Subsidies to Homeownership and Central City Rent

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Abstract. This paper analyzes the effects of German homeownership subsidies on the intra-city rent structure. Using a large-scale micro data set on German rent offerings, I first construct novel city rent indexes that include various rings around cities' CBDs. Using triple differences (TD) frameworks, I then estimate the introduction of the homeownership subsidies' effects on rent for the cities that received varying subsidy rates. The empirical results indicate that subsidies to homeownership lower central apartment rent premiums in those cities, where they give the "biggest bang for the buck". Consequently, I find that homeownership subsidies contribute to an increase in housing affordability through the price changes in the rental market: an increase in the subsidies leads potential homeowners to move away from the CBD, resulting in a decrease in the rental demand and lowering the rent.

Keywords: homeownership, housing subsidies, homeownership subsidy, triple differences
JEL Codes: H22, H71, R31, R38

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1 Introduction

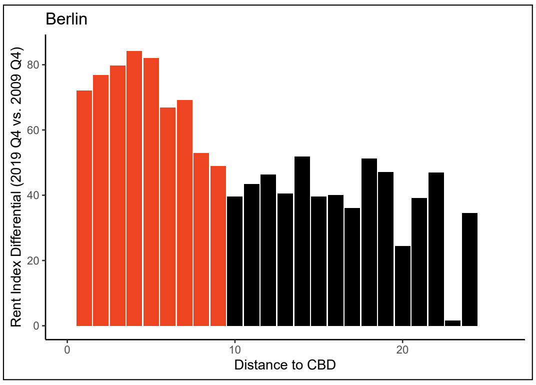
Surging rents and house prices in German cities have urged politicians to think about political countermeasures. Among calls for controlling rent or regulating housing companies, the focus also shifted to promoting owner-occupied housing. With its previous homeownership subsidy ("Eigenheimzulage") repealed in 2006, Germany revived its subsidies to homeownership in 2018. First-time homeowners–the targeted group of this homeownership subsidy–change their tenure from renting to owning, inducing a negative demand shock in rental housing markets. Tenure is closely linked to location, with rental housing almost exclusively located in apartments in multi-family houses, and thus near the city center. This paper provides an empirical test to the hypothesis that homeownership subsidies reduce demand for rental housing in central areas and thus reduce central apartment rents.

More specifically, I contribute to the literature in two ways. First, to the best of my knowledge, this paper is the first to analyze the effects of a lump sum homeownership subsidy on rents. Second, I construct a data set of the spatial structure of intra-city rents using a large micro-data set on apartment advertisements in 105 major German cities. I identify the subsidy's effects on cities' spatial rent structure by exploiting its design, which neither differentiated across cities nor across size nor across characteristics of the property. Although nominally solely depending on the number of children of the subsidy receiver, in real terms, it benefited prospective owner-occupiers in more affordable cities most, drawing them from central rental to peripheral owner-occupied housing. The results of several triple difference (TD) comparisons, exploiting variation in timing, intra-city apartment location, and inter-city levels of affordability, indicate that central city rent premium significantly fell with subsidy introduction.

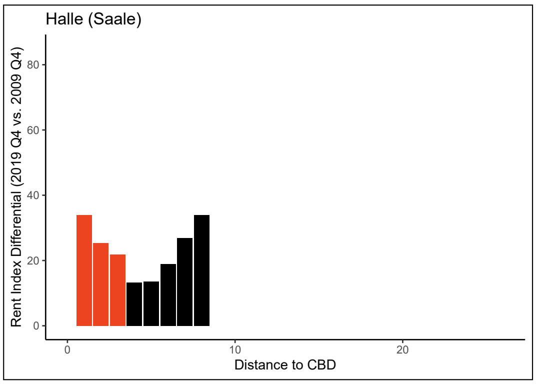
Homeowners predominantly occupy single and two-family houses, and those tend to be outside a city center.[1] Subsides to homeownership thus induce population flows from (central) rental to (peripheral) owner-occupied housing, as documented in Daminger and Dascher (2020).[2] Their paper analyzes intra-city population flows in the wake of

[1] Hilber (2007) finds that a detached house is substantially more likely to be owner-occupied than an apartment in a multi-family building. Ahlfeldt and Maennig (2015) document that close to 80% of one- and two-family houses are owner-occupied.

