every market segment that are indispensable for us constructing indices. Moreover, these variables are deemed the most crucial, and inclusion of additional characteristics thus does not impede the comparability between cities. In the case of

[3] For a subset of the cities, we have also constructed repeat-sales indices. However, it is worth noting that these indices tend to be upwardly biased when compared with the hedonic indices. This suggests that properties that are transacted more than once are not representative of the full sample of transacted properties and tend to appreciate more than the rest.

[4] For a detailed description of the variables used and the regression models employed for each city, please refer to the documentation available at GREIX.de.

apartments, these essential attributes comprise the living area, construction year, and neighborhood. For single-family houses, we consistently incorporate information on lot size, living area, construction year, and type (e.g. townhouse, detached house, etc.). For multi-family houses, we require the following characteristics: lot size, living area, neighborhood, and construction year.

Additionally, we always account for the non-linear effect of an extra square meter on the price by including the squared living area and squared lot size. The construction year is treated as a categorical variable, and the categories are delineated based on time-spans, due to its non-linear impact on the price. For instance, buildings constructed before World War I are accorded a premium, whereas those built shortly after World War II receive a discount, and newly constructed real estates once again receive a premium. Hence, by always using the construction year we are able to implicitly control for newly build real estate in all market segments. The time-dummy rolling window approach has a distinct advantage in that it enables the continuous updating of coefficients (β^k) over time. This means that the method can account for changes in the impact of property characteristics on the price, such as how an extra square meter of living area affected prices differently in the 1960s compared to the present day.

Data enrichment and missing data. It is important to note that the data obtained from the GAAs may not always encompass all the relevant characteristics required to explain the price of a property. This may be due to the fact that in analog or older digital data, some attributes were simply not collected, or in recent years, the GAAs are unable to gather certain variables. However, despite these limitations, we have the benefit of an exceptionally long period of micro-level transaction data, which allows us to observe multiple transactions of a specific property in many cases, even in a relatively subdued real estate market like Germany. Through the use of precise location information provided by the GAAs, such as the address or a property/apartment ID, we are able to substitute missing data with existing information, provided that the construction year remains constant between transactions.

Some transactions may still have missing variables, which requires us to consider how to handle this missing data. While one option is to simply delete transactions that have missing information in at least one of the essential attributes we require, we avoid this approach because it can introduce selection bias. The missing data is likely not random, so deleting those cases could lead to inaccurate results. Another option is to impute the missing variables, such as using the lot size to estimate the living area.

While we did consider this approach, we found that including missing-dummies in the hedonic regressions is superior, not only when comparing the methods applied on datasets with complete information, but also for the flexible application to categorical variables like year of construction or building type. Thus, proceeded with the missing-dummy method.[5]

It's worth noting that there is no available data for Munich in 1991 and 1992. To estimate the evolution of the price index for these years, we used interpolation. We calculated the average price increase per square meter for various types of apartments, depending on factors such as their size, age, and location. We then computed a weighted average of these increases across different groups to determine the city-wide average increase. We also repeated this process for each neighborhood.

Data cleaning. The data acquired from the GAAs is subject to a rigorous cleaning process before being utilized in our hedonic regressions. We exclusively use the adjusted purchase price of genuine transactions, discarding cases marked as offers, appraisals, or those that never occurred. Transactions that are not at arm's length (i.e. transactions where there is reason to believe that the price does not correspond to a market price) are also removed from the data set, either flagged by the GAAs or identified by us, including those between relatives, involving real estate subject to specific rights that affect the price, co-ownership or heritable building rights. Additionally, we exclude real estate that was sold but only constructed three or more years later. Multi-family houses with more than 20% commercial use are not considered, and the data is windsorized by removing outliers individually for each year. We discard data that falls above the 99th percentile or below the 1st percentile of purchase price, lot size, and living area. Furthermore, we eliminate duplicates via the property/apartment ID from the dataset, retaining only one observation for transactions with the same price and characteristics within a small time window (e.g. the second entry usually includes some kind of addendum). Finally, we remove all transactions of the same property within a small time window that differ in price.

Market segments and frequency. Using hedonic regression methods, we constructed housing price indices for three distinct market segments in each city: multi-family housing, single-family housing, and apartments. Yearly indices were developed for

[5]For a comprehensive explanation of this technique and its implementation in the regression models used for each city, please refer to the documentation available at GREIX.de.

each segment, while quarterly indices were predominantly created for apartments, given their prevalence in major German cities. This enables us to also generate annual apartment indices at the subcity level. To divide the city into different regions, we mostly adhered to the existing "Stadtbezirke" definitions, but we also utilized price-level and geographical proximity conditions to redefine the regions when necessary. Throughout this process, we received valuable feedback from local GAAs, allowing us to leverage their local expertise. As transaction numbers for the other two market segments in major German cities are comparatively lower, we cannot develop indices for these segments with the same city division. However, subcity indices for these market segments with a different city division may be available in the future.

3.1 Constructing the composite index for Germany (GREIX)

Not only have we created indices for individual cities, but we have also developed a composite index that reflects the broader price trends across all 18 cities included in our study. As these 18 cities represent nearly one-fifth of the population and almost one-fourth of the total real estate transaction volume in Germany, the GREIX captures a significant segment of the German housing market.[6] We have given this composite index the name "German Real Estate Index" or "GREIX" for short. To create this index, we combine the individual city indices (GREIXX) by weighting them according to the volume of transactions. For each city i and period t we build the corresponding weight, W_t^i, as the city-specific share of the total transaction volume in all 18 cities in euros in that period:

$$W_t^i = \frac{\sum_j P_{jt}^i}{\sum_{n=1}^{18} \sum_j P_{jt}^n} \quad \forall j \in i, n \tag{2}$$

where P_t^j is the sales price in euros of transaction j in period t. Following the best practises in the literature (Balk et al., 2014) and to ensure that fluctuations in the weights do not lead to erratic changes in the index, we apply a Fisher weighting method. This method involves taking a geometric average of two different price indices: the Laspeyres index, which uses weights from the base period, and the Paasche index, which uses weights from the current period. This helps to provide a more stable and accurate representation of the price trends in the German real estate market over a

[6]These calculations were made by the authors based on the numbers provided in official report on the German real estate market *Immobilienmarktbericht Deutschland* (Ache, 2022).

long time period.[7] The GREIX index at time t with base period b is then calculated as follows:

$$GREIX_{b,t} = \left(\frac{\sum_{i=1}^{18} GREIXX_t^i W_b^i}{\sum_{i=1}^{18} GREIXX_b^i W_b^i} * \frac{\sum_{i=1}^{18} GREIXX_t^i W_t^i}{\sum_{i=1}^{18} GREIXX_b^i W_t^i} \right)^{1/2} \quad (3)$$

where the base period b is not fixed in time, but changes every two periods. We thus use a chain method to build the index, which is more suitable for time time-series with trends (Balk et al., 2014). Similar to the city-level indices, we also construct a composite index for each of the three market segments individually. We utilize the GREIX to construct a composite series for the average price per square meter. Initially, we calibrate our series to a weighted average price per square meter across cities in the most recent period, with transaction volume serving as the weighting factor for each city. Subsequently, we employ the growth rates of the GREIX to extrapolate the series backward in time.

3.2 Adjusting for consumer price inflation

Due to significant variations in consumer prices over time, it is useful to compare house prices after adjusting for inflation, i.e., in real terms. Let $CPI_{b,t}$ be the consumer price index at period t in Germany with base 100 period b, and $GREIX_{b,t}$ be the composite index at the same period t and with base 100 period b. We then calculate the inflation-adjusted GREIX as follows:

$$\text{Real GREIX} : GREIX_{b,t} = \frac{GREIX_{b,t}}{CPI_{b,t}} \quad (4)$$

Please note that in this paper, we will use both nominal and real (inflation-adjusted) indices. In particular, for long-term comparisons, the real indices are more appropriate. All throughout the paper, we use the official consumer price index from the German statistical agency DESTATIS.

3.3 Comparison with existing real estate indices in Germany

A number of different real estate indices for Germany exists, each employing a unique blend of data types. In this subsection, we give a brief overview and compare our series to official real estate price index offered by the German Federal Statistical

[7] It should be noted that Destatis uses a Laspeyres weighting. Given that the Destatis index only covers a relatively short period of time, the choice of weighting scheme is not fundamental.

Office, as well as explore commercial providers categorized into three distinct groups based on their underlying data. For those seeking additional information, a carefully compiled (albeit incomplete) table of real estate index providers can be found in Appendix B. In general, our new indices have four main characteristics that distinguish them from the rest.

- First, we use actual sales prices for the universe of transactions in German cities, unlike other commercial providers who base their indices on subsets of transactions and, in some cases, do not even use actual sales prices. This is particularly important because, as mentioned earlier, the German real estate market is not very liquid, so commercial providers may have a very low number of observations for specific periods and cities.

- Second, we provide a fully transparent documentation that includes a detailed description of our methodology. Other providers, with the partial exception of Destatis, typically provide only intransparent descriptions of the methodology used. This is particularly relevant as housing price indices can be highly sensitive to changes in methodology.

- Third, our indices are the only ones that cover the entire historical period since the 1960s, cover multiple cycles and hence allow for more precise estimations. It should be noted that housing cycles typically last for at least ten years, meaning that most providers contain only one cycle in their series (Bracke, 2013).

- Fourth, our indices are the only ones that offer insight at the within-city level. We show in Section 4 that there is a large degree of variation in the evolution of prices within cities in Germany.

Destatis. As elaborated in Chapter 2, the GAAs maintain a comprehensive record of real estate transactions throughout Germany, providing the most extensive dataset available on the country's housing market. This vast dataset has been utilized by the German Federal Statistical Office, Destatis, to construct hedonic house price indices. However, despite having access to the same data, Destatis' analysis exhibits several shortcomings in comparison to our own. To begin with, their study lacks historical depth as it only includes data from 2000 onwards, and ignores additional data that halp build better indices. Moreover, an index for apartments was only introduced in

2010, and it took until the final quarter of 2015 for five separate indices—categorized by municipality population sizes—to be established. Destatis' methodology of pooling cities in Germany together (i.e., the seven largest cities) to create a single index for this group conceals considerable heterogeneity between these cities. Furthermore, by not offering indices at the sub-city level heterogeneity diverse developments found within individual cities are not available.

As of now, Destatis is not yet fully transparent about its hedonic regression methods, including the specific parameters employed. It appears that Destatis does not actively engage with the local GAAs and uses their expertise to build better indices. Another major drawback is that Destatis releases new data with a delay of three months, making it difficult to use for higher frequency financial analysis.

Commercial providers. Destatis is the sole provider of house price indices that rely on data from the GAAs, yet there exists a number of other providers using different data set.

- Asking prices from advertisements: Some providers rely on (online) advertisement data. Such data are informative, but do not encompass the universe of transactions as not every property is advertised before being sold, and many apartments are not sold at the asking price. In the academic literature, there is disagreement about the use of asking prices to study real estate market cycles (Ahlfeldt, Heblich, and Seidel, 2023; Han and Strange, 2016; Lyons, 2019). Some research indicates that the accuracy of asking prices depends on factors such as socio-demographics and market cycles (Miller and Sklarz, 1986; Knight, Sirmans, and Turnbull, 1994; Genesove and Mayer, 2001; Hayunga and Pace, 2017). Notably, these studies suggest that asking prices are least reliable during market peaks and troughs. As a result, the accuracy of indices based on online advertisement data in capturing real estate market trends during downturns remains uncertain. Moreover, providers relying exclusively on online advertisement data may face limitations in historical perspective, as their indices typically date back to the mid-2000s at the earliest. Typically, commercial providers often lack transparency regarding their methodology and the specific attributes employed.

- A second category of providers typically draws upon a blend of appraisal data, transaction data from selected real estate agents, and supplementary expert opinions.[8] In recent times, some have also incorporated online advertisement data. Although this diverse data mix enables the construction of series with earlier origins, dating back to the mid-1970s or late 1980s, these data sets fail to capture the entire spectrum of transactions. Consequently, they may present a skewed representation of the overall market, contingent upon the specific real estate agents and surveyors included in the sample. Reports are typically published with a time lag of three to six weeks, and comprehensive information (e.g., for all cities) is not made publicly accessible to avoid undermining their commercial goals.

- The final type of indices comes from providers who use transactions that involve banks. Although these indices are based on actual transactions, they may present a biased portrayal of the market since only transactions with bank financing are reported. In addition to only covering a part of the market, the providers also have access to a subset of the banking market. The market share on the mortgage market ranges between 20% to 40%. Similar to other categories, these providers lack the historical perspective, as their indices generally originate in the mid-2000s. While some providers calculate indices for individual cities, they do not extend to the neighborhood level. One prominent example is the index provided by the "Verband deutscher Pfandbriefbanken" (vdp). The vdp collects mortgage data from approximately 700 banks, produces separate indices for apartments and single-family homes in the Top-7 cities on a quarterly basis. They report that their data covers a maximum of 35% of the residential mortgage market in Germany.

With regard to mortgage based price indices, it is crucial to contextualize the market shares of the providers using mortgage data, particularly as transaction numbers have experienced a significant decline. When examining the number of transactions in the Top-7 cities during the last quarter of 2022, a noticeable decrease is evident. For instance, in Düsseldorf and Frankfurt, apartment transactions have recently dipped to around 370. As the vdp data cover only 35% of the mortgage market, the number of transactions quickly becomes extremely small. In a heterogeneous market like housing, this makes it challenging to draw accurate conclusions about price developments. The situation becomes even more concerning for single-family home transactions. For

[8] Bulwiengesa, Immobilienverband Deutschland IVD, and Sprengnetter are the main providers relying on this kind of data.

instance, in Düsseldorf and Frankfurt, the universe of transactions in this market segment was less than 70. This means that data providers like the vdp that only have access to a fraction of these transactions quickly face severe limitations, in particular at turning points where the number of transactions drops very fast.

Figure 1 illustrates this point. It presents a comparison of the annual growth rates for apartments between our city-level GREIXX and the vdp-created equivalent from 2004 to 2022. As can be seen, average growth rates tend to be similar, but on a quarterly level the correlations can be low.

Table 3 more formally displays the differences in standard deviations between our city-level GREIXX and the vdp-created equivalent for year-on-year quarterly growth rates. The vdp indices demonstrate lower volatility across all cities, as evidenced by smaller standard deviations. The differences between the growth rates of GREIXX and vdp are statistically significant for 6 of the 7 cities examined. This results is not specific for year-on-year growth rates of apartments but also holds for quarter-on-quarter growth rates and for single-family houses as displayed in the tables 7, 8 & 9 in the appendix.

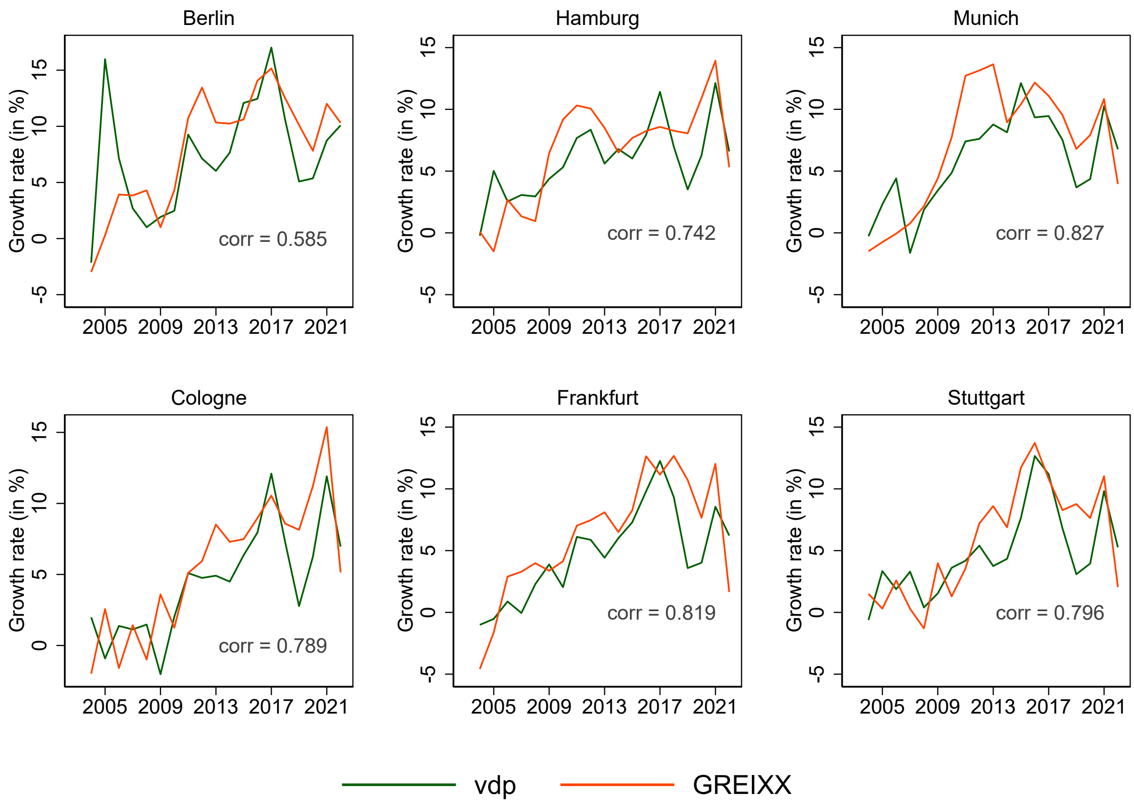
Table 3: *Standard deviations of GREIXX and vdp by city*

	Standard Deviation			
City	**GREIXX**	**vdp**	**Difference**	**p-value**
Berlin	6.26	5.43	0.84	0.350
Hamburg	5.12	3.54	1.57	0.002
Munich	5.60	4.32	1.27	0.016
Cologne	5.26	4.20	1.07	0.038
Frankfurt	6.01	4.23	1.77	0.005
Stuttgart	5.32	3.94	1.38	0.010
Duesseldorf	5.67	3.12	2.55	0.000

Note: The table reports the standard deviations, differences of these standard deviations, and p-values obtained from an F-test, aimed at determining if GREIXX's standard deviations of the year-on-year quarterly growth rates are statistically significantly larger than those of vdp for the TOP7-cities.

This result is puzzling as both the GREIXX and vdp utilize the same hedonic methods and characteristics of an apartment as controls, with the former encompassing the entire universe of transactions and the latter using only a subset. Theoretically, this should make the vdp indices more volatile. The observed inconsistency suggests that the vdp may be applying some form of smoothing to their data, implying that it may not accurately capture market turns.[9]

Figure 1: *Comparison growth rates of GREIXX and vdp*



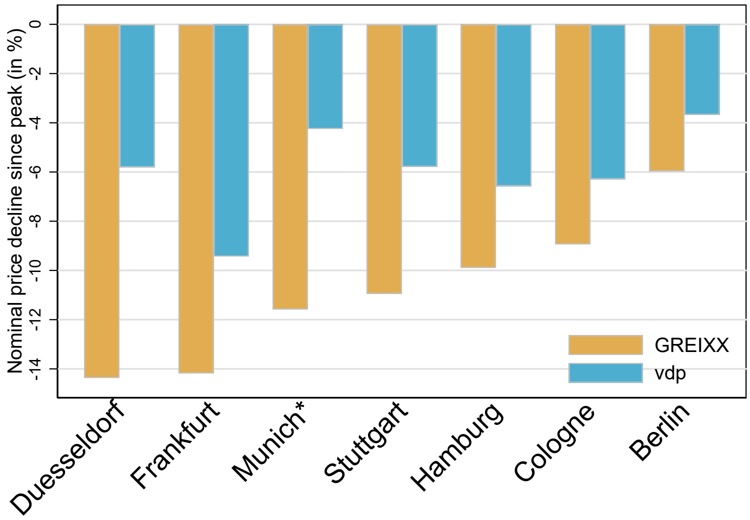
Note: The figure shows the yearly growth rates of the city-level indices GREIXX and vdp for apartments between 2004 and 2022.