[2] And this is also true for the specific subsidy under review in this paper: According to an interim status report, until May 2020 (i.e. after roughly 4/5 of the planned program duration) close to 85% of all subsidy applications were for the purchase or construction of houses with the small remainder being applications for apartments.



Berlin, 2009-2019



Halle, 2009-2019

Figure 1: Rent Index Differential in Rings

Note: This figure has the ring rent index differential between Q3-2009 and Q3-2019 for the city of Berlin on the left and the city of Halle an der Saale on the right. Every bar has the rent differential (y-axis) as a function of the distance to the city center (x-axis). While central rings (orange) apartment rent growth overshadowed that of decentral rings in Berlin, this was not the case for, the substantially smaller and more affordable, city of Halle an der Saale. Source: Author's calculations.

a similar subsidy's removal and finds that the removal steers people to live in the city center, contributing to a "central living renaissance". This paper follows up the analysis and documents changes in the spatial rent structure in the wake of a homeownership subsidy introduction. As new owner-occupiers at the peripheries have been city-center renters before, their move into homeownership corresponds to a negative demand shock in central rental markets.

Baum-Snow and Han (2021) find that the housing supply elasticity is lowest near the city center and increases monotonically with distance to the center, meaning that in positive demand shocks, housing in central areas cannot be added swiftly enough and results in price rather than quantity changes. In negative demand shocks however housing can, at least in the short term, not simply be demolished, resulting in a supply curve that is "kinked downwards" (Glaeser and Gyourko 2005). Consequently, negative demand shocks–which I suspect the homeownership subsidy to trigger in central rental markets–will result in higher vacancies and lower (housing service) prices, i.e. rents.[3]

Figure 1 visualizes rent development in city rings over time for two selected cities, Berlin on the left and the (substantially smaller, more affordable) city of Halle in the German

[3]As only prospective owner-occupiers without prior real estate ownership in Germany are eligible for the subsidy, they truly must have been renters before.

state of Saxony-Anhalt on the right. Each bar represents the rent index differential between 2009 Q4 and 2019 Q4 (and thus enveloping policy introduction in 2018 Q3) for a concentric [j, j+1)-km ring around the respective city's CBD. Bars in red belong to central while those in black belong to peripheral rings.[4] The figure not only reveals that, compared to each city ring's respective baseline rent in 2009 Q4, Berlin experienced significantly larger increases in rents. It also shows that, while the biggest rent increases in expensive Berlin had to be endured by new tenants in central apartments, more affordable Halle saw this high rent increases not exclusively in the city's center. While renters wanting to live in Berlin's center rather than at its outskirts clearly had to pay an increasing premium for that location choice, this does not apply to the same extent in Halle. This advantage (and its development) of central rents over peripheral rents can be paraphrased as "central rent premium" (development), and exploring it in the course of subsidy introduction is the main subject of this paper.

The differing central rent premium development by city affordability is not restricted only to these two example cities in Figure 1 but can be identified as a pattern in the whole sample of cities. Subsidy amount is tied to the number of children and is thus fixed in nominal terms, but of course not in real terms. Families in affordable cities benefit more than their counterparts in expensive cities, where the subsidy in real terms is just a "drop in the bucket". Affordable cities' families use the subsidy to move into their owner-occupied home at the outskirts, lowering demand for (predominantly central) rental apartments and thus this segment's rents. What this paper now argues is that, had federal government not introduced the homeownership subsidy, affordable cities' central rent premium developments would have followed the same pattern as that of their expensive peers. Halle's central apartment rent increase thus would have greatly outpaced its peripheral rent increases, similar to Berlin's development. In my regression analyses, controlling for many other (partly unobservable) factors that drive rental markets, I find that the central rent premium of affordable cities, compared with their expensive peers, rises *less* strongly with subsidy introduction. In that sense, subsidy introduction *dampened* central rent premium surge in affordable cities while expensive cities have not experienced a similar relief.