Furthermore, our investigation delves into the differences at the current turning point by comparing the quarterly growth rates of GREIXX and vdp-indices for apartments in 2022. Figure 2 illustrates the cumulative decline in nominal prices from the peak of the price boom in 2022 to the first quarter of 2023 for the largest cities in Germany. We present both the drop in our indices (GREIXX) and the indices from vdp. As depicted in the Figure, it becomes evident that vdp underestimates the drop

[9]Additionally, we conduct a systematic comparison of the year-on-year growth rates for quarterly city-level apartment indices between the GREIXX and its vdp-created counterpart. A notable observation is the statistically significant difference between the two indices. This finding remains consistent across various regression specifications. The positive coefficients indicate that, on average, the indices based on mortgage data tend to underestimate the growth in comparison to the GREIXX. The results can be found in table 10 in appendix 8.

for all cities when compared to our index. Additionally, we also analyse the price growth rates in the final quarter of 2022, as this period marked the first instance of negative year-over-year growth rates for a majority of the cities in our sample. The Top-7 cities' vdp-indices do not show a broad decrease in prices compared to the previous year. Even in cases where the vdp-indices indicate falling prices, the decline is less pronounced than that predicted by GREIXX. On average, GREIXX displays a 6 percentage point lower year-over-year growth rate than the vdp-indices in the fourth quarter of 2022. This outcome corroborates that the vdp-indices fall short in capturing the turning point and, more specifically, its intensity. This development is not specific to the quarter nor to the segment of apartments. The findings of this study are not limited to to this particular quarter or the segment of apartments. In fact, similar results can be observed in the single-family house market as well. According to GREIXX, the fourth quarter of 2022 saw an average growth rate 4.26 percentage points lower than the vdp-indices. This trend continues into the first quarter of 2023, where GREIXX reports a 5.05 percentage point lower growth rate for apartments and a substantial 6.88 percentage points lower growth rate for single-family houses. Additionally, by examining the quarter-to-quarter growth rates of the last two quarters in 2022 and the first quarter of 2023, which represent the turning point in quarter-to-quarter trends, it becomes clear that GREIXX observes a more significant decline than the vdp-indices. On average, GREIXX records a 1.85 percentage point lower growth rate than the vdp-indices for apartments and a 2.2 percentage point lower growth rate for single-family homes. These results can be found in Table 11 in the Appendix.

Figure 2: *Price correction from peak in %, GREIXX & vdp*



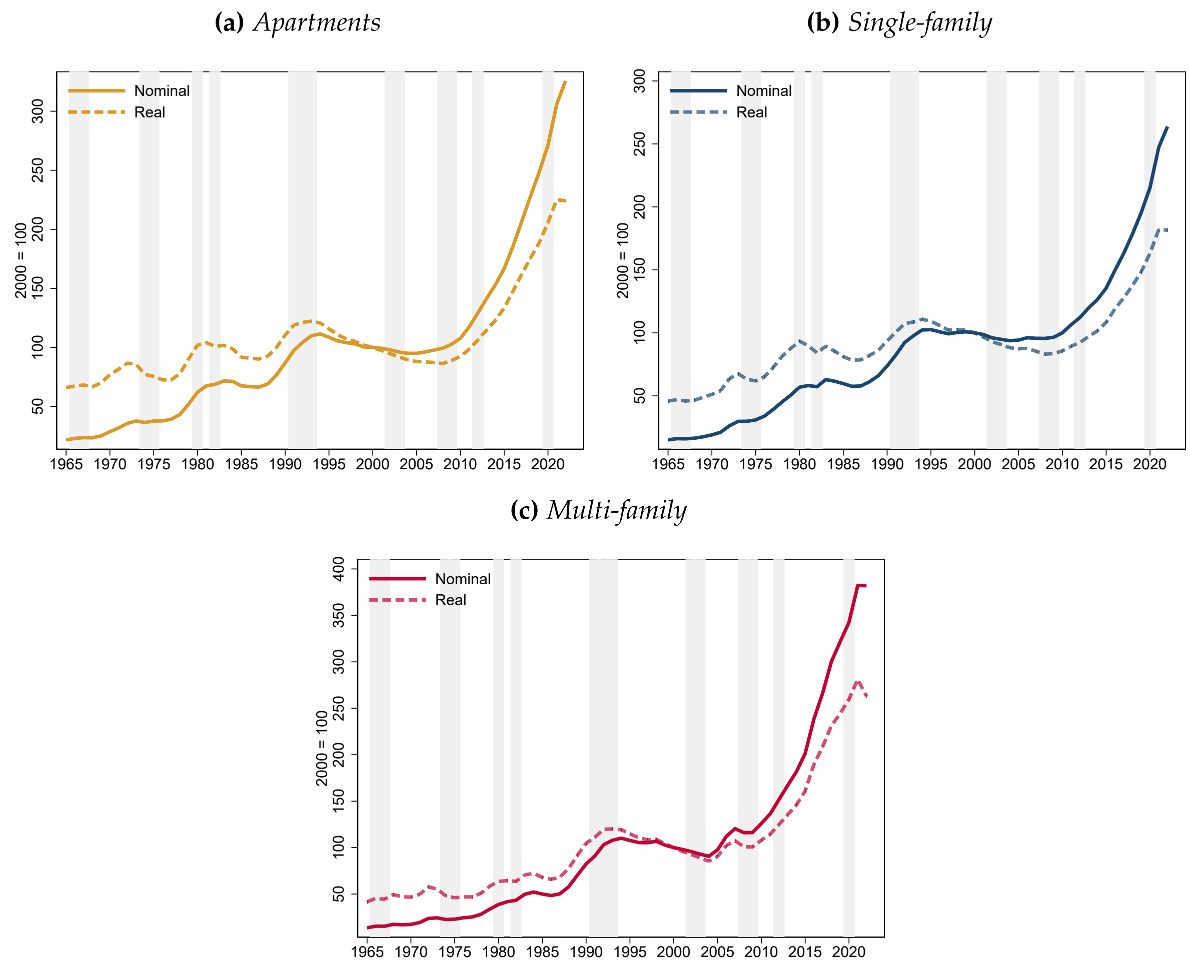
Note: This Figure displays the cumulative drop in nominal prices from peak to 2023q1 for the GREIXX and the vdp indices. For Munich the comparison date is 2022Q4 and not 2023Q1, as we are missing that data point.

4 The evolution of housing prices in German cities

In this section, we will explore the evolution of housing prices in Germany over the past sixty years. To begin with, we will investigate the long-term trends in the German housing market between 1960 and today, with a focus on the differences across cities and market segments. Across most cities and market segments, there was a period of moderated price growth until the 1990s, followed by a phase of stagnation, and eventually, an unprecedented period of high housing price growth in the 2010s.

4.1 The long-run evolution of housing prices since the 1960s

Figure 3: *GREIX composite index for different market segments, 1965-2022*



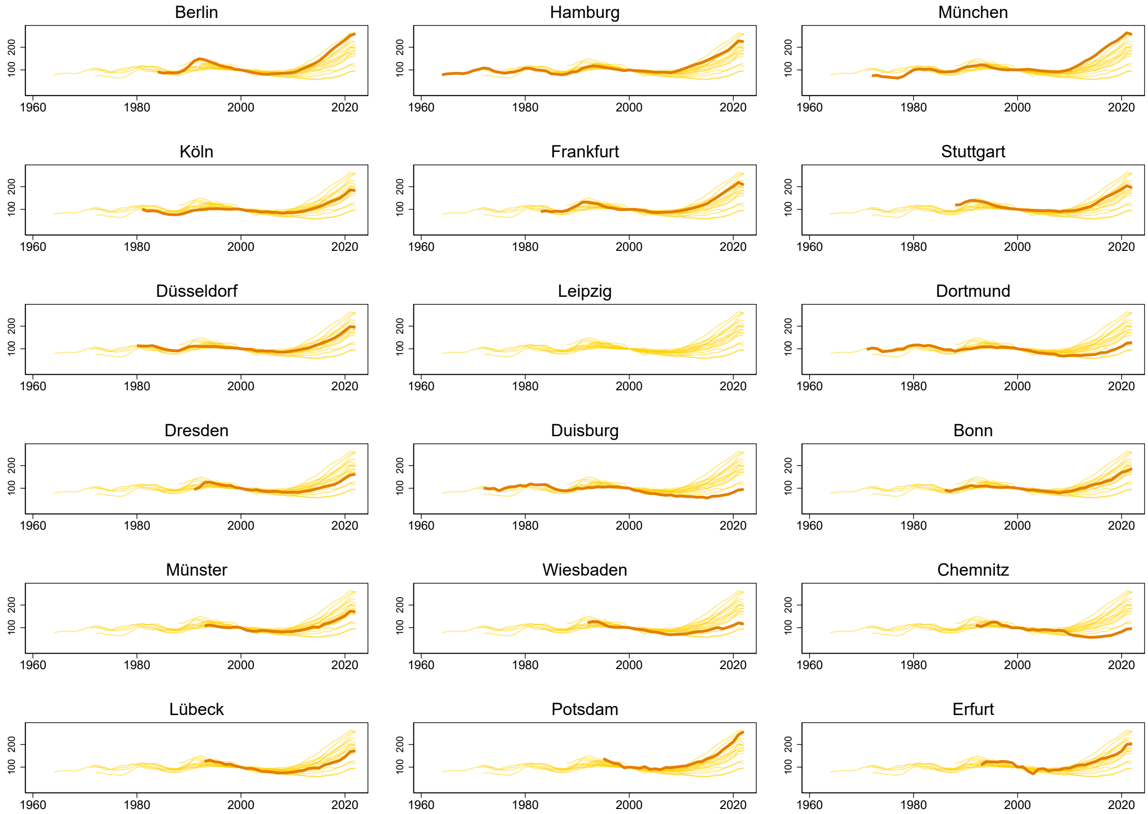
Note: The figure shows nominal and CPI-adjusted yearly housing price indices for different cities. Shaded areas represent recessions in Germany according to the Bundesbank.

The composite index for Germany – GREIX. Figure 3 depicts the nominal and inflation-adjusted yearly housing price indices from 1965 to 2022 for three market segments: single-family houses, multi-family houses, and apartments. The base year for the index is 2000. A strong positive trend in prices is observed across all market segments, with inflation-adjusted apartments being three times more expensive on average than they were in the 1960s. The real price of single-family houses has increased by a factor of four, and that of multi-family housing by a factor of six over the same period.

A consistent pattern for the evolution of housing prices is clear across all market segments. Initially, there was a long period of moderate housing price growth from 1960 to 1990. Prices stagnated after (with a short-lived boom in East Germany) and downward adjusted in real terms until after the Global Financial Crisis. During this period and depending on the market segment, real prices decreased by 5% to 18% from their 1990 level. The past decade witnessed unprecedented price growth across all market segments. At present, nominal prices are 3-4 times higher than in 2008.

Individual city indices. Figure 4 displays the CPI-adjusted apartment housing price indices for all the cities in our sample, providing a more comprehensive exploration of the heterogeneity discussed earlier. Figure 4 confirms that the the cycles exhibit a degree of synchronization, with variations in starting and ending points as well as the intensity of peaks and troughs. Notably, the most recent boom appears to be exceptional in its duration for every city within the sample. In Figures 27 and 28 in the Appendix, we present comparable graphs for the real price indices of single-family and multi-family houses. In general, the trends mentioned previously also hold true for these other market segments.

Figure 4: ***Real apartment price indices by city, 1960-2022***



Note: The figure shows cpi-adjusted apartment hedonic price indices for all cities in our sample. The darker line always represents the price series for the respective city.

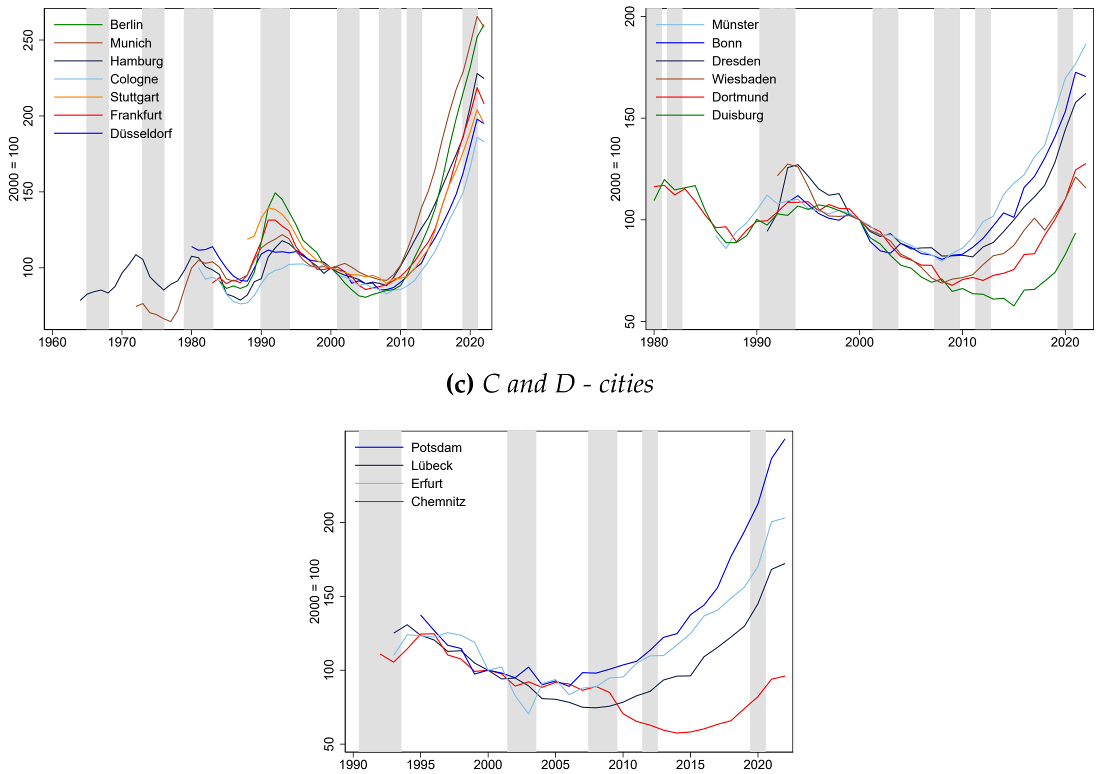
Figure 5 shows the evolution of hedonic apartments prices since 1960 until today for all cities in our sample but grouped according to the common city classification described earlier. Panel (a) illustrates the price development of the Top-7 cities, and it is evident that all cities exhibit a similar pattern in the recent decades. The reunification of Germany marked a turning point as it led to a halt in the booming real estate market, and a period of almost 15 years of price declines followed. While the peak in the early 1990s showed some variation among cities, the trough was highly synchronized. The aftermath of the global financial crisis in 2007-2008 marked the beginning of the next boom phase, and although the trend looks similar for all cities, the starting point was not fully synchronized, and the peak in 2021/2022 exhibits substantial variation.

Panel (b) highlights that cities from group B also exhibit similar cycles to the Top-7 cities, but with some differences in the details. On average, the peak in the early 1990s was less pronounced compared to group A, and the downturn was longer and less synchronized among the cities in group B. The recent boom phase began earliest in 2010, while for some cities, it did not start until the mid-2010s. Additionally, this boom did not reach the same heights as the Top-7 cities. Overall, the cities in group B show less homogeneous price evolution compared to the top-7 cities.

Panel (c) illustrates the cities from groups C and D, and while the cycles are also evident here, the evolution is even more heterogeneous among these cities. This is evident in the recent boom, which started in some cities, such as Potsdam or Lübeck, around the same time as in the Top-7 cities. However, in other cities, such as Chemnitz, the boom only started around 2015. Moreover, while Lübeck is experiencing a price increase comparable to cities in groups A and B, the price evolution of Chemnitz is very detached from these groups.

Figure 5: *Real house price indices for apartments for different city classifications, 1960-2022*

(a) *A - cities (Top 7)* **(b)** *B - cities* **(c)** *C and D - cities*



Note: The figure shows real yearly housing price indices for apartments for different city classifications. Shaded areas represent recessions in Germany according to the Bundesbank.

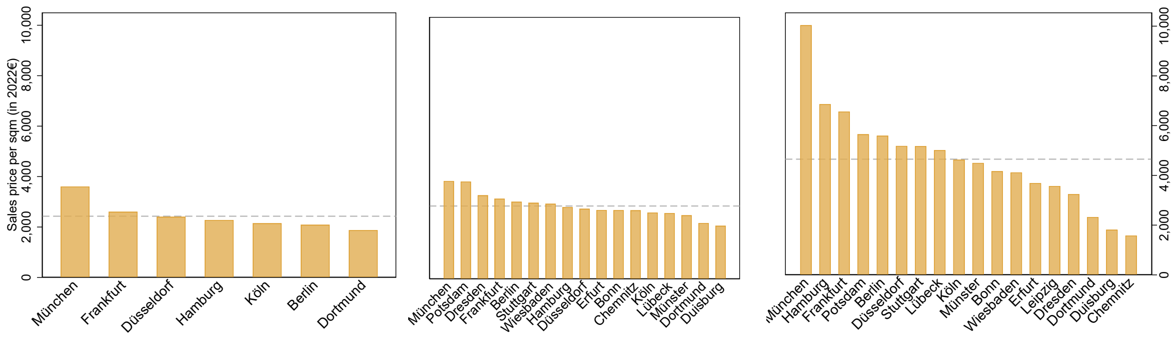
4.2 City-level square meter prices in the long run

Up until now, we have examined the historical trends of housing price indices in various cities and market segments. However, these indices do not provide us with information on the actual price levels of each city, nor do they allow for relative price comparisons across or within cities. Therefore, in this section, our focus turns to the analysis of the price per square meter of living space, which enables a more precise comparison of housing price levels. Figures 6, 7, and 8 present these levels for the three market segments. The cities are consistently arranged in a descending sequence based on their average price. It is essential to note that the figures depict average 2022 constant prices, which allows for comparisons across different periods.

Figure 6 presents the price levels for three distinct years for apartments: 1986, 1996, and 2022. In each of these years, cities within the Top-7 group consistently rank among those with the highest price per square meter. Generally, the prices for cities in groups B to D tend to be lower, though there are a few exceptions. Over the years, the disparity in price levels appears to have grown. This trend is particularly pronounced among cities in groups B to D. For instance, the average price in Lübeck in 2022 is approximately triple that of Chemnitz. It becomes clear that the significant price increase, even when accounting for real terms, originates from the period between 1996 and 2022 rather than from 1986 to 1996. For cities in the TOP-7 group, prices more than doubled from 1986 to 2022. Conversely, the price trajectories for cities in groups B to D exhibit greater heterogeneity. Some cities, such as Lübeck and Bonn, witnessed substantial price increases, while others, like Dortmund and Duisburg, experienced a decline in real prices.

Figure 6: *Average price per sqm for apartments by city (in 2022€)*

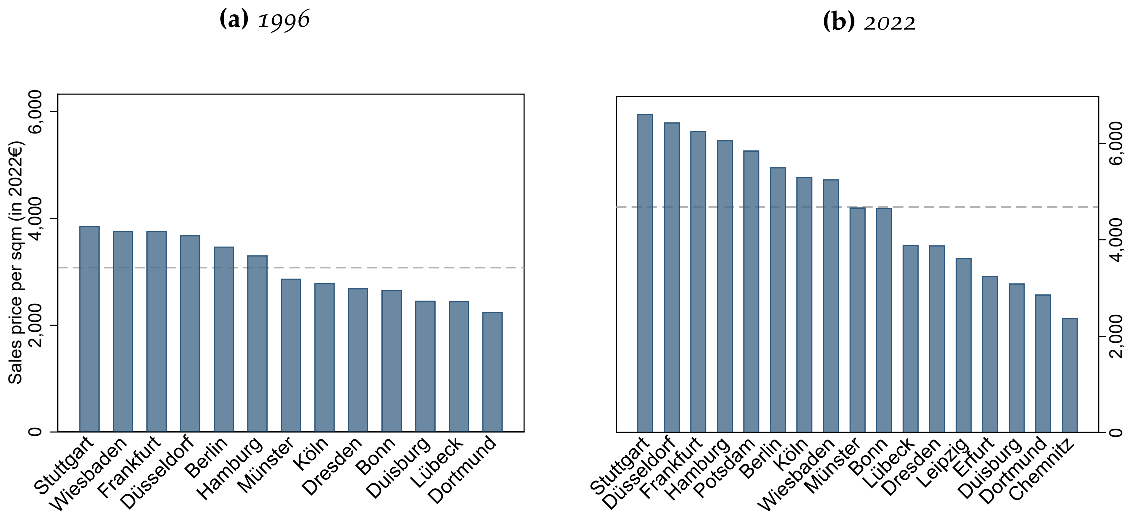
(a) *1986* **(b)** *1996* **(c)** *2022*



Note: This graph shows the mean transaction price per square meter for apartments by city for 1986 (Panel (a)), 1996 (Panel (b)) and 2022 (Panel (c)). The dashed line displays the sample mean value. The prices are in constant Euros (2022).

Figure 7 displays the price levels for single-family houses in two separate years: 1996 and 2022. The trends observed in the apartment market appear to carry over to the single-family house market as well. In 1996, cities within the A-group already had the highest prices in Germany, and by 2022, these cities continue to lead. Notably, the dispersion of prices has widened over time. For instance, Dusseldorf's prices were roughly 50-60% higher than Dortmund's in 1996, whereas in 2022, Düsseldorf's prices are more than double those of Dortmund. This growing disparity is also evident among cities outside the Top-7 group. While Bonn and Duisburg had strikingly similar prices in 1996, by 2022, Bonn's prices have risen to about 40% higher than those of Duisburg.