This paper contributes to two distinct strands of the literature: Previous work that deals with the effects of housing subsidies on prices by e.g. Sommer and Sullivan (2018), Davis (2019) or Hilber and Turner (2014) shows that subsidizing homeownership through

[4]Here, central rings are defined as rings within the first third of all of a city's rings.

the tax code might result in rising house prices, with Carozzi et al. (2020) or Krolage (2020) finding the same for direct homeownership subsidies. Effects of rental subsidies on apartment rents are studied by Eerola and Lyytikäinen (2021), Gibbons and Manning (2006) or Eriksen and Ross (2015). They find substantial subsidy capitalization in rents. Braakmann and McDonald (2020) study the effect of rental subsidies on house prices with the same result of subsidy capitalization in prices. This paper attempts to fill a gap in this literature by analyzing the impact of lump sum *homeownership* subsidies on *rents*. But it also adds to the literature dealing with homeownership subsidies' spatial implications, such as Muth (1967), Glaeser (2011) or Daminger and Dascher (2020). If, as this strand argues, subsidies to homeownership contribute to suburban living, these population ("goods") shifts should also translate into shifts in associated (relative) market prices.

Additionally, this contribution seeks to complement the literature that deals with housing supply's price and rent implications. Mense (2021) shows that total new housing supply, i.e. housing for both tenure types, reduces rents throughout the rent distribution. Germany's subsidy provided a link between the two tenures by incentivizing moves from rental to owner-occupied housing. And although both new and existing owner-occupied housing units have been subsidized, a substantial portion of the subsidy has been used to build new housing units. Through this filtering mechanism from rental to owner-occupied housing, the subsidy has relieved pressure on rental markets by encouraging a move to owner-occupied homes.

The paper has six sections. Section 2 introduces the subsidy design. Section 3 describes the empirical data, explains the construction of the panel of city-ring-quarter/year rent indexes and presents some graphic representations of intra-city rent development. Section 4 turns to the empirical analysis, which identifies the subsidy introduction's effects on the spatial structure of city rents by exploiting different treatment intensities by city affordability. Section 5 presents the results, finding that subsidy introduction dampened affordable cities' central rent premium growth. Section 6 concludes and provides some policy implications.

2 Context and Program Description

Four phases in subsidizing homeownership can be distinguished in Germany post World War II: In a first phase (1949–1995), investments in owner-occupied housing were tax-deductible. Phase 2 (1996–2005) consisted of a direct subsidy for purchasing or constructing owner-occupied housing (*Eigenheimzulage* or EZ for short). The EZ was repealed at the end of 2005 without replacement. In the following twelve years (2006–2017), the third phase, there was no distinct federal policy to promote homeownership. In 2018, a new support program (*Baukindergeld*, or BK for short) was introduced, which pays out subsidies to households with children for the construction and purchase of owner-occupied housing.

This paper examines the transition from phase three to phase four, the introduction of BK in 2018. Table 1 shows the main characteristics of the subsidy. All households with at least one child in custody are eligible. The taxable income of households with one child may not exceed € 90,000, with this threshold being increased by € 15,000 with each additional child. The subsidy promotes the purchase of owner-occupied condos and houses, both newly built and existing.

On June 26, 2018, the coalition committee of the Federal Government agreed that the BK should be granted retroactively as of January 1, 2018 and until December 31, 2020. This meant that only properties for which the purchase agreement had been signed by December 31, 2020 or, in the case of new buildings, for which planning permission had been granted by this date, were eligible.[5] On July 5, 2018, the German Bundestag passed the corresponding legislative resolution. Since September 18, 2018, applications can be submitted to *Kreditanstalt für Wiederaufbau (KfW)*, a German state-owned development bank. According to the KfW, applications can be submitted until December 31, 2023 at the latest. The BK represented a huge part of the federal subsidy budget: A total of just under € 10 billion is earmarked for the three-year program, while only around € 5 billion were planned for social housing construction in the entire legislative period (four years).

The individual subsidy amount is based solely on the number of children, with a (program total) amount of € 12,000 being paid for each child in the household. The subsidy is not a one-time payment but is spread evenly over a period of ten years. The BK is,

[5]With the coronavirus outbreak delaying many building permit processes, this deadline has been extended to March 31, 2021.