Figure 7: *Average real price per sqm for Single-Family by city (in 2022€)*

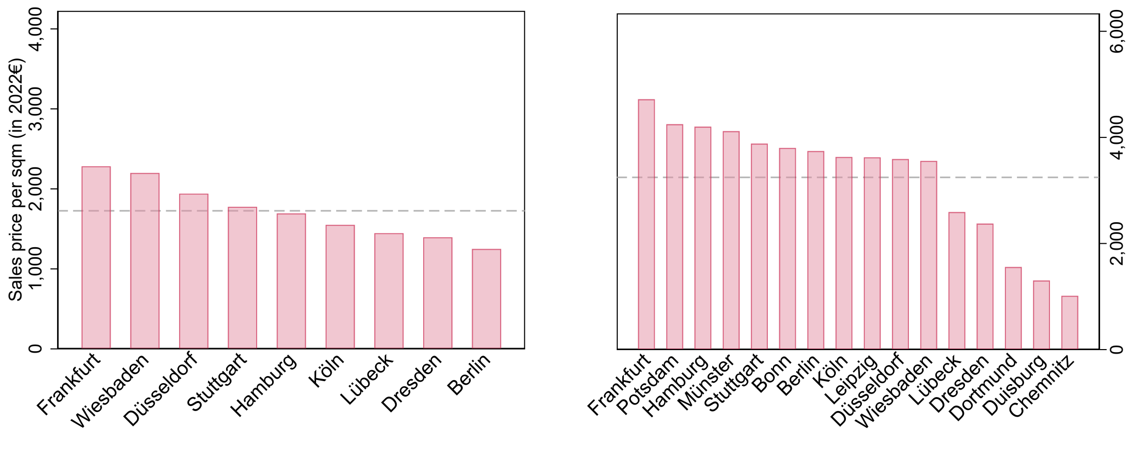


Note: This graph shows the mean transaction price per square meter for single-family housing by city for 1996 (Panel (a)) and 2022 (Panel (b)). The dashed line displays the sample mean value. Prices are in constant Euros (2022).

Figure 8 provides the price levels for multi-family houses during two separate years - 1996 and 2022. It is evident that the market trends observed in other segments also apply to the multi-family housing market. However, the B-group cities' prices appear to be either comparable or even higher than some of the Top-7 cities in both years. Despite this, there is a noticeable heterogeneity between cities observed in both years in groups A and B, and it has significantly increased over time. For instance, in 1996, prices in Frankfurt and Hamburg were approximately 20-30% higher than Lübeck and Dresden. But in 2022, prices in Frankfurt and Hamburg have surged to be about 60-70% higher than Lübeck and Dresden. Figure 8 also shows a remarkable increase in the prices of multi-family houses in Berlin, where prices have almost tripled between 1996 and 2022.

Figure 8: *Average real price per sqm for Multi-Family by city (in 2022€)*

(a) *1996* **(b)** *2022*



Note: This graph shows the mean transaction price per square meter for multi-family housing by city for 1996 (Panel (a)) and 2022 (Panel (b)). The dashed line displays the sample mean value. The prices are in constant Euros (2022).

4.3 Increasing divergence in housing prices across cities

In the previous section, we observed a growing divergence in housing price levels across our sample cities. Specifically, we noted that the disparity between expensive cities like Munich or Hamburg and less expensive cities such as Dortmund or Chemnitz has widened over time, particularly in the past two decades. This trend of rising dispersion in housing prices echoes what has been observed in many other countries worldwide, including the U.S. and U.K. (Gyourko, Mayer, and Sinai, 2013). This phenomenon has been linked to negative economic impacts, such as restricting internal migration as prices become unaffordable in so-called 'superstar' cities, inducing a spatial mis-allocation of human capital that leads to severe economic losses (Hsieh and Moretti, 2019).

To gauge the magnitude of this dispersion in our sample, we analyzed the relative prices between the most and least expensive cities from 1995 to 2022. We start in 1995 to have a balanced panel of cities. We then calculated the ratio of the average apartment square meter price in the most expensive to the cheapest city. The results are presented in panel a of Figure 11.

The ratio was around 2 in 1995, meaning that, on average, prices in Munich, the most expensive city in our sample, were double those in Duisburg, the cheapest city in 1995. By 2022, this ratio had increased to almost 6, indicating that prices per square meter in Munich were almost six times higher than those in Chemnitz, the cheapest city in our sample by 2022. This represents an almost three-fold increase in dispersion across cities, a number which is well in the upper-bound of what has been shown for other countries for approximately the same period (Amaral et al., 2023).

As can be seen in Figure 11, the gap began to widen significantly during the global financial crisis in 2007, but plateaued in 2015 and has since decreased slightly. This trend can be attributed to variations in the timing of the latest boom across cities. For instance, while the boom started in Munich as early as 2009, it did not begin until around 2015 in more periferal cities like Chemnitz or Duisburg. However, once the boom began in peripheral cities, it was quite intense, which accounts for the slower rate of divergence after 2015. This phenomenon is consistent with the notion that high-income buyers were compelled to move to peripheral cities due to the exorbitant prices in major cities. These insights regarding the duration and intensity of the housing price boom by city and market segment can be found in Figure 30 in the appendix.

5 Price developments within cities

We will now look into the evolution of prices within cities through the lense of our new neighborhood-level indices. Thanks to the granularity of the GAA data, we can, for the first time, create housing price indices at the level of neighborhoods. This allows us to analyze the variation in housing price evolution within cities, which is hidden in city-level price indices.[10] Just as we found growing gaps in housing prices across cities, we also find evidence of a growing dispersion in the value of housing prices within cities over the last thirty years. Since reunification, more expensive neighborhoods have, on average, experienced stronger price appreciation, thereby widening the gap with cheaper neighborhoods. However, there are some notable exceptions, such as Kreuzberg-Neukölln in Berlin. Furthermore, there are indications that in the later stage of the booming years in 2010, neighborhoods with lower average prices witnessed particularly strong price growth.

The neighborhood-level indices start in the 1980s for most cities, and we focus

[10]This section will build on yearly frequency indices that extend up to end-2022. In the following section, we will shift our focus towards the present state of the housing market and study the quarterly series.

exclusively on indices for apartments, as this market segment has the largest number of transactions. To define the neighborhoods, we rely on the expert knowledge of local GAAs and used existing geographical boundaries of smaller city divisions (e.g., *Ortsteile* or *Gemarkungen*) to build larger city divisions that had enough observations for us to build a housing price hedonic index. For more information about the exact definition of neighborhoods, please refer to our data appendix.

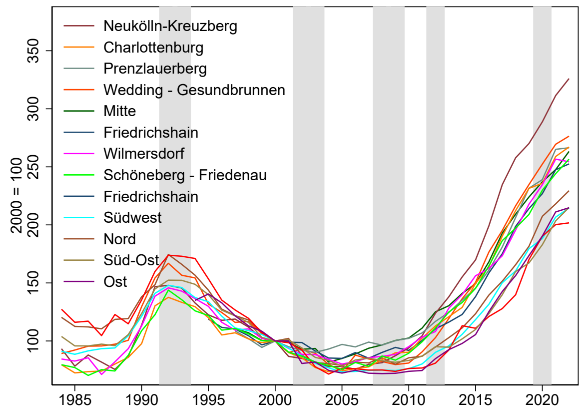
In Figure 9, we present the inflation-adjusted apartment price indices by neighborhood in the largest six German cities. The graph reveals two noteworthy patterns.

Firstly, by examining the indices, which are all set at 100 as a reference point, we can observe significant disparities in the price boom over the past two decades across cities. For instance, several neighborhoods in cities like Berlin, Hamburg, and Munich have witnessed cumulative growth rates exceeding 160% after accounting for inflation in most neighborhoods between 2000 and today. During this period, in the worst-performing neighborhood in Munich, Aubing-Pasing, prices went up by 122%, conversely, Cologne's best-performing neighborhood, Innenstadt, experienced a growth of 120%.

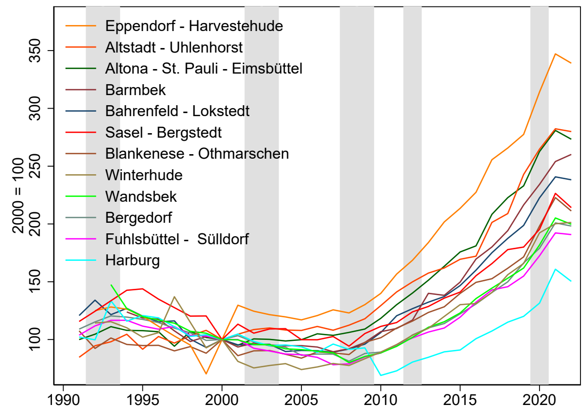
Secondly, a common trend emerges across all cities. Over the last forty years, housing prices in neighborhoods have exhibited a robust synchronization, with a noticeable upward trajectory in recent decades. However, these positive trends significantly vary among neighborhoods within each city. This discrepancy becomes evident during the notable price boom of the 2010s. Although all neighborhoods experienced price increases, the magnitude varied substantially. Neighborhoods such as Kreuzberg in Berlin, Eppendorf in Hamburg, and Maxvorstadt in Munich encountered considerably stronger price growth compared to the rest of their respective cities. To analyze this issue in more detail, we need to examine the evolution of price levels in neighborhoods over time. In Figure 10, we plot the average nominal price per square meter for apartments in the different neighborhoods of the six largest German cities over time. Square meter prices exhibit a similar pattern to the price indices over time. While there is a clear positive trend, the image also reveals that the relative prices of neighborhoods diverge over time. While Schwabing-Munich was, on average, 10% more expensive than Untersendling-Munich back in 1995, nowadays this gap has increased to 30%, which means that the gap has grown by a factor of 3 in the space 25 years.

Figure 9: *Yearly inflation-adjusted apartments price index for different neighborhoods, 1975-2022*

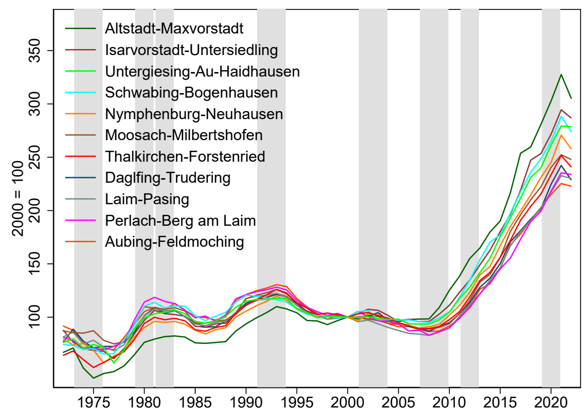
(a) *Berlin*



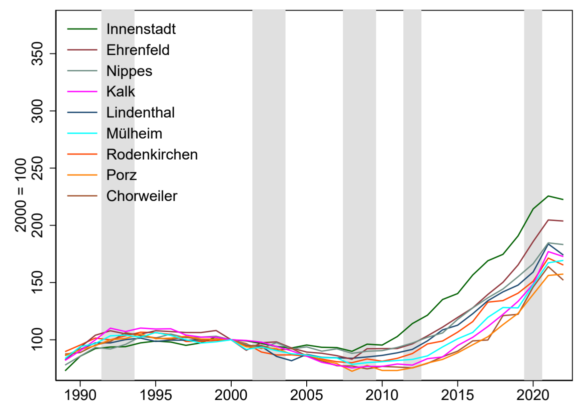
(b) *Hamburg*



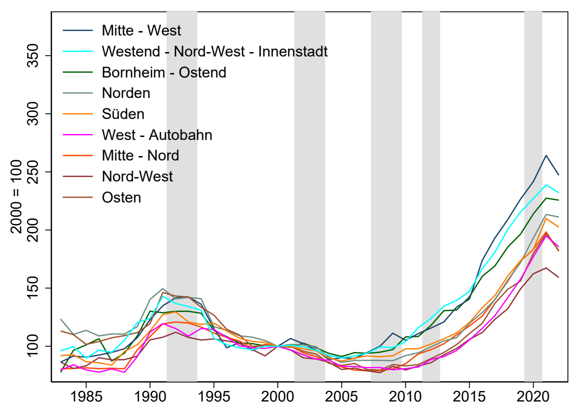
(c) *Munich*



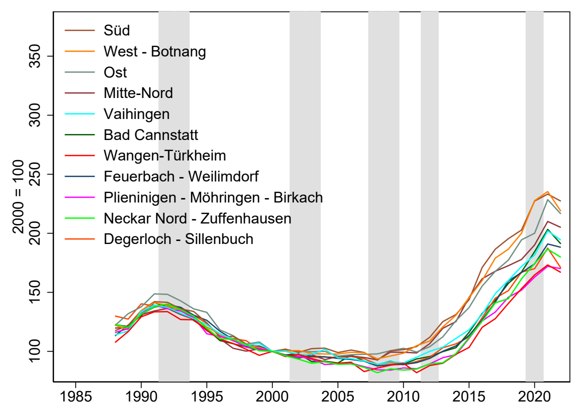
(d) *Cologne*



(e) *Frankfurt*



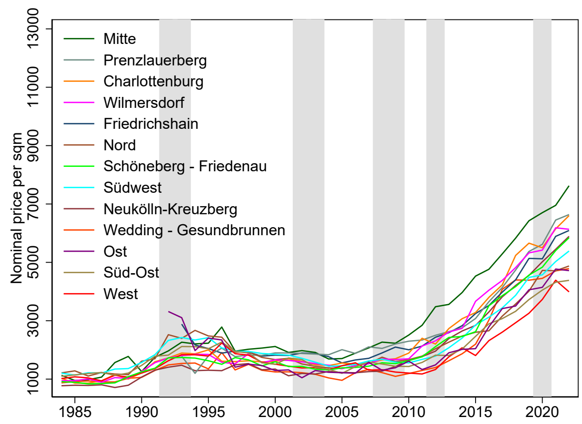
(f) *Stuttgart*



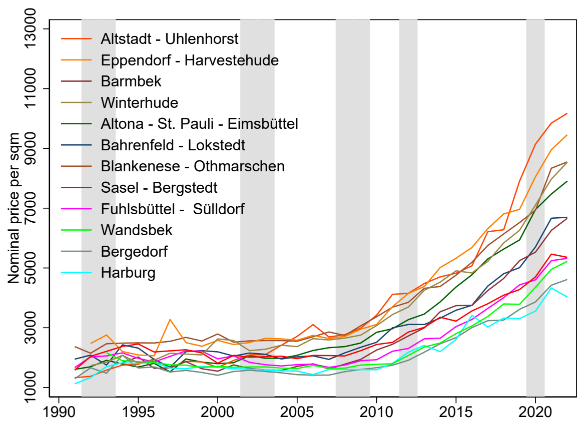
Note: The figure shows nominal yearly apartment price indices for neighborhoods in Berlin, Hamburg, Munich, Cologne, Frankfurt and Stuttgart. Shaded areas represent recessions in Germany according to the Bundesbank.

Figure 10: *Average nominal price per square meter for apartments, 1975-2022*

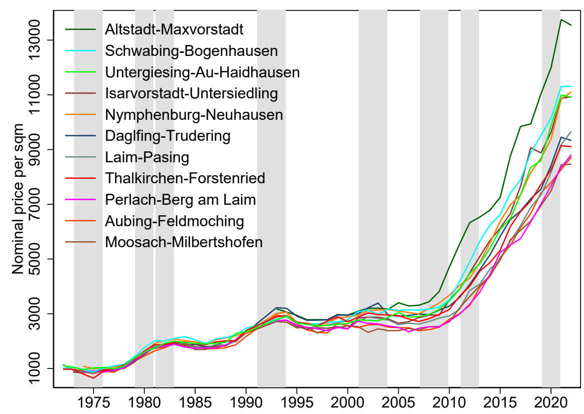
(a) *Berlin*



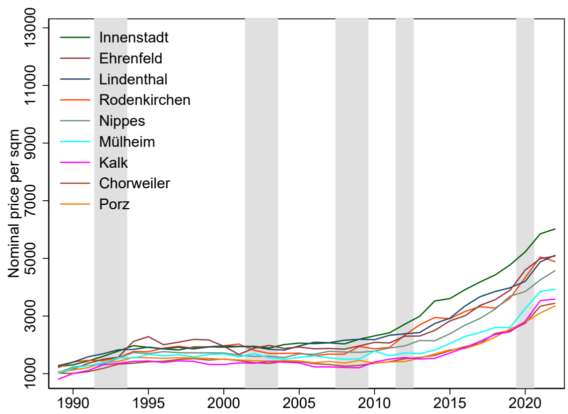
(b) *Hamburg*



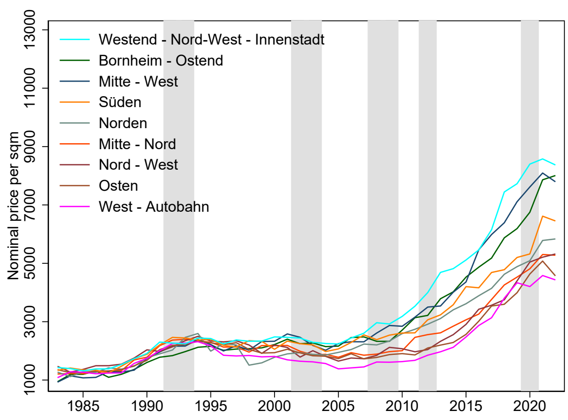
(c) *Munich*



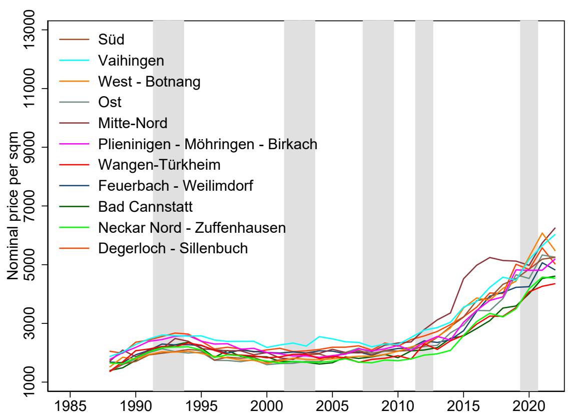
(d) *Cologne*



(e) *Frankfurt*



(f) *Stuttgart*



Note: The figure shows nominal yearly average apartment prices per square meter for neighborhoods in Berlin, Hamburg, Munich, Cologne, Frankfurt and Stuttgart. Shaded areas represent recessions in Germany according to the Bundesbank.

To investigate the continuous increase in price disparity among neighborhoods within each city, we analyze the ratio between the most expensive and least expensive neighborhoods over time. To eliminate potential bias caused by variations in the time coverage of neighborhood indices within a city, we perform this comparison during a period when we have balanced panels within each city. Moreover, to ensure that our findings are not influenced by the change in the marginal price of specific housing characteristics, we employ hedonic indices to measure the relative prices across neighborhoods. The outcomes are depicted in Figure 11.

Figure 11: *Ratio of most- to least-expensive, 1990-2022*

(a) *Across-cities* **(b)** *Within-city*

Note: The figure shows the average ratio of the nominal hedonic price per square meter between 1990 and 2020 between the most- and least-expensive city (Panel(a)) and the most- and the least-expensive neighborhood (Panel (b)). Panel (a) is based on a balanced panel of 16 cities from 1995 to 2022. Panel (b) is based on a panel of neighborhoods for 16 cities since 1990, where within-city panels are balanced. Shaded areas are national recessions as defined by the Bundesbank.

In 1990, the ratio was approximately 1.3, meaning that the most expensive neighborhood was, on average, 30% more expensive than the cheapest. As shown in the Figure, this ratio increased significantly over time, particularly between 2005 and 2010. This was due to the fact that the strong price boom of the last decade began earlier in the more expensive neighborhoods and only later affected the least expensive neighborhoods, in the early 2010s. The ratio then leveled off in the 2010s, indicating that prices were increasing at similar rates in both cheaper and more expensive neighborhoods. At the end of the sample period in 2022, the ratio was approximately 1.7, signifying that the most expensive neighborhoods are now 70% more expensive than the cheapest. This suggests that, on average, the price gap between neighborhoods within the cities in our study has more than doubled between 1990 and 2022.

As previously mentioned, the ratio of the most expensive to the cheapest neighborhood remained constant during the 2010s boom and even decreased slightly towards the end of the decade. This suggests that within-city housing prices may have converged over this period in Germany. To verify this hypothesis, we examined the real growth rates of the most and least expensive neighborhoods over time. Specifically, we investigated whether neighborhoods that currently have prices above the median also exhibit higher price growth rates in the future.