Table 1: Design of Baukindergeld (BK)

Beneficiary	Entitled beneficiary	Households with children
	Maximum taxable hh. income	€ 90,000
	Threshold increase per child	€ 15,000
Object	Subsidized property	Owner-occupied housing (house & condo / new & existing)
Subsidy	Funding start	Year of move-in
	Funding period	9 subsequent years
	Assessment basis	Number of children
	Yearly subsidy amount (per child)	€ 1,200

Note: This table has the features of Germany's homeownership subsidy called "Baukindergeld". The rather unique aspect of the subsidy is that it is solely tied to the number of children living in the household, handing out a total of € 12,000 per child over the course of ten years. Applications (and payments) were tied to actual occupancy of the owner-occupied housing, making it possible to submit the application only after moving in. Source: Kreditanstalt für Wiederaufbau (KfW).

in nominal terms, equally granted, i.e. irrespective of the location of the property. To illustrate the importance of the BK in financing homeownership, I take the example of a family with two children who is eligible for support. This family receives a subsidy of € 24,000 for both, either the purchase of an existing property or the construction of a new home. If it purchases a property in an expensive city for e.g. € 200,000, the share of the subsidy in investment costs is 12%. If, on the other hand, it buys a comparable property in an affordable city for half the price, the share of the subsidy is doubled, to 24%. This illustrates that, although the subsidy is the same in nominal terms everywhere, the real subsidy rate varies greatly with property price and hence a city's real estate affordability.[6]

It should be emphasized that the application for BK was downstream and was only possible after the owner-occupied home was actually occupied. Thus, in the case of the purchase of existing housing, the move must have already taken place, while in the case of new construction, both construction and move-in must have taken place. While new construction naturally takes longer than simply moving into an existing home, both result in a negative demand shock to the rental housing market. Thus, the expectation is

[6] As much as I would like to infer the spatial distribution of subsidy take-up, and thus the intensity of treatment, directly from micro data, these are not available to me.

that effects on the rental market in the short run–for the first quarters–will arise from moves into existing housing, while in the longer run the effects of new construction add on as well.[7]

3 Data and Rent Index Construction

3.1 Data

I use data from several sources to analyze the intra-city development of rents in all German urban municipalities (*Kreisfreie Städte*). Rental advertisement data is from the Ruhr Research Data Center at the RWI - Leibniz Institute for Economic Research.[8] It contains all rental apartment advertisements and their characteristics from Germany's largest real estate platform immobilienscout24.de from 2008 Q1–2020 Q1.[9]

Usually, a property's geographic coordinates would be used to spatially locate it in a city area. Unfortunately, exact coordinates of the advertised properties are missing in the data. For the 2011 census however, the surface of Germany was overlaid virtually with a 1x1-km grid to enable data analyses independent of administrative boundaries. Real estate ad data includes information on the assignment of properties to census grid cells.[10] Geographic information system (GIS) steps proceed as follows: Whenever possible, I define city hall as the Central Business District (CBD).[11] Using GIS-techniques, I determine the centroid of each grid cell located within an administrative city boundary. Next, I determine the linear distance between each cell centroid and the CBD, and group

[7] And this is also what early descriptive statistics from the regional building society (*Landesbausparkasse*) about the uptake confirm: For the few months in 2018, the share of subsidy applications for new owner-occupied homes in all applications of 2018 was 14%, while it rose to 27% in 2019 and to 32% for the first months of 2020.

[8] In Germany, rents are not officially registered or consolidated. I use the asking rent at the end of an advertisement's term (creators can adjust the asking rent during the ad's time on the platform), as I assume that to be very close on the actual contractually agreed rent. Additionally note that negotiating rents is uncommon in Germany.

[9] The market for rental houses is hardly existent in Germany. Though I also have data on that market, this partial data set has too few observations to estimate effects on city ring level consistently. Additonally note that the latest rental observations in my data set are from February 2020 and thus predate the coronavirus outbreak in Germany.

[10] GIS shapefiles describing the administrative boundaries and the census grid come from the Federal and State Statistical Offices.

[11] Some cities do not have a (historical) city hall. In these cases, I choose the historical marketplace or a building or square that can reasonably be considered part of the city's nucleus. Holian (2019) confirms for the US that city hall is a relatively accurate measure of CBD location.