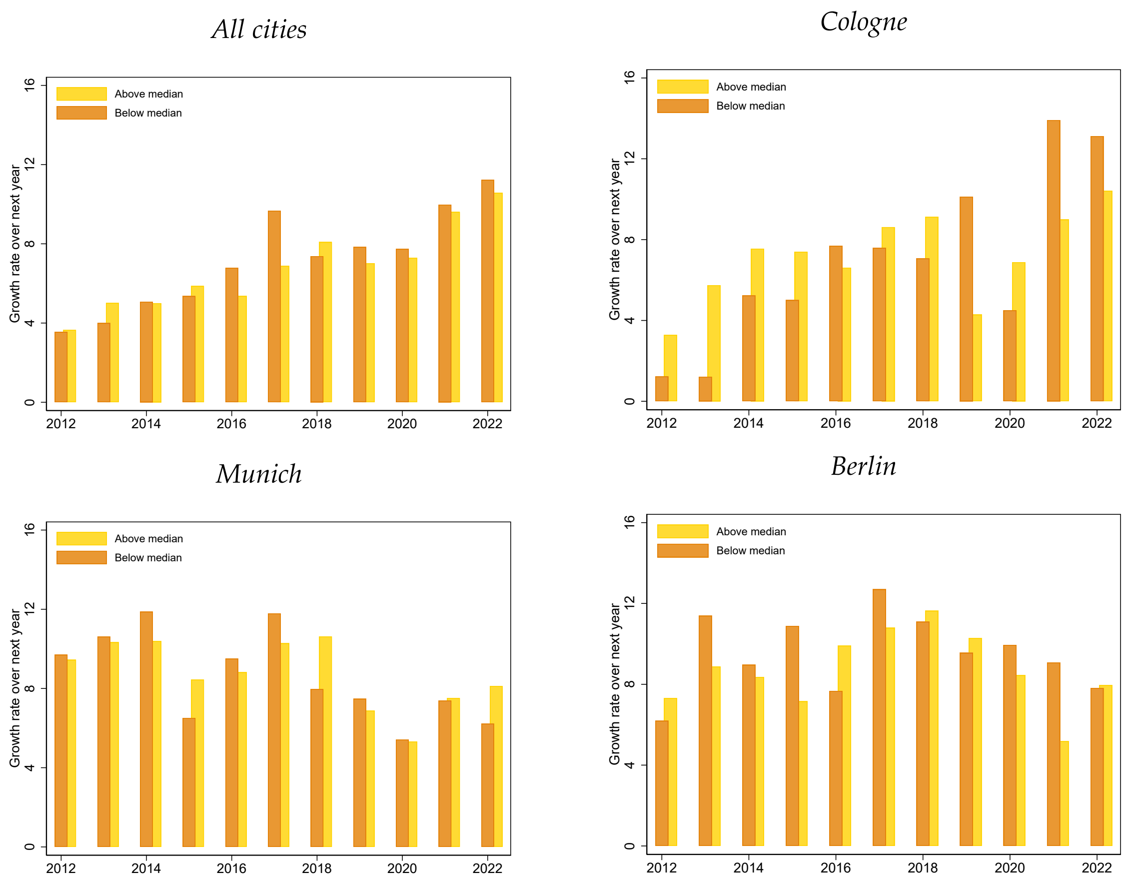
In Figure 12, we present the growth rate of prices in the next year relative to the price level one year before. We do this for neighborhoods that are more expensive than the median and those that are less expensive. We display the average results of this analysis across all cities in our sample in panel (a) and then for Munich, Berlin and Cologne individually.

For the complete sample, it becomes clear that at the beginning of the 2010s boom, housing prices were growing faster in the more expensive neighborhoods. This indicates that the actual boom started earlier in the most expensive parts of the city. However, around 2014, the momentum changed to the cheaper neighborhoods, and they started to experience stronger price growths. This suggests a spill-over effect during the boom, where high-income buyers started to look for more affordable locations surrounding the expensive neighborhoods, leading to a surge in prices in the cheaper areas. This effect became more pronounced towards the end of the boom.

However, this general trend differs somewhat by city. In some cities, such as Cologne, the general pattern is quite evident, with more expensive neighborhoods experiencing the strongest price increases at the beginning of the 2010s, with the momentum shifting to cheaper neighborhoods around 2014. For other cities, the pattern differs slightly. For instance, in Munich, there does not seem to have been a real spill-over effect, as more expensive neighborhoods were experiencing higher growth rates towards the end of the period. In contrast, in Berlin, prices grew more in the less expensive neighborhoods, leading to a catch-up effect.

Overall, the price ratio between the most and least expensive neighborhoods declined during the 2010s, as seen in Figure 11. However, as can also be seen from the Figure, this was not sufficient to reverse the long-term trend of increasing price divergence in German cities.

Figure 12: *Within-city dispersion: growth rates of above- and below median neighborhoods, 2012-2022*



Note: The figure shows the cumulative growth rate of real apartment price indices over the next two years for the neighborhoods below and above the median price. Panel (a) displays results averaged across all our sample and the other panels display the results for Munich, Berlin and Cologne separately.

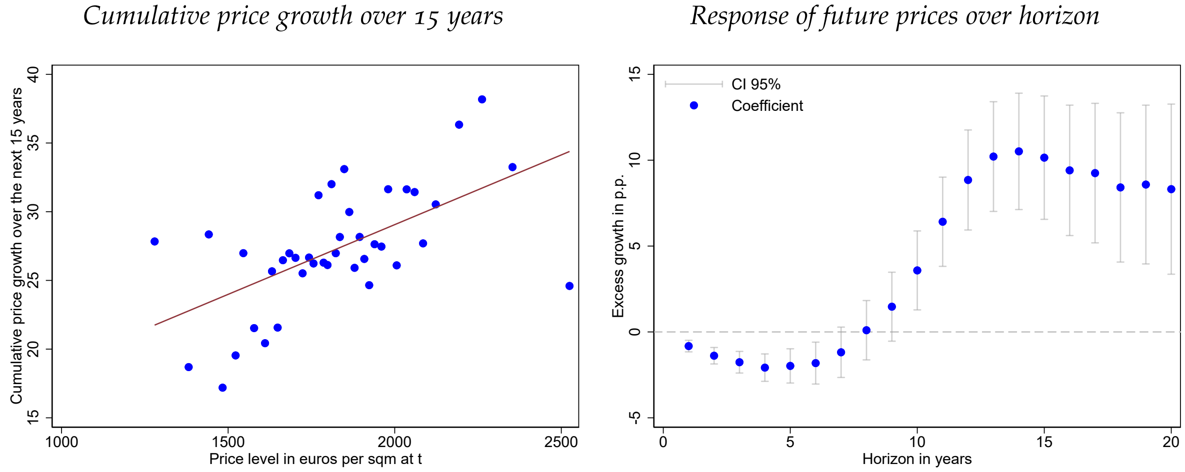
Regression analysis. Drawing inspiration from the extensive body of literature on economic divergence and convergence among various countries (e.g Durlauf, 1996), we apply similar methodologies to gain deeper insights into the patterns of divergence in housing prices within German cities over the past three decades. By adapting the methods utilized in that literature, we aim to enhance our understanding of the dynamics at play in the realm of housing price divergence. We conduct a regression analysis of future price growth against the current relative price level, to determine whether pricier areas of the city experienced more significant price appreciation. Specifically, we run the following regression:

$$log(P^j_{i,t+h}) - log(P^j_{i,t}) = \beta * Price^j_{i,t} + \delta_t + \kappa_i + \epsilon^i_t, \tag{5}$$

where $P^j_{i,t}$ is the value of the index in neighborhood j of city i at time t, $Price^j_{i,t}$ is the average price per square meter in neighborhood j of city i and δ_t and κ_i are year and city fixed-effects. Note that given the year and city fixed-effects we are analyzing the variation within city and within a year, which means that we are testing whether neighborhoods which are more expensive than the rest of their city in a given year also have higher cumulative price growth rates than the rest of their city in the future. Figure 13 depicts the results of the regression analysis conducted over a 15-year period.

The result is that neighborhoods with higher current price levels tend to have experienced more significant cumulative price growth than other areas in the future. This suggests that prices within cities diverged over time, with more expensive neighborhoods becoming even more expensive. In Panel b, we plot the regression coefficient β over different time horizons. The graph shows that prices diverge over the longer term. In terms of interpretation, we can interpret β as the effect of an increase in the relative price of a neighborhood today on its cumulative excess price growth in the future. For example, if a specific neighborhood was on average 1000€ per square meter more expensive than the average in the city in 2000, then in the last 20 years prices in that neighborhood grew on average by approximately 10 p.p. more than the average in the city. Over shorter periods, prices seem to converge. This result is driven by the second phase of the latest boom. As was discussed above, from 2014 onward, cheaper neighborhoods started to appreciate at higher rates than the more expensive neighborhoods, however this effect was not sufficiently strong to overturn the long-run divergence in prices.

Figure 13: *Price growth vs. initial price level*



Note: The figure shows the binscatter of cumulative real price growth for apartments on initial prices at the neighborhood level controlling for city and year fixed effects (Panel a) and the coefficient of cumulative real price growth for apartments on initial price level controlling for city and year fixed-effects (panel b).

6 Best performing markets

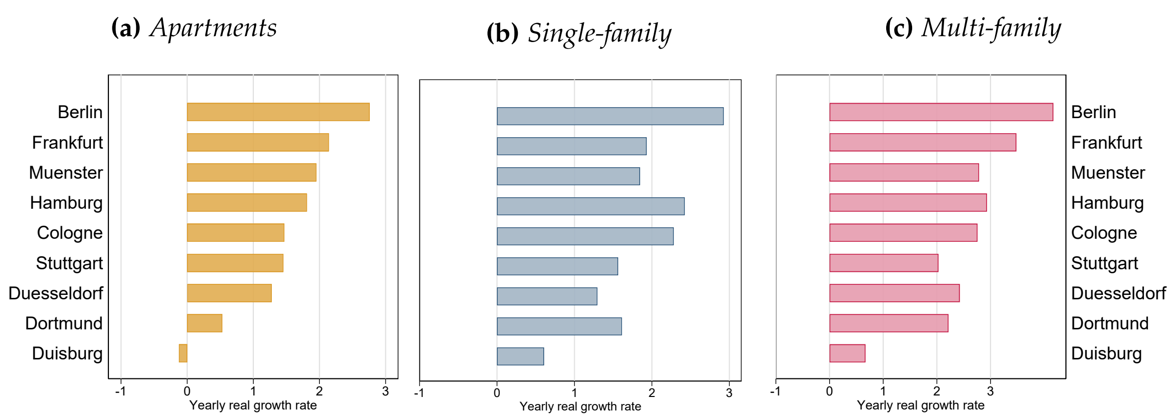
In this subsection we want to explore the best performing markets over various time spans. We will start by comparing growth rates of the individual GREIXX on the city level to find the best performing city and then move to compare the subcity-level indices to find the best performing neigborhood among all cities. Throughout this section, we will start by comparing the price growth since the 1960s, but our main focus will be on the post-2000 period, where we have a balanced data set. The numbers displayed in the graphs in this section can also be found in Table format in the appendix section C.2.1.

6.1 Best performing city

Since 1960s. Figure 14 presents the average real growth rates for the entire period beginning in 1960, during which information for at least one market segment is available over a sufficiently long time frame. In Berlin, apartment prices have experienced an average annual growth of 2.76% adjusted for inflation from 1984 to the present, corresponding to a cumulative growth of 184% between 1984 and 2022. In other words, according to our index, apartment prices are now 184% more expensive than they were in 1984 after adjusting for inflation. On the other hand, real aparmtne prices in Frankfurt have grown at a slightly lower rate, just above 2%. This means that in Frankfurt, prices are 122% more expensive today than they were back in 1984.

To gain a better understanding of how real estate prices have changed since the 1960s, it's useful to examine the growth rates for single-family and multi-family homes, which typically have longer data series. In Berlin, for instance, after adjusting for inflation, real prices of multi-family and single-family homes have increased by an astounding 900% and 430%, respectively, since 1965. It's worth noting that our index for Berlin only covers the western part of the city before 1992. Similarly, in Hamburg, real multi-family homes are now 350% more expensive than they were in 1965, while single-family homes have increased by 250%. It is worth noting that the data for different cities and market segments have varying starting dates, which may limit the comparability of the data. Therefore, in the following paragraphs, we will focus on periods for which we have comparable data across cities and market segments. Specifically, we will examine the periods after the reunification and after 2008.

Figure 14: *Average real yearly growth rate by city and segment, full sample*



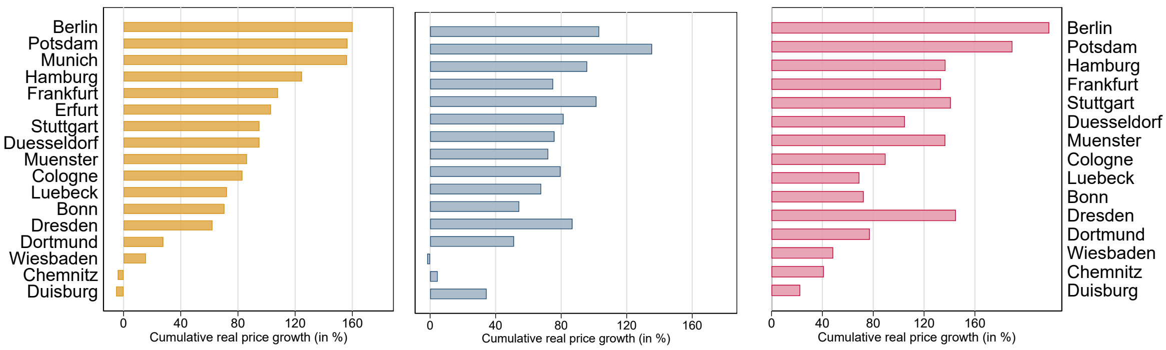
Note: This graph shows the mean yearly real growth rate of apartments (Panel (a)), single-family houses (Panel (b)) and multi-family houses (Panel (c)). Growth rates are measured in log points. The period covered is 1960 to 2022, except for the cities where the data starts later.

Post 2000 To enable a more comparable analysis and include additional cities, Figure 15 displays the cumulative real growth rates for German cities since 2000. As shown in Figure 15, there is a significant degree of variation in housing price increases across German markets since 2000. For instance, in Berlin and Munich, real apartment prices have risen by almost 160% since, adjusting for inflation, whereas in Chemnitz, prices have dropped by nearly 3%. Prices in Potsdam have also increased at the same pace as in the largest cities, this is not so surprising given the proximity of Postdam to Berlin. It's worth noting that housing prices in the former GDR cities experienced a brief period of strong growth after 1990, but then declined sharply from the mid-1990s until the early 2010s. This can be seen more clearly in Figure 5. For a more detailed look at the yearly growth rates, we have included a figure in the appendix that shows the average annual real growth rates over the same period. Please refer to Figure 32 for the results.

When focusing on apartment prices, we observe that the Top-7 cities generally experience higher real growth rates than smaller cities, with cumulative real growth ranging from 80% to 160%. The market segment of single-family houses does not display the same pattern as apartments, as some cities from Group B exhibit similar growth rates to those from Group A. The best-performing city since 2000 for single-family houses has been Berlin, but Dresden has had a surprisingly strong price appreciation as well. The multi-family houses market does not exhibit a specific pattern between cities from categories A and B either. The highest growth rates within this market segment surpass those of the other two segments. Multi-family houses have experienced the strongest growth in Berlin, with an cumulative real growth rate of 180%.

Figure 15: *Cumulative real price growth by city and segment since 2000*

(a) *Apartments* **(b)** *Single-family* **(c)** *Multi-family*



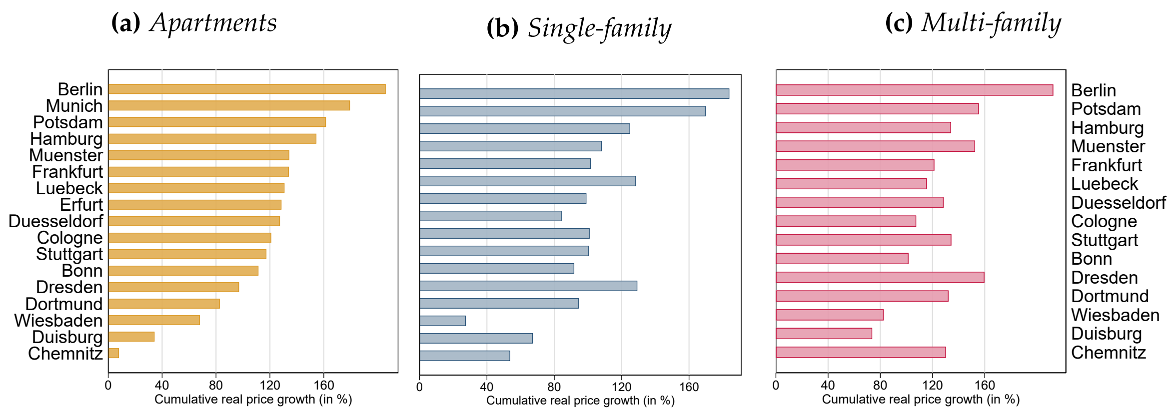
Note: This graph shows the cumulative CPI-adjusted growth rate of prices for apartments (Panel (a)), single-family houses (Panel (b)) and multi-family houses (Panel (c)). Cumulative real growth rates are measured in percentage. The period covered is 2000 to 2022.

Post 2008. Let's take a closer look at the latest housing boom, which began with the recovery from the global financial crisis in 2007-2008. It's worth noting that unlike other OECD countries, Germany's housing prices weren't significantly impacted by the financial crisis. In fact, housing prices started to rise in Germany during or shortly after the crisis, following a period of stagnation (Knoll, Schularick, and Steger, 2017).

Figure 16 illustrates the cumulative price growth between 2008 and today for all cities in our sample. What's truly remarkable is that all cities in our sample experienced a positive trend in real price growth since 2008. In fact, none of the cities in our sample had negative real-growth rates across any of the market segments between 2008 and today. This information can be found in Figure 32 in the appendix, where we display the average yearly real growth by cities over the same period.

Furthermore, yearly growth rates have been notably high, with the highest growth rates for market segments ranging from over 6.5% for single-family homes to more than 7.5% in the apartment market. This means that in cities like Berlin, Hamburg, or Frankfurt, prices have increased by more than 100% since 2008 in real terms across all three market segments. In contrast to the period since reunification, Berlin has seen the strongest price increases in all markets, with apartments now costing more than 170% of their 2008 value. On the other hand, the real condo prices in Chemnitz have only seen a modest cumulative increase of around 3% over the same period. In the next section, we'll delve into this heterogeneity in more detail, analyzing the timing of the boom and showing how it varied from city to city.

Figure 16: *Cumulative real price growth by city and segment since 2008*



Note: This graph shows the cumulative CPI-adjusted growth rate of prices for apartments (Panel (a)), single-family houses (Panel (b)) and multi-family houses (Panel (c)). Cumulative real growth rates are measured in percentage. The period covered is 2008 to 2022.

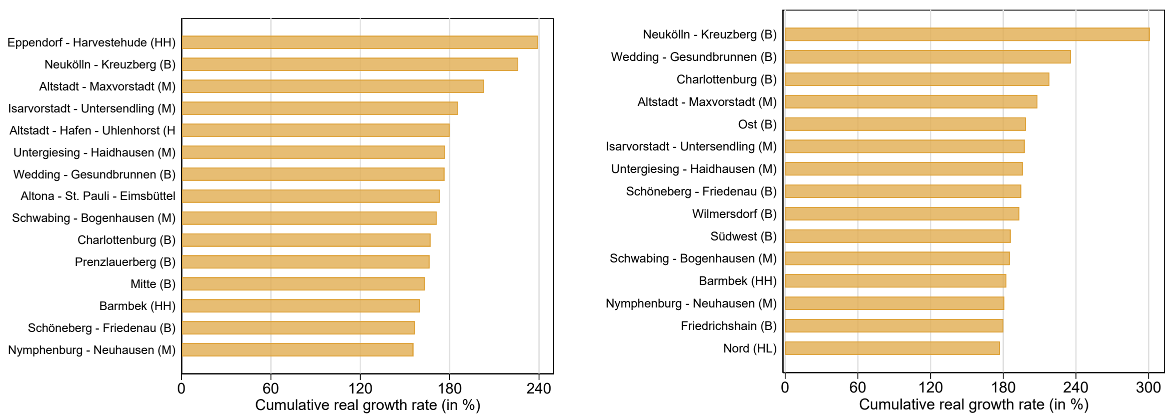
6.2 Best performing neighborhoods

Having analyzed the best-performing cities across various time spans, we now shift our focus to understanding which neighborhoods are leading the pack and whether these markets are dominated by the top-performing cities identified in the previous section. The numbers displayed in the graphs in this section can also be found in Table format in the appendix section C.2.2.