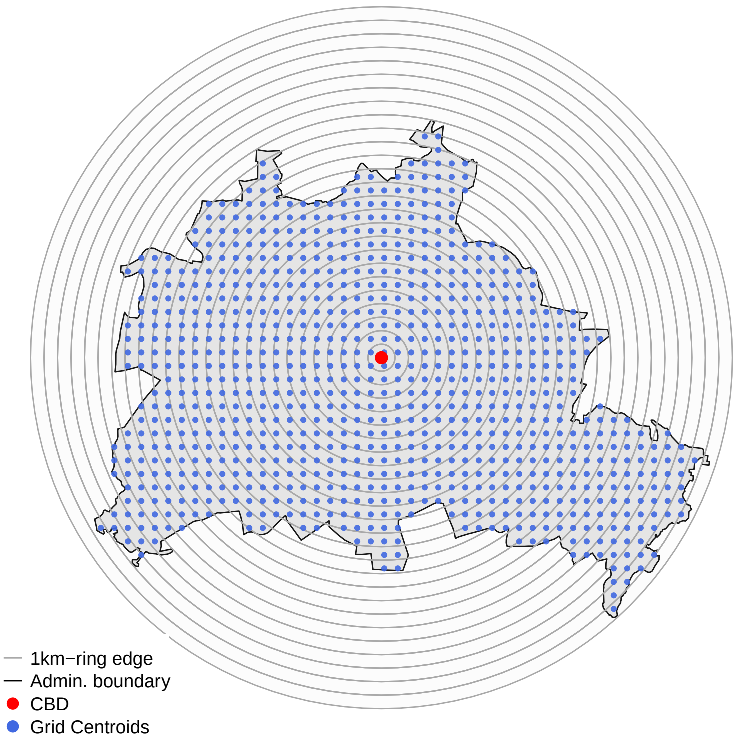


Figure 2: Assignment of census grid cells to distance rings

Note: This figure shows the assignment of apartments to city rings in Berlin. The black solid line marks Berlin's administrative boundary, grey solid lines mark boundaries of 1km-wide rings, blue dots are the centroids of 1x1km grid-cells, and the red dot marks the CBD. Apartments in a specific grid are assigned to the distance ring the grid's centroid lies in. Source: Author's illustration using shapefiles from the Federal Agency for Carthography and Geodesy.

the grid cells into 1-km wide rings around the CBD.

Figure 2 visualizes the assignment of grid cells to these distance rings using Berlin as an example. It shows the CBD (*Rotes Rathaus*, red dot) within the administrative borders of Berlin. The blue dots are all centroids of 1x1km grid cells within Berlin's administrative boundaries. Starting from the CBD, cell centroids are aggregated into $j = \{1, \ldots, J\}$ 1km-wide concentric rings. Each real estate ad is assigned to the distance ring in which its grid cell (centroid) is located.

Table 2 shows descriptive statistics for the data set. In total, roughly 9.5 million observations are used to calculate ring rent indexes. The average apartment has a monthly net rent of €571 and about 70 square meters of living space spread over 2.5

Table 2: Descriptive Statistics of Rent Data

Property-related Variables			City-related variables		
Variable	Mean	Std. Dev.	No. of ...	Mean	Std. Dev.
Net Rent [in €]	571.37	416.26	Obs. per City	87,840	182,071
Living Space [in sqm]	70.69	29.97	Obs. per Quarter	195,400	33,214
Number of Rooms	2.52	0.96	Obs. per Ring	354,615	510,733
Year of Construction	1968	30.86	Obs. per City per Quarter	1,531	464
Distance to CBD [in km]	4.87	3.43	Obs. per City per Ring	8,473	19,040
Balcony [D]	0.60	0.49	Obs. per Quarter per Ring	7,586	10,589
Garden [D]	0.16	0.37	Obs. per City per Quarter per Ring	196.55	444.49
Guest Bath [D]	0.19	0.32			
Fitted Kitchen [D]	0.35	0.48			
Cellar [D]	0.54	0.50			
First Occupancy [D]	0.09	0.29			
Number of Cities: 109					
Number of Rental Advertisements: 9,574,605					
Number of Quarters: 49					

Note: This table has descriptives on the rent data. Dummy variables are indicated by [D]. Data: Author's calculation using RWI's dataset "RWI-GEO-RED: Real Estate Data".

rooms. More than half of the apartments have a balcony or access to a cellar, while only 16% have access to a garden. Confidence in the representativeness of the sample is strengthened by the average year of construction (1968) and the fact that more than 90% of apartments are not first-time occupied; the sample is therefore not crowded by recently built and renovated apartments that might experience a separate rent premium and could distort rent indexes. The right panel of Table 2 shows city or, more precisely, index-related descriptives. It dispels concerns that data scope is not sufficient for index construction: On average, each city's rings have roughly 200 rental observations per quarter that can be used for the estimation.[12]

3.2 Hedonic Rent Index Construction

Next, I estimate hedonic rent regressions on the city level and separately for all cities in the sample.[13] The aim of the ring rent indexes computed from these regressions is to measure rent development over successive periods, controlling for quality characteristics of the apartment. Hence, the computed indexes use constant property characteristics and

[12] Although it has to be noted that the standard deviation is rather large - central rings in Berlin of course have significantly more apartment offerings each quarter than peripheral rings of small Schweinfurt.

[13] A joint hedonic regression of all cities with all rings at all points in time would require enormous computing power. It is reasonable to consider each city as a closed real estate market.

show the pure price changes over time. I construct rent indexes P_j^t using the Hedonic Dummy (HD) approach, which directly shows the marginal change in quality-adjusted price with respect to time t and ring j. Using a log-linear model, the estimated coefficients of the time and ring fixed effects refer to the marginal percentage change in rents in period t^t and ring j_j relative to period t^0 and ring j_1. Thus, a transformation of the estimated coefficients directly yields ring rent index P_j^t.[14]

The hedonic regression is given as

$$E\left(\mathrm{y}_{hj}^t|\mathrm{x}_{hj}^t\right) = \alpha + \sum_{k=1}^{K} \beta_k \, \mathrm{z}_{hjk}^t + \sum_{j=2}^{J} \gamma_j \, \mathrm{RING}_{hj} + \sum_{t=1}^{T} \theta^t \, \mathrm{TIME}_h^t + \sum_{j=2,t=1}^{J,T} \lambda_j^t \, \mathrm{RING}_{hj} \times \mathrm{TIME}_h^t \,, \tag{1}$$

where the dependent variable y is the log net rent of real estate ad h in ring j at time t. K characteristics of property h are contained in vector z[15]. $\mathrm{RING_j}$ is a dummy variable for the location of h, turning 1 if h is located in distance ring j and zero else. Its coefficient γ_j captures time invariant price differences between rings. $\mathrm{TIME^t}$ is a dummy variable turning 1 if rental advertisement h ended in t, indicating a successful lease, and zero elsewise. Its coefficient θ^t captures city-wide developments over time that affect all city rings. Finally, $\mathrm{RING_j} \times \mathrm{TIME^t}$ is an interaction term with λ_j^t capturing ring specific rent developments over time.

Coefficients γ_j, θ^t and λ_j^t are of particular interest, as by correctly evaluating them, rent indexes for every ring j at time t, P_j^t, can be obtained. The omitted dummy variables of RING and TIME are reference categories. These omitted dummies are the most central ring $j = 1$ and the first quarter in the data sample $t = 0 = 2008$ Q1, respectively. In a log-specification, coefficients γ_j, θ^t and λ_j^t express the log-change to the reference, so one obtains index values by simply exponentiating the relevant estimated coefficients and multiplying by 100. The index value P_j^t for the reference, P_1^0, therefore is $\exp(0) \cdot 100 = 100$, while the index values of $j = 1$ for all the other points in time

[14] Compared to other approaches such as the hedonic characteristics approach, there is no need to define a "mean", "median" or "representative" dwelling. On the downside, the HD approach implicitly restricts quality characteristics of properties to be constant over time. In my robustness checks, I also calculate a Laspeyres-type double imputation index, which overcomes both shortcomings. Further, for excellent summaries of computation, strengths and weaknesses of the various approaches to estimating price indexes see Hill (2011), Haan (2010), Diewert et al. (2008) or Silver (2016).

[15] The exact specification of vector z is explained in detail in the appendix.