Figures 17 and 18 provide a visual representation of the cumulative inflation-adjusted growth rates for the 15 best and 15 worst-performing neighborhoods in our sample since 2000 and since 2008. When we consider the cities with the highest growth rates during this time period, it becomes clear that the neighborhoods from these cities also exhibit the highest growth rates. Notably, the best-performing neighborhoods are exclusively from the top seven cities. Conversely, neighborhoods in cities from the former GDR appear to have performed poorly, in line with the performance of their respective cities. However, some neighborhoods from the top-performing cities also make this list. For example, the performance of Cologne-Chorweiler has been amongst the worst in German. from the Interestingly, several neighborhoods are from the city of Dresden, which, at the city level, ranks among the top five performers. This observation underscores the increased divergence within the city.

Figure 17: *Cumulative real price growth for 15 best-performing neighborhoods*

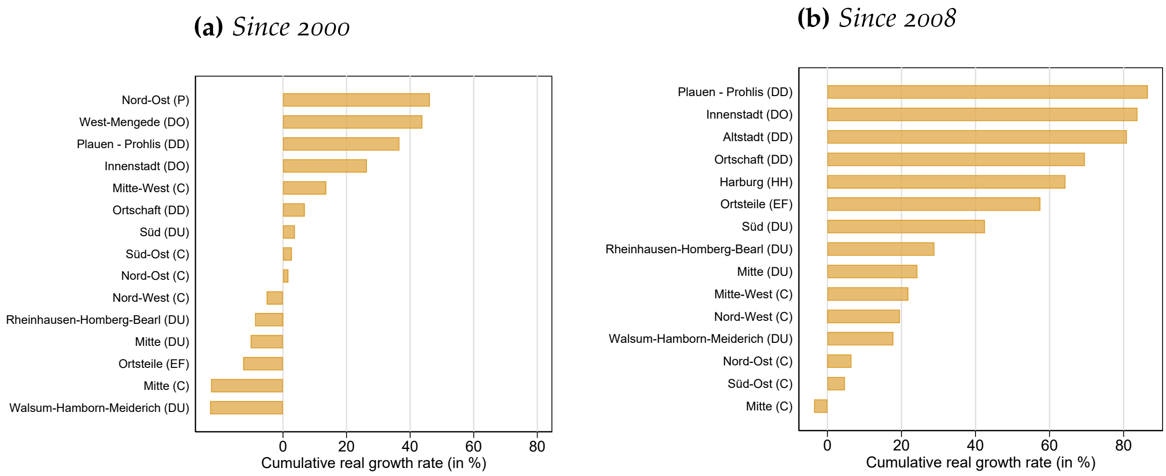
(a) *Since 2000* **(b)** *Since 2008*



Note: This graph shows the cumulative CPI-adjusted growth rate of prices for apartments for the seven best- and seven worst-performing neighborhoods in our sample since 2000 (Panel (a)) and since 2008 (Panel (b)).

Furthermore, the neighborhoods with the highest growth rates are usually central or preferred neighborhoods, which also have high price levels, such as Hamburg-Eppendorf, Munich-Maxvorstadt, or Altstadt in Hamburg. The cumulative real growth rates for these neighborhoods range from 180% to 240% since 2000. When we look at the data since 2008, we see that the cumulative price growth has been particularly strong in neighborhoods in Berlin. Neukölln and Kreuzberg are especially impressive examples, with real apartment prices having increased by almost a factor of four.

Figure 18: *Cumulative real price growth for 15 worst-performing neighborhoods*



Note: This graph shows the cumulative CPI-adjusted growth rate of prices for apartments for the seven best- and seven worst-performing neighborhoods in our sample since 2000 (Panel (a)) and since 2008 (Panel (b)).

For more numbers on the performance of the neighborhoods within the largest German cities, please refer to the tables in Appendix section C.2.

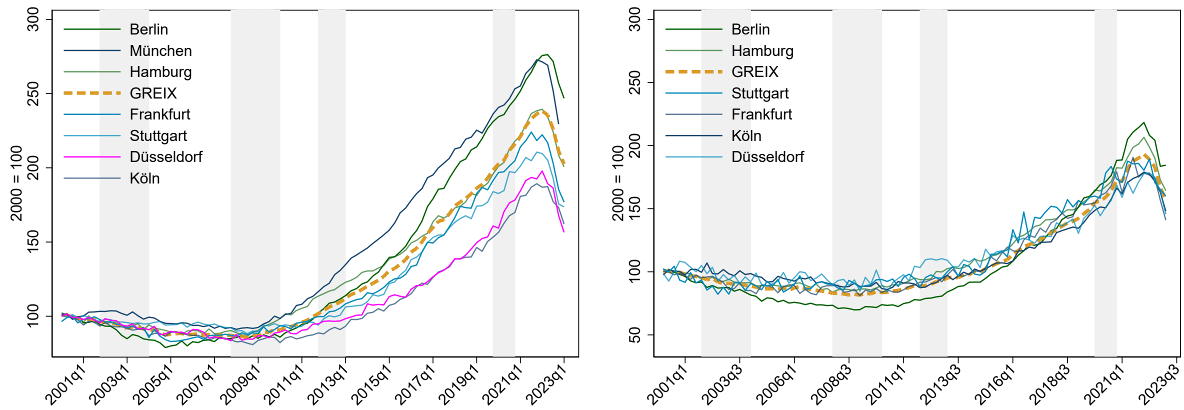
7 From boom to bust? The current state of the German housing market

In this section, we zoom in on the latest developments in the German real estate market. As previously mentioned, the recent boom phase was unparalleled in terms of its duration and scale. We will closely examine this period, paying particular attention to its heterogeneity across both time and space. Subsequently, we will delve into the most recent quarters of the German housing market and present initial evidence on the extent of the ongoing price correction.

Displayed in Figure 19 are inflation-adjusted price indices for the seven largest cities and the GREIX. The Figure demonstrates that the price boom was not uniform across all locations, and that the correction since 2002 has also been more pronounced in some cities than in others.

Figure 19: *Quarterly inflation-adjusted price indices by city and segment, 2000q1 - 2023q1*

(a) *Apartments* **(b)** *Single-family*



Note: Panel (a) displays the CPI-adjusted price index for apartments for different and the GREIX. Panel (b) displays the CPI-adjusted price index for single-family housing for different cities and the GRREIX.

7.1 The downturn since 2022

As evidenced by the figures presented in the previous section, the housing price boom came to a halt in most German cities during the latter half of 2022, and a significant price correction is under way, accompanied by a reduction in the number of properties being transacted in the market. Table 4 presents the nominal drop in apartment prices for the largest German cities and our composite index from their peak in 2022. In all these cities, the decline has been quite significant and follows several years of substantial price appreciation. Among the major cities in Germany, Frankfurt has experienced the largest drop, with nominal prices decreasing by 12% from their peak. Conversely, Berlin and Cologne have undergone smaller corrections, with nominal prices declining by approximately 6% from their peak. The current situation is also characterized by high levels of inflation, prompting us to examine the price correction after adjusting for inflation.

Table 4: *Cumulative apartment price growth by city and for the GREIX*

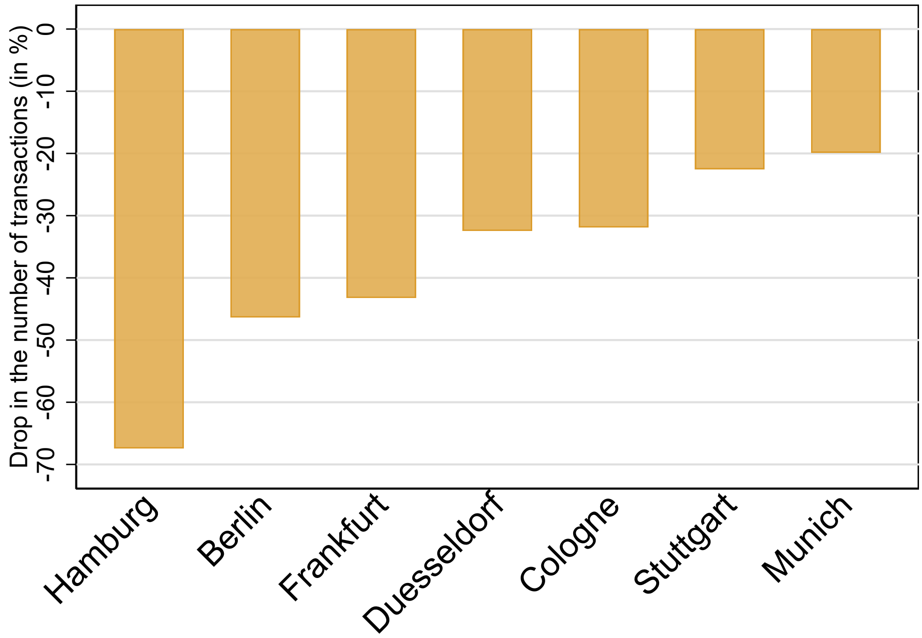
	Cumulative nominal price growth (in %)		
City	since 2000	since 2008	from Peak
Berlin	160.2	205.9	-6.0
Hamburg	124.6	154.5	-9.3
Munich*	156.3	179.4	-8.6
Cologne	83.0	121.0	-5.6
Frankfurt	107.9	134.1	-12.2
Stuttgart	94.9	117.4	-9.1
Duesseldorf	94.9	127.5	-14.4
GREIX	225.6	227.8	-8.0

*Note: Table reports cumulative apartment price growth between since 2000, 2008 and between peak and 2023q1 for all cities in our sample that start before 2000. For the cities marked with a *, we calculate the drop from peak to 2022Q4, as we are missing data for the first quarter 2023 for these cities.*

Figure 21 displays the inflation-adjusted yearly growth rates for apartments in our composite GREIX index alongside the yearly change in the total number of transactions in the sample cities during this period. The first negative growth rates could be observed in the latter half of 2022. Real prices decreased by more than 10% in the last quarter of 2022 and the first quarter of 2023 compared to the previous year, resulting in an overall decrease of 15% in apartment prices from their peak in the first quarter of 2022. This significant decrease in prices was mirrored by a decrease in the number of transactions, with year-on-year drops of more than 50%, meaning that half as many transactions occurred in the last quarter of 2022 as compared to the peak in the last quarter of 2021.[11] This trend is also evident at the city level, as apartment transactions in Berlin decreased from approximately 3000 in the last quarter of 2021 to 1600 in the final quarter of 2022, a drop of almost 50%. Here, as well, there is considerable heterogeneity across cities. In Hamburg transactions have dropped by more than 60%, while in Munich the drop is close to 20%. These results can be found on Figure 20, which displays the drop in the number of apartment transactions between the last quarter of 2021 and the last quarter of 2022 for the seven largest cities in Germany. Figure 35 in the appendix displays the drop for all the cities in our sample.

[11] At present, Destatis has yet to provide an estimate for the first quarter of 2023. However, based on a comparison between the index's peak and the latest available data point from 2022 Q4, there appears to be a 6% decline in single-family house prices across Germany.

Figure 20: *Drop in number of apartment transactions between 2021Q4 and 2022Q4 (in %)*

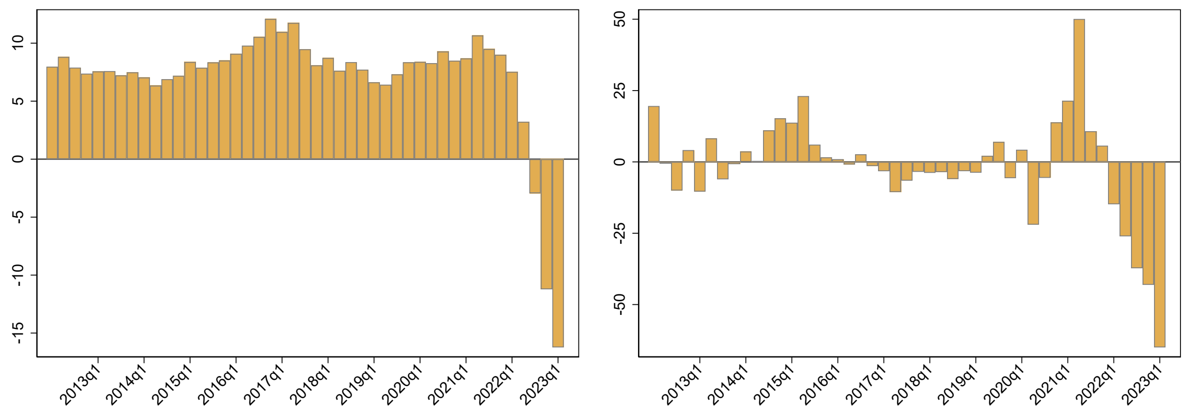


Note: The Figure displays the fall in the number of transactions between the last quarter of 2021 and the last quarter of 2022 for the largest seven cities in Germany in percent.

The fall in prices has been even more pronounced in the other market segments. As shown in Figure 36 in the appendix, prices of multi-family and single-family houses, have dropped on average by 35% and 23% from the peak, respectively, after adjusting for inflation. It is worth noting that, unlike in other historical periods of high inflation rates (Deutsche Bank Research, 2023; Ranaldi and Schularick, 2023), so far the housing market does not appear to have provided a hedge against the strong increase in consumer prices.

Figure 21: *Price growth and number of transactions GREIX-Apartments, 2012q1 - 2023q1*

(a) *Yearly change in real price index (in %)* **(b)** *Yearly change in transaction number (in %)*



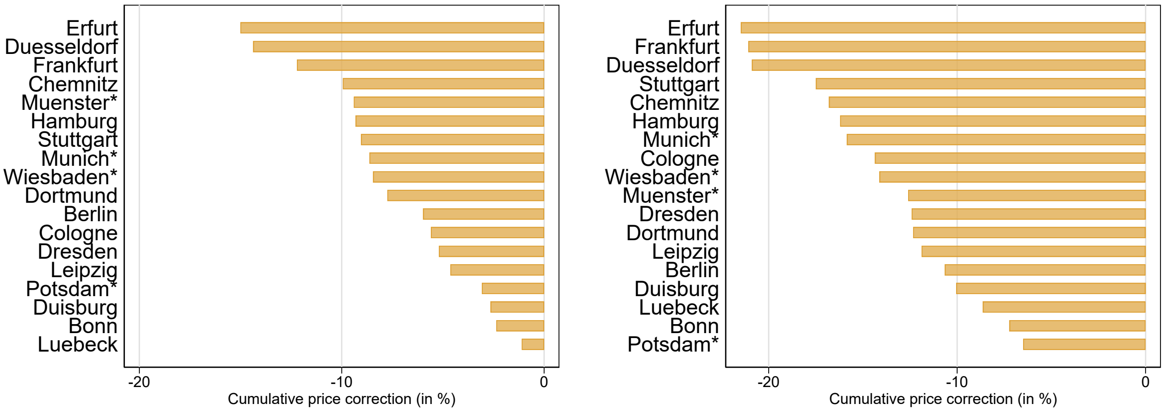
Note: Panel (a) displays the CPI-adjusted yearly growth rate in the quarterly apartments-GREIX. Panel (b) presents the number of transactions per quarter after cleaning. Please note that the figures for the first quarter of 2023 are still provisional as the Gutachterausschüsse are currently in the process of collecting data.

Every city in our sample, without exception, has experienced a decline in prices since 2022, following years of robust price growth. However, the extent of the price correction varies considerably among cities. In Figures 22 and 23, we present the cumulative real and nominal price decrease between the index's peak in 2022 and the first quarter of 2023 for both apartments and single-family houses. Given the large inflation rates since the beginning of 2022, the drops in real terms are significantly larger. Note that the city ranking is not the same for the drop in nominal and real terms since the cities differ in the timing of their peak. The data suggests that real apartment prices have adjusted more noticeably in larger cities, except for Berlin. For instance, prices in Frankfurt have dropped by more than 20%, whereas in Bonn, the decline is less than 10%. The exact numbers underlying these graphs can be found in the tables in the Appendix section C.2.1.

The price correction is stronger for single-family houses than for apartments for all cities in our sample, but there doesn't appear to be a clear pattern across cities. We also display the results for multi-family houses in the Appendix. The downturn appears even more pronounced for multi-family houses.

Figure 22: *Price correction from 2022 peak to 2023q1 by city for apartments*

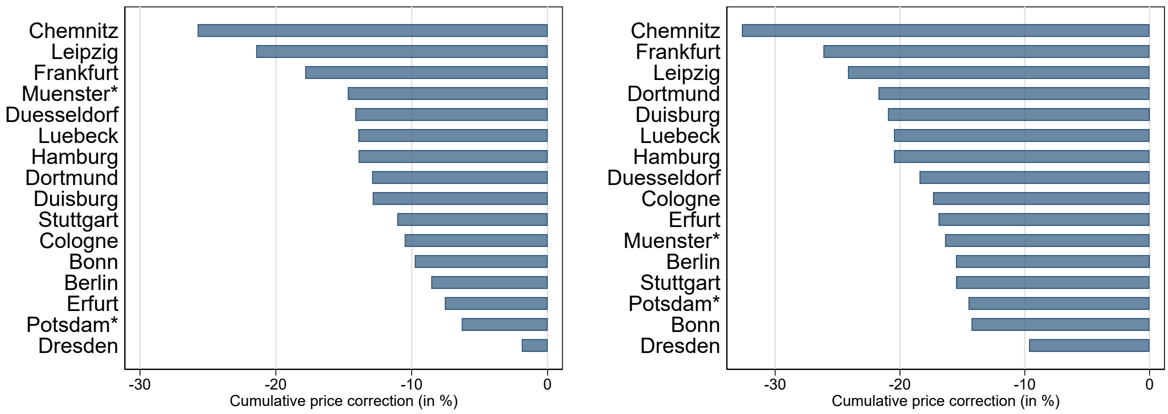
(a) *Nominal* **(b)** *Inflation-adjusted*



*Note: Panel (a) displays the nominal cumulative price decrease between peak in 2022 and the first quarter of 2023. Panel (b) displays the CPI-adjusted cumulative price decrease between peak and the first quarter of 2023. Note that the city ranking is not the same for both panels since the cities differ in the timing of their peak. For the cities marked with a *, we calculate the drop from peak to 2022Q4, as we are missing data for the first quarter 2023 for these cities.*

Figure 23: *Price correction from 2022 peak to 2023q1 by city for single-family houses*

(a) *Nominal* **(b)** *Inflation-adjusted*



Note: Panel (a) displays the nominal cumulative price decrease between peak in 2022 and the first quarter of 2023. Panel (b) displays the CPI-adjusted cumulative price decrease between peak and the first quarter of 2023.

7.2 Nowcast of trends in Q2 2023

The long-run housing price series provides us with a wealth of information to analyze correlations not only within our housing price series, but also between our housing price series and macroeconomic variables such as GDP and consumption. Additionally, many of these macroeconomic variables are published on a monthly basis, including interest rates, providing us with timely and relevant data. Using macroeconomic data and historical correlations, we can construct a nowcasting model that tracks current-quarter housing prices in real time.

Constructing the model, we build on the latest dynamic factor model methods (Reichlin, Giannone, and Banbura, 2011). This model first extracts common factors from our historical data and then uses these factors alongside the most up-to-date information on macroeconomic variables to make predictions about the current direction of housing prices. Formally, a dynamic factor model can be represented as follows:

$$x_t = \Lambda f_t + \epsilon_t \tag{6}$$

$$f_t = \sum_{i=1}^{p} A_i f_{t-i} + B u_t, \quad u_t \sim i.i.d.\ \mathcal{N}(0, I_q), \tag{7}$$

where x_t is a vector of N quarterly time series transformed to satisfy the weak stationarity assumption. Equation 6 determines that our quarterly time series depend on a set of r unobserved factors f_t and a mean-zero idiosyncratic component, ϵ_t. Equation 7 imposes the structure of a VAR(p) process on the factors f_t, where u_t are mean-zero innovations to the factors, which are subject to q common shocks. Furthermore, we assume that the idiosyncratic disturbances ϵ_t are uncorrelated with the factor innovations at all leads and lags.

To implement the dynamic factor model in our setting, we first transform our time series into a stationary state by taking first-differences or percentage changes of our data. For this exercise, we restrict our dataset to the post-1984 period since a significant portion of our series begins in that period. Before 1984 our data set is very unbalanced. Along with our quarterly housing price series for different market segments and cities, we incorporate quarterly time-series data on the total number of transactions and several macroeconomic variables for Germany into our model, displayed in table 5.

To strengthen the credibility of our nowcast, we are not just drawing upon the usual macroeconomic indicators. Instead, we have enriched our predictive model by integrating transaction data, obtained from a subset of cities within the current quarter. This incorporation of micro-level data equips us with the ability to anticipate the development trends of all other cities. In essence, our nowcast weaves together both the macroeconomic variables and micro-level transaction data, giving us a more nuanced and comprehensive picture.

To determine the appropriate number of factors (r) and the number of shocks to the factors (q), we follow the method developed by Bai and Ng (2002) and Bai and Ng (2007).

Table 5: *Description of the external regressors used in the nowcasting model*

Variable	Source	Frequency	Time Coverage
Population	Destatis	Quarterly	1991Q1 - 2022Q2
GDP Index	OECD	Monthly	1990M1 - 2022M11
GDP per Capita	Destatis	Quarterly	1991Q1 - 2022Q4
Unemployment rate	OECD	Quarterly	1990Q1 - 2022Q4
CPI	Destatis	Monthly	1991M1 - 2023M4
Short-Term Interest Rate	OECD	Monthly	1990M1 - 2023M4
Long-Term Interest Rate	OECD	Monthly	1990M1 - 2023M4
Mortgage Volume	Bundesbank	Quarterly	1990Q2 - 2022Q3

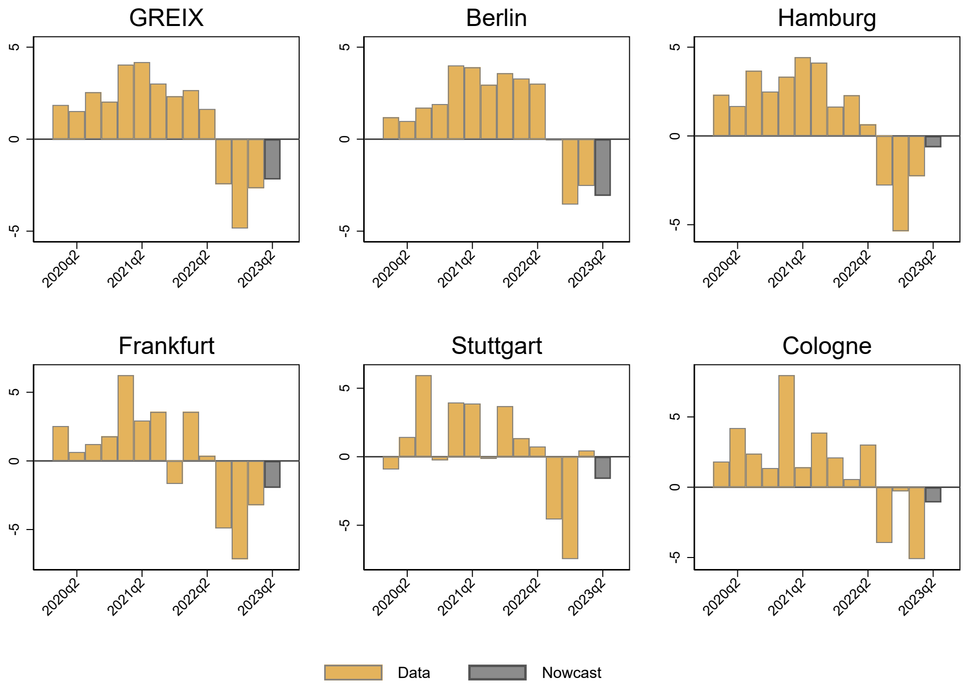
Note: This table displays the data source, frequency and time coverage of the external regressors that have been added to the dynamic factor model used to produce the nowcast.

We focus on the nowcast for our apartment and single-family indices. The nowcasted growth rates from our dynamic factor model for the second quarter of 2023 are shown in Figure 40 and 25. According to the nowcast, prices are still expected to drop in most cities, albeit at a somewhat smaller rate than in the first quarter of 2023. We nowcast that the nominal quarter-on-quarter decline in the apartments GREIX is around 2%. Given that quarterly inflation is predicted to stay around 2%, this means that we predict that real prices will be back to the level of the first quarter of 2020. In terms of relative difference to the 2022 peak, our nowcast predicts a slight decrease to a drop of 19% from peak in the second quarter down from the fall in 15% in the first quarter.

While the prevailing trend indicates a continued reduction in prices, the deceleration in the rate of this reduction suggests the initial signs of market stabilization. It is important to caveat that the predictive accuracy of our nowcast model tends to reduce for forecasts extending further into future quarters. Nevertheless, the predictive models for the remaining part of 2023 align with the hypothesis of market stabilization. This theory is further supported by the data currently available from this quarter. Further numbers on the nowcasting of the second quarter of 2023 can be found in the Tables in the Appendix section E.

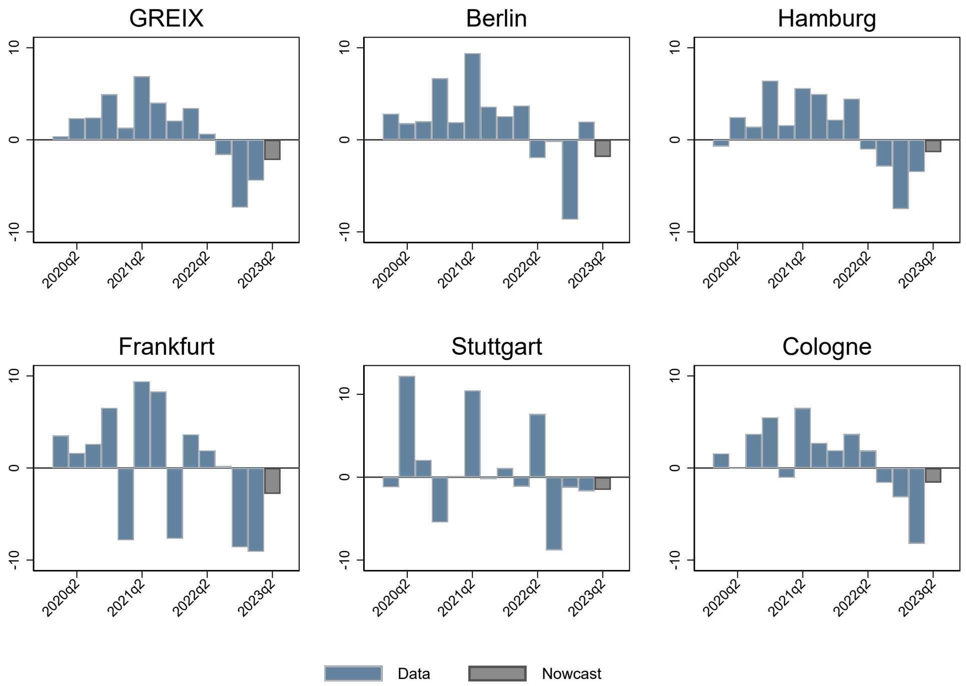
Robustness To provide empirical evidence, we can refer to the housing market in Frankfurt. The data already available for the second quarter of 2023 shows a minor contraction of the index, a decrease of about 2% relative to the first quarter of 2023. This subtle decline supports our hypothesis of a gradual transition towards market stabilization. Additionally, and in accordance with the method proposed by Domenico Giannone, Reichlin, and Small (2008), a balanced panel is required to execute the nowcast. This involves replacing missing values with the series median, which is then smoothed using a moving average. Consequently, the series derived through this procedure contain information that is independent of the data offered by other contemporaneous variables. Due to this characteristic, any series with more than a third of missing values is deemed unsuitable and thus excluded. However, such exclusion may result in the non-capturing of certain unobserved factors present between some series. Since estimating these unobserved factors is a central element in performing a nowcast, we undertake robustness checks with varying data sets to account for potential discrepancies. We execute the same dynamic factor model, but with two distinct data restrictions: first, data post 2000, and second, data post 2004. Remarkably, both estimations yield nowcasts that are closely aligned with the baseline case, with the GREIX showing a nominal decline of 2% compared to the previous quarter. These robustness checks, visualized in the Figures in Appendix section E, serve to affirm the reliability of our nowcasting approach.

Figure 24: *Nominal quarterly price growth for apartments by city, 2018q1-2023q2*



Note: The figure shows q-o-q nominal growth rates for apartments for the period between 2018q1 and 2023q2. The growth rate for 2023q2 is nowcasted using a dynamic factor model estimated using data since 1985.

Figure 25: *Nominal quarterly price growth for single-family by city, 2018q1-2023q2*



Note: The figure shows q-o-q nominal growth rates for apartments for the period between 2018q1 and 2023q2. The growth rate for 2023q2 is nowcasted using a dynamic factor model estimated using data since 1985.

8 Conclusion

Attaining greater transparency in the German housing market remains an essential objective, as previous data limitations impeded the ability to closely monitor house price trends and associated wealth gains across geographic regions in a timely fashion. The introduction of the German Real Estate Index (GREIX) and its various subindices for individual cities, neighborhoods, and market segments fundamentally alters this landscape by providing high-quality, geographically detailed, and timely price indices for the nation. This innovation will enable households to make more informed decisions, and concurrently, facilitates the development of improved policies tailored to address the complexities of the housing market. The German Real Estate Index serves as a testament to the importance of continued advancements in data-driven methodologies for fostering a transparent and equitable housing market. Furthermore, the German Real Estate Index is an example of a successful cooperation between public bodies, such as the GAA, and academic research institutions, the MacroFinance Lab and the ECONtribute Excellence Cluster. This collaborative effort underscores the significance of fostering relationships in promoting data-driven methodologies for fostering a transparent and equitable housing market.

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Appendix

A Data set construction and data sources

Figure 26: *Jurisdiction areas GAAas as of 2021*

Source: Immobilienmarktbericht Arbeitskreis der Oberen Gutachterausschüsse for the year 2021; Immobilienmarktbericht 2021.

B Housing price index methodology

Table 6: *Overview of existing real estate indices in Germany*

Index provider	Underlying data	Coverage	Method
Destatis	Transaction data from the GAAs	National & for aggregated index for largest 7 cities	Hedonic model
VdP	Transaction data from mortgage contracts from 700 banks	National & for largest 7 cities	Hedonic model
Sprengnetter	Appraisals & transaction data provided by real estate agents	National index	Hedonic model
Bulwiengesa	Appraisals, online adverstisement data & transaction data provided by real estate agent	National & for 127 cities	Hedonic model
GEWOS	Appraisals & online adverstisement data	City-level indices	Average value method
IVD	Appraisals & transaction data provided by real estate agents	National & for 450 cities	Average value method
Value AG	Online advertisement data	National index & city-level indices	Hedonic model
Europace	Transaction data from mortgages	National indices	Hedonic model

Note: VdP stands for Verband deutscher Pfandbriefbanken

Table 10 presents a comparison of the year-on-year growth rates for quarterly city-level apartment indices between the GREIXX and its equivalent created by vdp. A notable observation from the table is the statistically significant difference between the two indices. This finding remains consistent across various regression specifications, including those that account for city and year fixed effects. The positive coefficients indicate that, on average, the indices based on mortgage data tend to underestimate the growth in comparison to the GREIXX. For instance, in the specification incorporating both city and year fixed effects shown in the final column, these indices underestimate the average growth rate by approximately 36 basis points.

Table 7: *Standard deviations of GREIXX and vdp by city for apartments*

	Standard Deviation			
City	**GREIXX**	**vdp**	**Difference**	**p-value**
Berlin	2.16	1.72	0.43	0.021
Hamburg	2.04	1.36	0.67	0.000
Munich	2.10	2.09	0.01	0.447
Cologne	2.31	1.38	0.94	0.000
Frankfurt	2.75	1.46	1.29	0.000
Stuttgart	2.33	1.54	0.79	0.000
Duesseldorf	2.73	1.20	1.53	0.000

Note: The table reports the standard deviations, differences of these standard deviations, and p-values obtained from an F-test, aimed at determining if GREIXX's standard deviations of the quarter-on-quarter quarterly growth rates are statistically significantly larger than those of vdp for the TOP7-cities.

Table 8: *Standard deviations of GREIXX and vdp by city for single-family*

	Standard Deviation			
City	**GREIXX**	**vdp**	**Difference**	**p-value**
Berlin	7.47	6.07	1.40	0.057
Hamburg	5.73	3.65	2.08	0.000
Munich	.	3.81	.	.
Cologne	5.59	4.17	1.42	0.017
Frankfurt	6.62	3.79	2.83	0.000
Stuttgart	7.12	3.10	4.02	0.000
Duesseldorf	6.93	4.83	2.10	0.002

Note: The table reports the standard deviations, differences of these standard deviations, and p-values obtained from an F-test, aimed at determining if GREIXX's standard deviations of the year-on-year quarterly growth rates are statistically significantly larger than those of vdp for the TOP7-cities.

Table 9: *Standard deviations of GREIXX and vdp by city for single-family*

	Standard Deviation			
City	**GREIXX**	**vdp**	**Difference**	**p-value**
Berlin	2.76	1.86	0.90	0.000
Hamburg	2.41	1.49	0.92	0.000
Munich	.	1.16	.	.
Cologne	2.87	1.52	1.35	0.000
Frankfurt	4.32	1.24	3.09	0.000
Stuttgart	7.12	1.05	6.08	0.000
Duesseldorf	5.82	1.58	4.23	0.000

Note: The table reports the standard deviations, differences of these standard deviations, and p-values obtained from an F-test, aimed at determining if GREIXX's standard deviations of the quarter-on-quarter quarterly growth rates are statistically significantly larger than those of vdp for the TOP7-cities.

Table 10: *Comparison of GREIXX with vdp*

	Greixx			
Indices Mortgages	0.8332***	0.8319***	0.4373**	0.3609**
	(0.0640)	(0.1077)	(0.1906)	(0.0903)
City-FE	No	Yes	No	Yes
Year-FE	No	No	Yes	Yes
N	380	380	380	380
R^2	0.44	0.44	0.71	0.72

Robust standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Note: This table shows regressions of year-on-year growth rates for quarterly city-level apartment indices constructed with mortgage data on its equivalent GREIXX between 2004-2022.

Table 11: *Comparison of vdp and GREIX nominal growth rates*

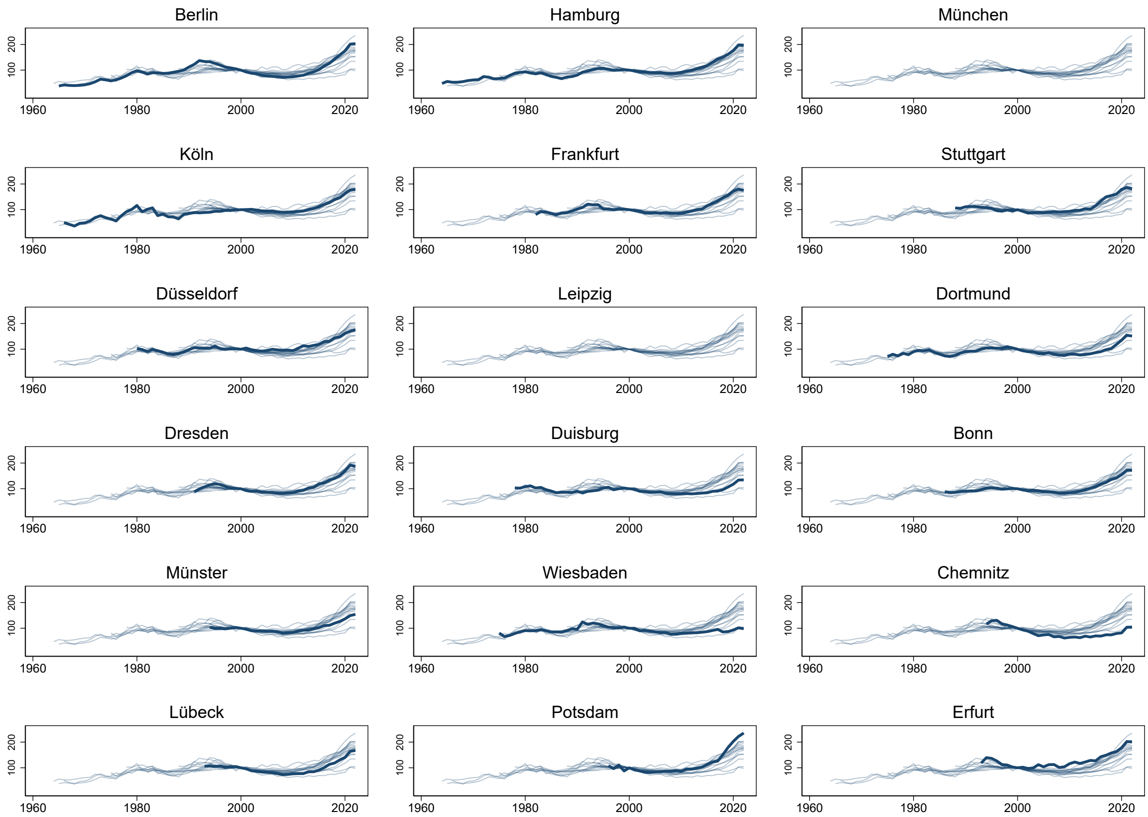
	2022 Q4 (y-o-y in %)		2023 Q1 (y-o-y in %)		Drop since peak (in %)	
City	**GREIXX**	**vdp**	**GREIXX**	**vdp**	**GREIXX**	**vdp**
Berlin	2.73	6.13	-3.10	-0.48	-5.98	-3.68
Hamburg	-5.08	0.24	-9.31	-4.85	-9.90	-6.58
Munich	-8.63	0.46	-9.83	-3.77	-11.59	-4.25
Cologne	-0.64	0.56	-6.14	-5.08	-8.95	-6.29
Frankfurt	-7.80	-1.91	-13.86	-8.43	-14.18	-9.44
Stuttgart	-9.47	-0.23	-10.27	-4.98	-10.94	-5.79
Duesseldorf	-5.33	2.70	-14.37	-4.15	-14.37	-5.81

Note: This table displays the yearly growth rates for the GREIXX and the vdp indices. For Munich the data displayed refer to 2022Q4 as data is missing for the first quarter of 2023.

C Evolution of housing prices in German cities

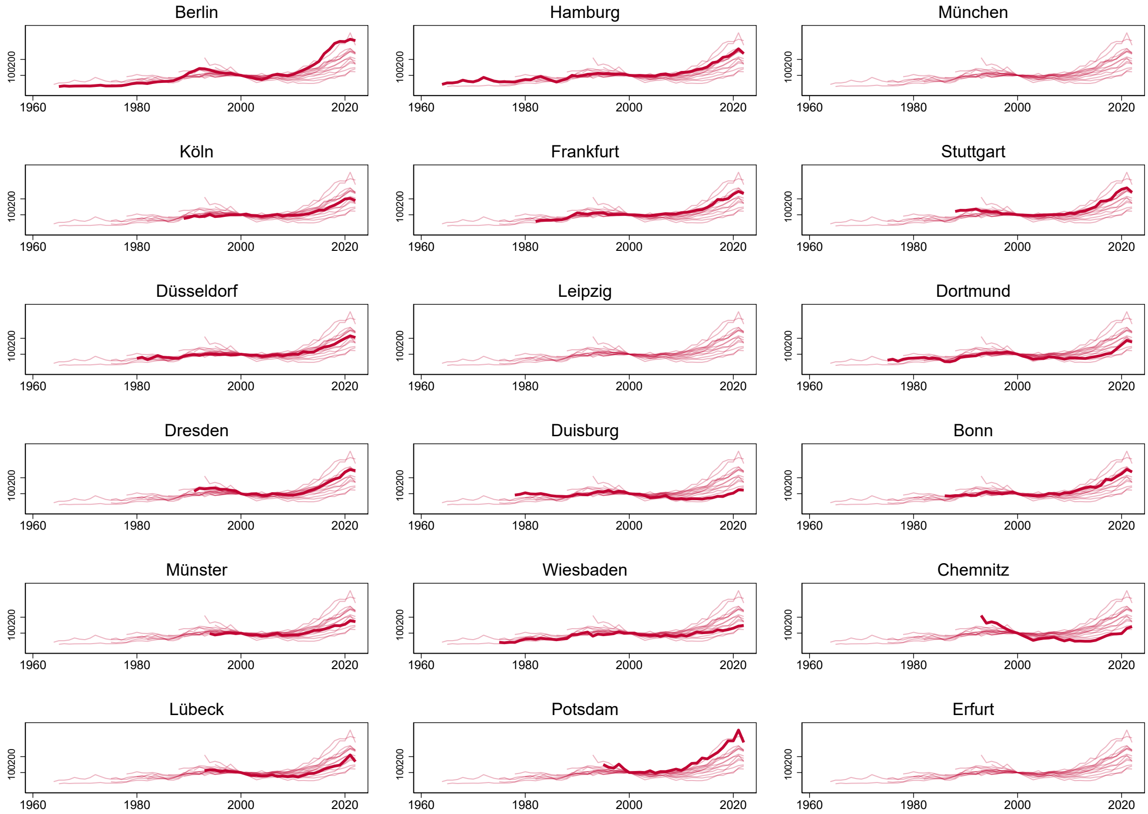
C.1 Long-run evolution of housing prices

Figure 27: *Real apartment price series by city, 1960-2022*



Note: The figure shows cpi-adjusted single-family hedonic price indices for all cities in our sample. The darker line always represents the price series for the respective city.

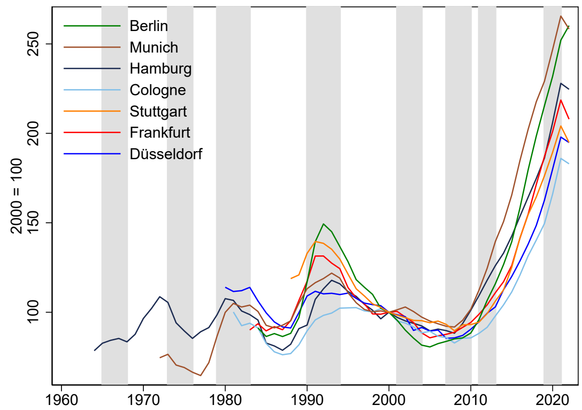
Figure 28: *Real multi-family price series by city, 1960-2022*



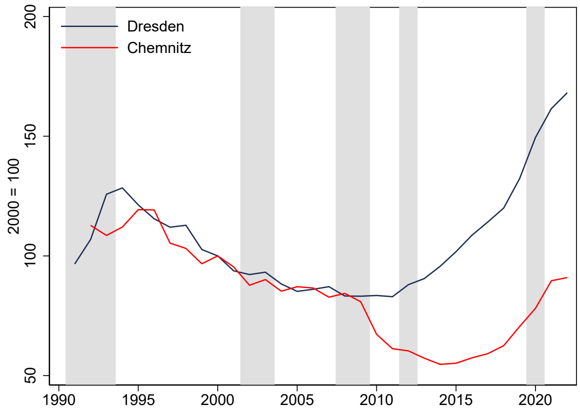
Note: The figure shows cpi-adjusted multi-family hedonic price indices for all cities in our sample. The darker line always represents the price series for the respective city.

Figure 29: *CPI-adjusted yearly house price indices for condos for different city classifications, 1960-2022*

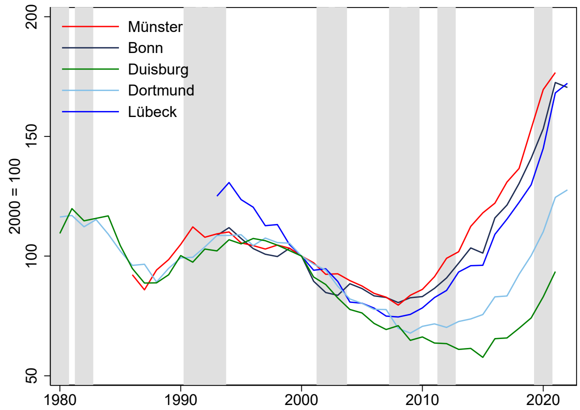
(a) *Top 7*



(b) *East*

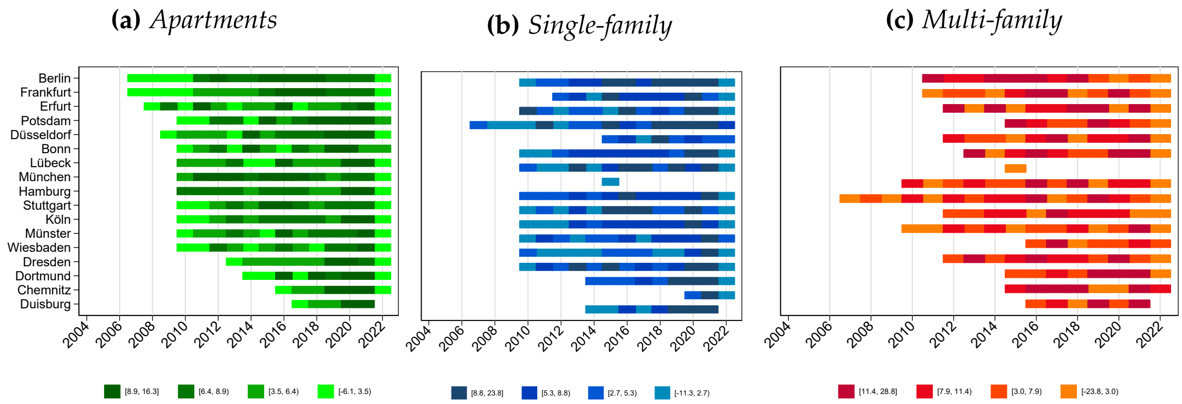


(c) *Medium and small cities*



Note: The figure shows real yearly housing price indices for condos for different cities. Shaded areas represent recessions in Germany according to the Bundesbank.

Figure 30: *Duration and intensity of boom by city and market segment*

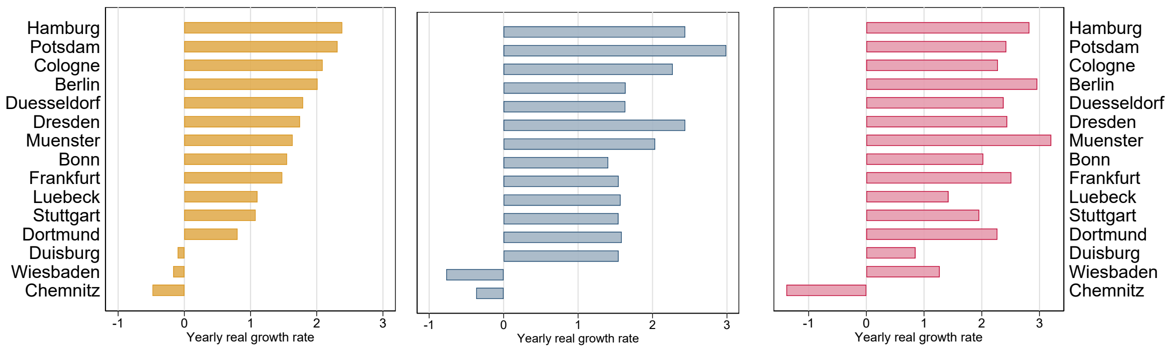


Note: This graph shows duration of the boom. We define the boom as the first period of three consecutive years with positive growth. The graph also shows the yearly real growth rates of apartments (Panel (a)), single-family houses (Panel (b)) and multi-family houses (Panel (c)) by different color shadings. Darker colors represent higher growth rates. Growth rates are measured in log points. The period covered is 2008 to 2022. Data for Munich is missing both for single-family as well as for multi-family housing.

C.2 Best performing markets

Figure 31: *Average real growth rate by city and segment since reunification*

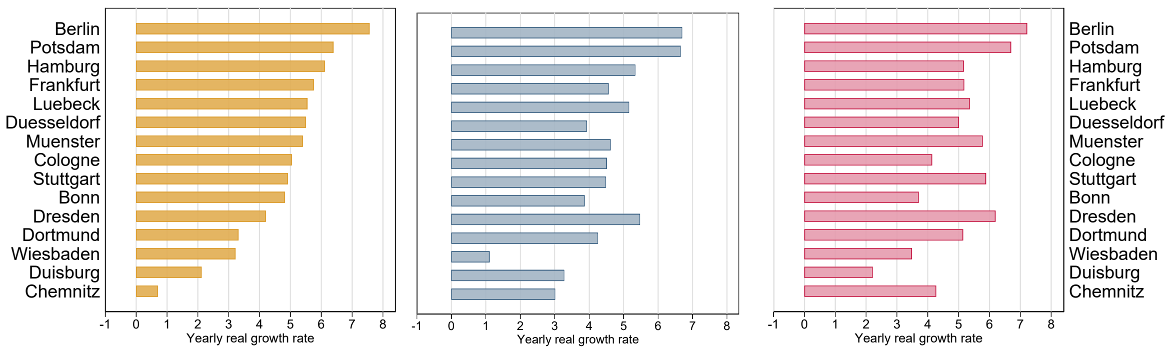
(a) *Condos* **(b)** *Single-family* **(c)** *Multi-family*



Note: This graph shows the mean yearly real growth rate of condos (Panel (a)), single-family houses (Panel (b)) and multi-family houses (Panel (c)). Growth rates are measured in log points. The period covered is 1992 to 2022.

Figure 32: *Average real growth rate by city and segment since 2008*

(a) *Condos* **(b)** *Single-family* **(c)** *Multi-family*



Note: This graph shows the mean yearly real growth rate of condos (Panel (a)), single-family houses (Panel (b)) and multi-family houses (Panel (c)). Growth rates are measured in log points. The period covered is 2008 to 2022.

C.2.1 Best-performing city

Table 12: *Cumulative apartment real price growth for by city and GREIX*

	Cumulative real price growth (in %)		
City	since 2000	since 2008	from peak
Berlin	160.2	205.9	-10.7
Potsdam*	156.4	161.6	-6.5
Munich*	156.3	179.4	-15.9
Hamburg	124.6	154.5	-16.2
Frankfurt	107.9	134.1	-21.1
Erfurt	103.0	128.6	-21.5
Stuttgart	94.9	117.4	-17.5
Duesseldorf	94.9	127.5	-20.9
Muenster*	86.4	134.4	-12.6
Cologne	83.0	121.0	-14.4
Luebeck	72.2	130.9	-8.6
Bonn	70.5	111.5	-7.2
Dresden	62.1	97.2	-12.4
Dortmund	27.7	82.8	-12.3
Wiesbaden*	15.7	68.0	-14.1
Chemnitz	-4.0	7.9	-16.8
Duisburg	-5.2	34.4	-10.1
GREIX	124.2	159.6	-15.0

*Note: Table reports cumulative apartment price growth between since 2000, 2008 and between peak and 2023q1 for all cities in our sample that start before 2000 in inflation-adjusted (real) terms. For the cities marked with a *, we calculate the drop from peak to 2022Q4, as we are missing data for the first quarter 2023 for these cities.*

Table 13: *Cumulative apartment nominal price growth for by city and GREIX*

	Cumulative nominal price growth (in %)		
City	since 2000	since 2008	from peak
Berlin	160.2	205.9	-6.0
Potsdam*	156.4	161.6	-3.1
Munich*	156.3	179.4	-8.6
Hamburg	124.6	154.5	-9.3
Frankfurt	107.9	134.1	-12.2
Erfurt	103.0	128.6	-15.0
Stuttgart	94.9	117.4	-9.1
Duesseldorf	94.9	127.5	-14.4
Muenster*	86.4	134.4	-9.4
Cologne	83.0	121.0	-5.6
Luebeck	72.2	130.9	-1.1
Bonn	70.5	111.5	-2.4
Dresden	62.1	97.2	-5.2
Dortmund	27.7	82.8	-7.8
Wiesbaden*	15.7	68.0	-8.4
Chemnitz	-4.0	7.9	-9.9
Duisburg	-5.2	34.4	-2.7
GREIX	225.6	227.8	-8.0

*Note: Table reports cumulative apartment price growth between since 2000, 2008 and between peak and 2023q1 for all cities in our sample that start before 2000 in nominal terms. For the cities marked with a *, we calculate the drop from peak to 2022Q4, as we are missing data for the first quarter 2023 for these cities.*

C.2.2 Best-performing neighborhood

Table 14: *Cumulative apartment price growth since 2000 for neighborhoods in Berlin*

	cumulative growth rate (in %)	
Neighborhood	Nominal	Real
Neukölln - Kreuzberg	373.6	226.1
Wedding - Gesundbrunnen	301.6	176.5
Charlottenburg	288.0	167.1
Prenzlauerberg	287.0	166.4
Mitte	282.4	163.3
Schöneberg - Friedenau	272.8	156.6
Wilmersdorf	269.5	154.4
Friedrichshain	266.9	152.6
Nord	233.4	129.5
Süd-Ost	212.4	115.0
Ost	212.0	114.8
Südwest	211.6	114.5
West	193.1	101.8

*Note: Table reports cumulative apartment price growth between 2000 and 2022 for all the neighborhoods within the city both in nominal as well as inflation-adjusted (real) terms. For the cities marked with a *, we calculate the drop from peak to 2022Q4, as we are missing data for the first quarter 2023 for these cities.*

Table 15: *Cumulative apartment price growth since 2000 for neighborhoods in Hamburg*

	cumulative growth rate (in %)	
Neighborhood	Nominal	Real
Eppendorf - Harvestehude	392.6	239.1
Altstadt - Hafen - Uhlenhorst	306.6	179.9
Altona - St. Pauli - Eimsbüttel	297.1	173.3
Barmbek	277.9	160.1
Bahrenfeld - Lokstedt	246.0	138.2
Sasel-Bergstedt	211.1	114.2
Blankenese - Othmarschen	206.9	111.3
Winterhude	192.4	101.3
Wandsbek	190.2	99.8
Bergedorf	188.0	98.2
Fuhlsbüttel - Eidelstedt - Sülldorf	177.2	90.8
Harburg	118.4	50.4

Note: Table reports cumulative apartment price growth between 2000 and 2022 for all the neighborhoods within the city both in nominal as well as inflation-adjusted (real) terms.

Table 16: *Cumulative apartment price growth since 2000 for neighborhoods in Munich*

	cumulative growth rate (in %)	
Neighborhood	Nominal	Real
Altstadt - Maxvorstadt	340.4	203.1
Isarvorstadt - Untersendling	315.1	185.7
Untergiesing - Au - Haidhausen	302.3	177.0
Schwabing - Bogenhausen	294.0	171.2
Nymphenburg - Neuhausen	271.2	155.6
Moosach - Milbertshofen	256.8	145.6
Thalkirchen - Forstenried	247.0	138.9
Feldmoching - Oberföhring	238.2	132.9
Perlach - Berg am Laim	234.7	130.4
Daglfing - Trudering	225.1	123.8
Aubing - Laim - Pasing	222.6	122.1

Note: Table reports cumulative apartment price growth between 2000 and 2022 for all the neighborhoods within the city both in nominal as well as inflation-adjusted (real) terms.

Table 17: *Cumulative apartment price growth since 2000 for neighborhoods in Cologne*

	cumulative growth rate (in %)	
Neighborhood	Nominal	Real
Innenstadt	223.3	122.5
Ehrenfeld	196.0	103.8
Nippes	166.2	83.2
Lindenthal	152.8	74.0
Kalk	150.9	72.7
Mülheim	146.0	69.3
Rodenkirchen	140.1	65.3
Porz	128.6	57.4
Chorweiler	120.9	52.1

Note: Table reports cumulative apartment price growth between 2000 and 2022 for all the neighborhoods within the city both in nominal as well as inflation-adjusted (real) terms.

Table 18: *Cumulative apartment price growth since 2000 for neighborhoods in Frankfurt*

	cumulative growth rate (in %)	
Neighborhood	Nominal	Real
Mitte-West	259.1	147.2
Westend/Innenstadt	237.0	132.0
Borneheim-Ostend	227.8	125.7
Norden	206.7	111.2
Süden	194.0	102.4
West-Autobahn	169.5	85.6
Osten	164.8	82.3
Mitte-Nord	164.0	81.7
Nord-West	131.2	59.2

Note: Table reports cumulative apartment price growth between 2000 and 2022 for all the neighborhoods within the city both in nominal as well as inflation-adjusted (real) terms.

Table 19: *Cumulative apartment price growth since 2000 for neighborhoods in Stuttgart*

	cumulative growth rate (in %)	
Neighborhood	Nominal	Real
Stuttgart Süd	230.1	127.2
Stuttgart West - Botnang	217.8	118.7
Stuttgart Ost	214.4	116.4
Stuttgart Mitte-Nord	197.8	105.0
Vaihingen	182.2	94.3
Bad Cannstatt	177.5	91.1
Feuerbach-Weilimdorf	173.3	88.2
Neckar Nord - Zuffenhausen	161.0	79.7
Degerloch - Sillenbuch	147.9	70.6
Plieningen - Möhringen - Birkach	147.1	70.1
Neckar Ost	142.4	66.9

Note: Table reports cumulative apartment price growth between 2000 and 2022 for all the neighborhoods within the city both in nominal as well as inflation-adjusted (real) terms.

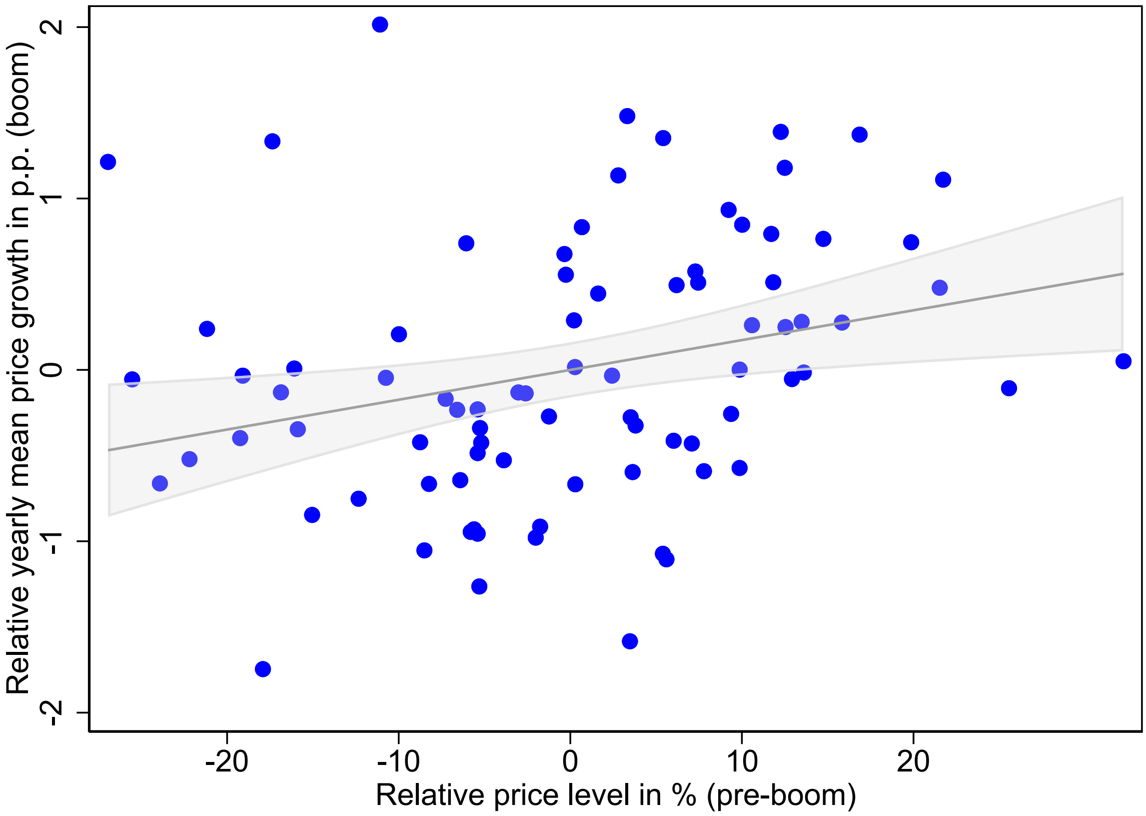
Table 20: *Cumulative apartment price growth since 2000 for neighborhoods in Duesseldorf*

	cumulative growth rate (in %)	
Neighborhood	Nominal	Real
Altstadt - Stadtmitte	235.8	131.1
Unterbilk - Hafen - Friedrichstadt	224.0	123.1
Oberkassel	212.8	115.4
Golzheim - Derendorf	212.3	115.0
Düsseltal - Flingern	196.1	103.8
Bilk - Oberbilk	189.0	98.9
Ludenberg - Gerresheim	166.0	83.1
Kaiserswerth - Rath	163.5	81.4
Benrath - Himmelgeist	154.1	74.9
Eller - Vennhausen	138.2	64.0

Note: Table reports cumulative apartment price growth between 2000 and 2022 for all the neighborhoods within the city both in nominal as well as inflation-adjusted (real) terms.

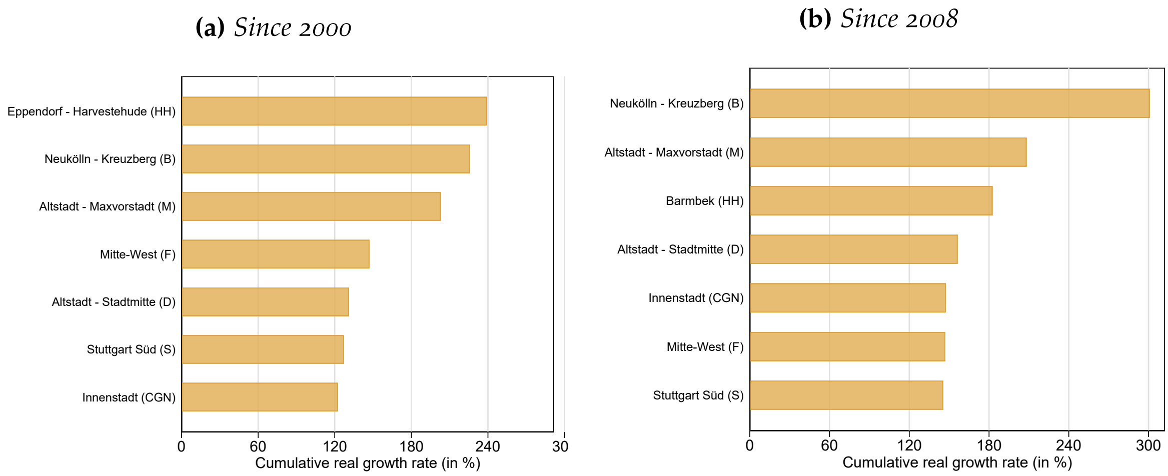
C.3 Neighborhood-level evidence

Figure 33: *Nominal house price growth for apartments vs initial price level by neighborhoods*



Note: The figure shows the neighborhood relative average yearly log nominal price growth to the city mean during the last housing price boom in Germany and the initial relative price difference to the city mean for the period for the four years before the start of the boom. The start of the boom phase is defined by city as the first period of 3 successive years of positive growth.

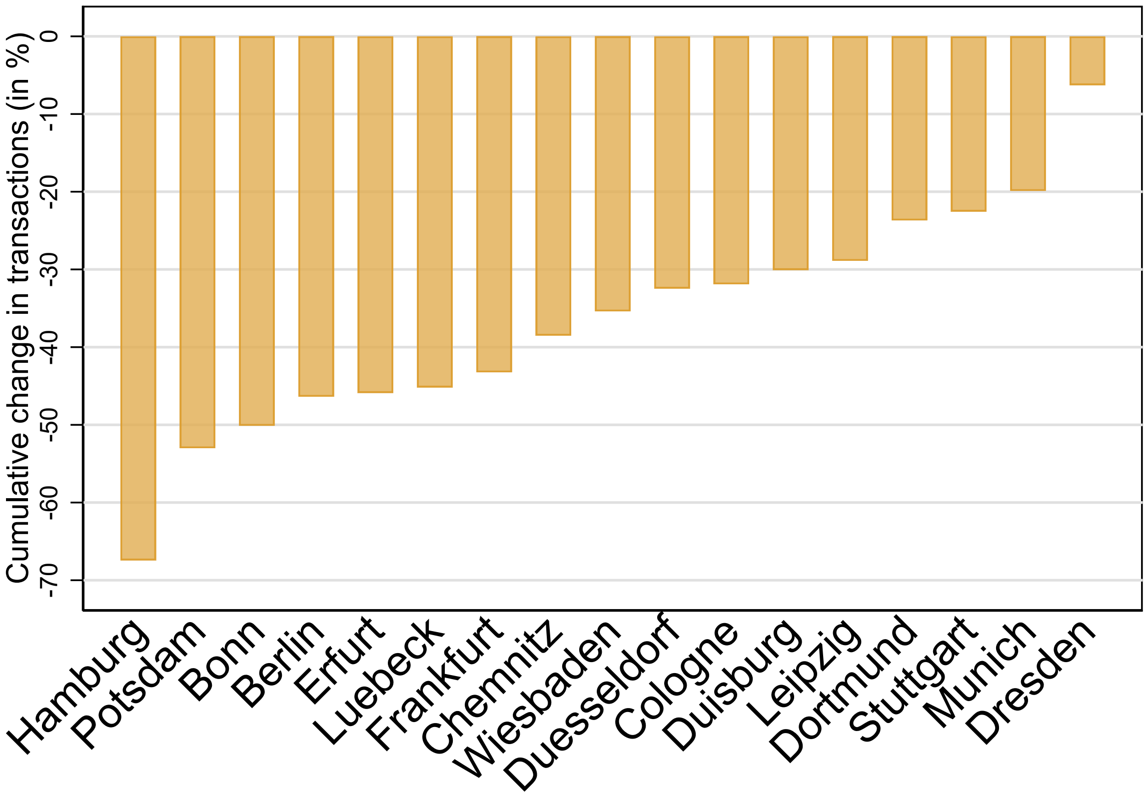
Figure 34: *Cumulative price growth for best neighborhoods in top-7 cities*



Note: This graph shows the cumulative CPI-adjusted growth rate of prices for apartments for the seven best-performing neighborhoods in the seven largest cities in Germany since reunification (Panel (a)) and since 2008 (Panel (b)).

D Price Correction

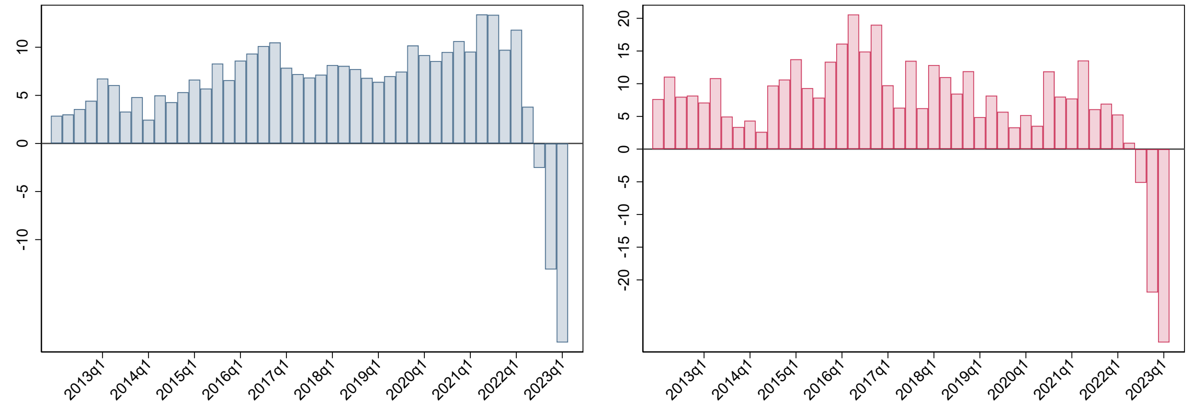
Figure 35: *Change in total number of apartment transactions between 2021Q4 and 2022Q4*



Note: Percentual change in the number of registered apartment transactions between 2021q4 and 2022q4.

Figure 36: *Price growth GREIX - single-family and multi-family, 2012q1 - 2023q1*

(a) *Single-family* **(b)** *Multi-family*



Note: Panel (a) displays the CPI-adjusted yearly growth rate in the quarterly Condos GREIX. Panel (b) presents the number of transactions per quarter after cleaning. Please note that the figures for the first quarter of 2023 are still provisional as the Gutachterausschüsse are currently in the process of collecting data.

E Nowcast

E.1 Nowcasting 2023q2

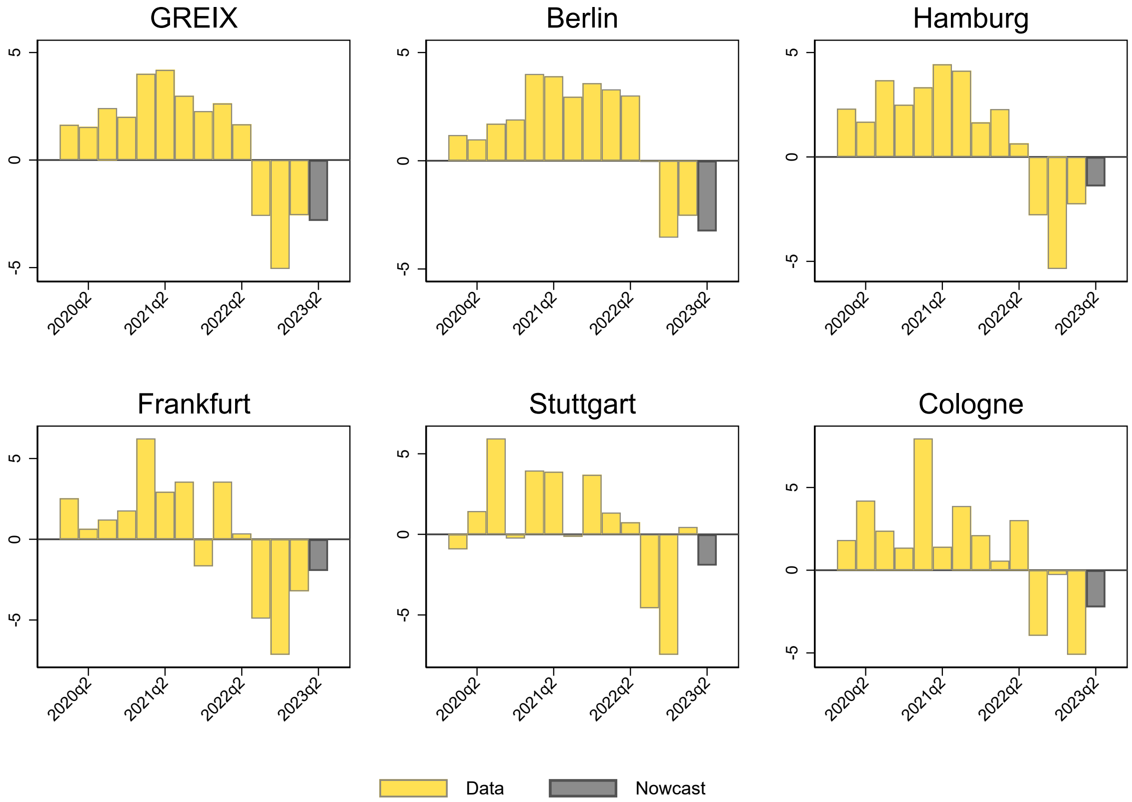
Table 21: *Quarterly nominal growth rates and fall from peak for apartments*

City	22Q4-23Q1	Peak-23Q1	23Q1-23Q2	Peak-23Q2
Erfurt	-12.7	-15.9	-3.0	-18.5
Duesseldorf	-5.5	-14.4	-1.5	-15.7
Frankfurt	-3.2	-14.2	-2.0	-15.9
Stuttgart	0.5	-10.9	-1.6	-12.4
Chemnitz	-9.2	-10.0	-1.4	-11.2
Hamburg	-2.3	-9.9	-0.6	-10.5
Cologne	-5.1	-9.0	-1.1	-9.9
Dortmund	0.0	-7.8	-0.8	-8.5
Dresden	-2.2	-6.8	-1.4	-8.1
Berlin	-2.5	-6.0	-3.1	-8.9
Duisburg	-2.3	-2.6	-0.5	-3.1
Bonn	5.7	-2.4	0.3	-2.0
Luebeck	3.4	-1.1	-0.1	-1.2
GREIX	-2.7	-9.5	-2.2	-11.5

Note: Table reports quarterly growth rates and cumulative growth rates between peak and first quarter of 2023 and second quarter of 2023. Values for second quarter are based on nowcasting model.

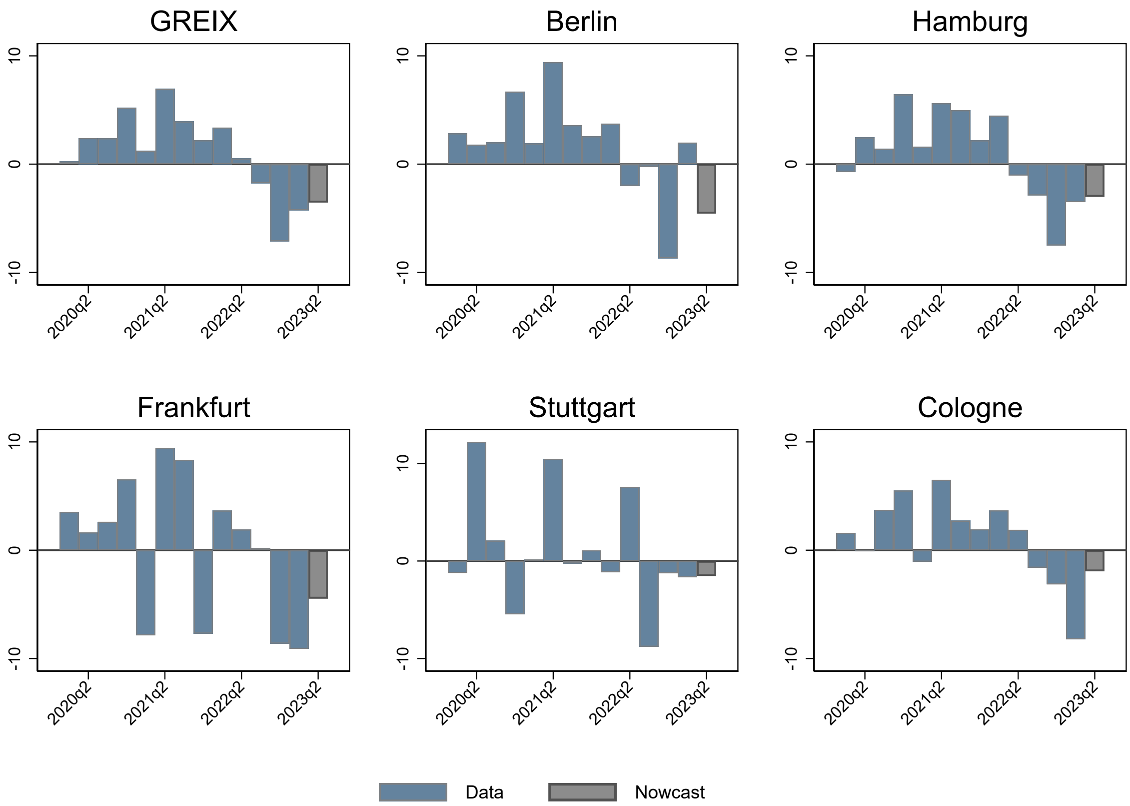
E.2 Nowcast qoq using data since 2000

Figure 37: *Nominal quarterly price growth for apartments by city, 2018q1-2023q2*



Note: The figure shows q-o-q nominal growth rates for apartments for the period between 2018q1 and 2023q2. The growth rate for 2023q2 is nowcasted using a dynamic factor model estimated with data since 2000.

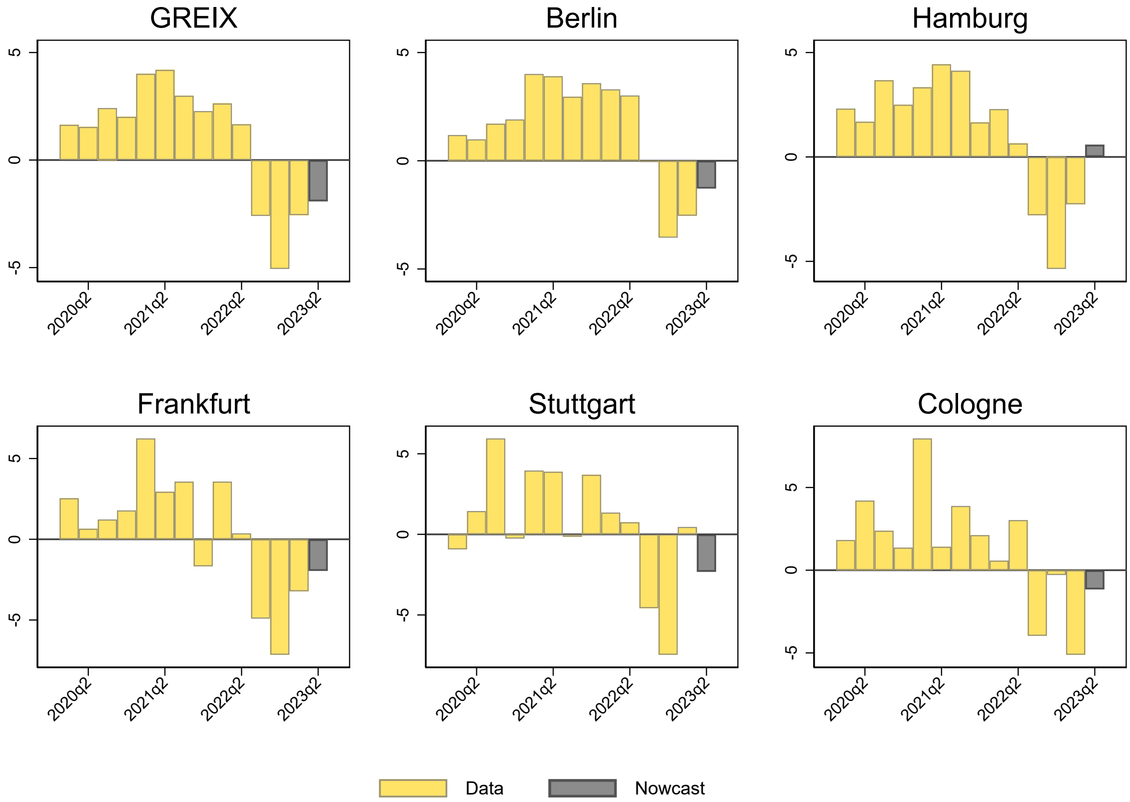
Figure 38: *Nominal quarterly price growth for apartments by city, 2018q1-2023q2*



Note: The figure shows q-o-q nominal growth rates for single-family housing for the period between 2018q1 and 2023q2. The growth rate for 2023q2 is nowcasted using a dynamic factor model estimated with data since 2000.

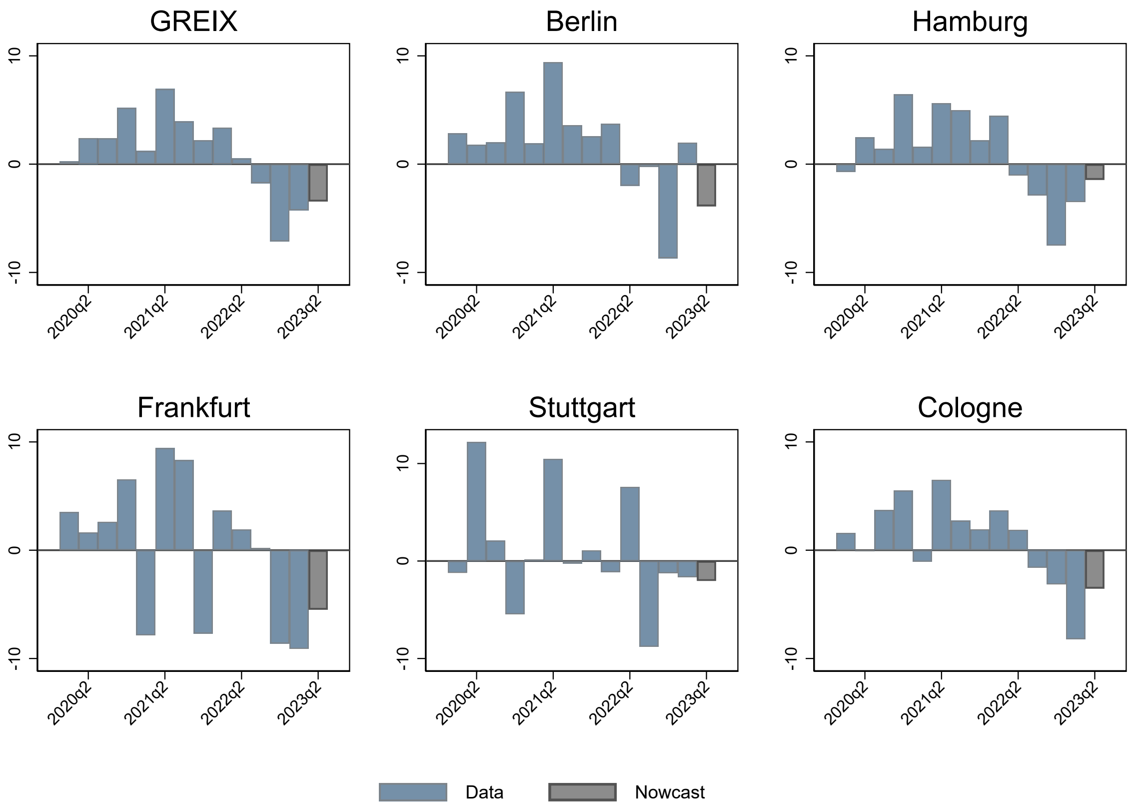
E.3 Nowcast qoq using data since 2005

Figure 39: *Nominal quarterly price growth for apartments by city, 2018q1-2023q2*



Note: The figure shows q-o-q nominal growth rates for apartments for the period between 2018q1 and 2023q2. The growth rate for 2023q2 is nowcasted using a dynamic factor model estimated with data since 2005.

Figure 40: *Nominal quarterly price growth for single-family by city, 2018q1-2023q2*



Note: The figure shows q-o-q nominal growth rates for single-family for the period between 2018q1 and 2023q2. The growth rate for 2023q2 is nowcasted using a dynamic factor model estimated with data since 2005.