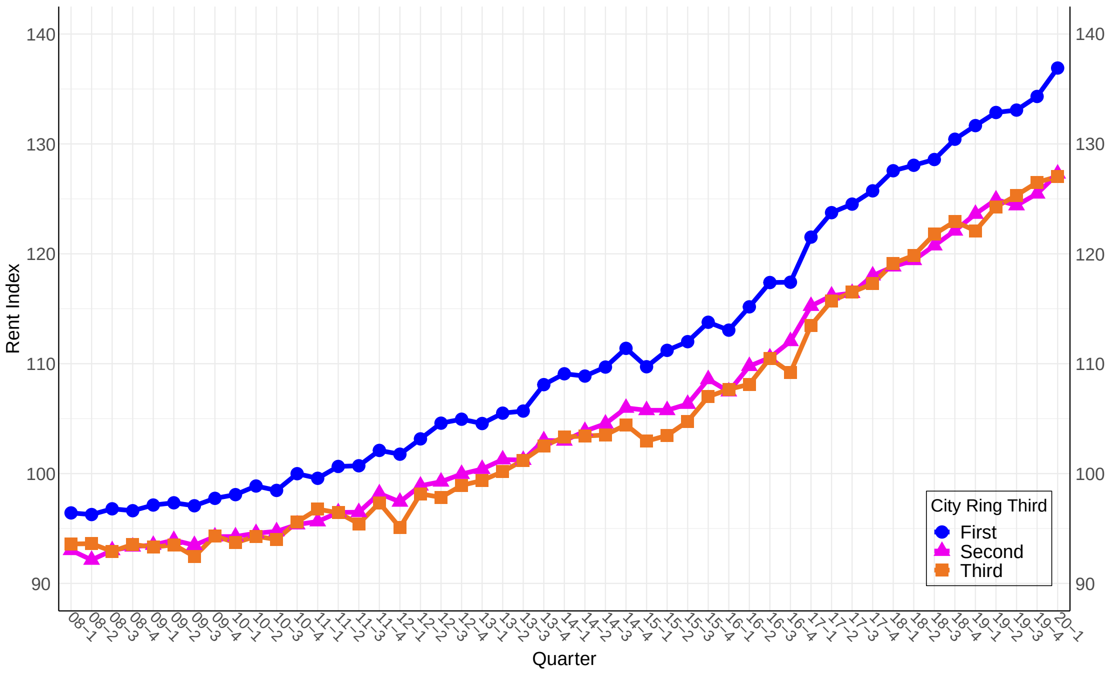


Figure 3: Apartment Rent Growth in City Ring Thirds

Note: This figure plots the means in apartment rents across cities in the first third (blue), the second third (magenta) and the third third (orange) over time. In the overall sample, there are no striking changes in relative rents over the period under consideration. Data: Author's calculations.

are obtained by evaluating θ^t as $\exp(\theta^{\mathrm{t}}) \cdot 100$. Index values for $j \neq 1$ in $\mathrm{t} = 0$ are, in a similar vein, calculated by $\exp(\gamma_{\mathrm{j}}) \cdot 100$. Calculation of index values for $j \neq 1$ in $\mathrm{t} \neq 0$ needs to consider the "city ring fixed effect" γ_j, the "time fixed effect" θ^t as well as the time-specific development of city rings, coefficient λ_j^t. The index values P_j^t for city ring j = 2, ..., J at time $t \neq 0$ are therefore calculated as $\left[\exp\left(\gamma_j + \theta^t + \lambda_j^t\right)\right] \times 100$.[16]

Initially, to make cities' different spatial extents more comparable, I aggregate every city's set of rings into consecutive subsets of thirds. I equate the 1st third of rings with central city rental apartments while the 2nd and 3rd thirds denote peripheral apartments. Figure 3 shows the average time development of rent indexes for all three city thirds. Rental apartments in the city center (red) are the most expensive over the entire period, while apartments in the 2nd (green) and 3rd thirds (blue) are hardly cheaper. The figure also reveals that the anecdotally strong rent increases in German cities over the last ten years are not exclusively driven by rents spiking in central locations, although they

[16] I also correct for a bias in P_j^t arising from the nonlinear transformation of a random variable, see appendix for details on index calculation.

seem to have enlarged their rent premium further.[17] Take as a brief numeric comparison two points in time: The first quarter in the data, 2008 Q1, and the last, 2020 Q1. Rent index differential between the 1st (central) third of rings and the 3rd (peripheral) third increased from 2.38 to 10.36. The cities' central rent growth over the period of these twelve years greatly outpaced that of the periphery. Since judging from a graph always contains imponderables, it is unwise to infer subsidy introduction effects directly from the average rent development in Figure 3. Here, effects are masked by averaging in the presence of great heterogeneity across cities in factors that affect housing prices, e.g. the centralization of amenities, the spatial distribution of employment, transportation infrastructure or natural features and building regulations that affect housing supply.[18]

Figure 4 returns to ring rent indexes and visualizes them as the "spatial intra-city rent structure" for three quarters in the data (in columns), the first two (2009 Q4 and 2014 Q4) predating subsidy introduction while the last (2019 Q4) was substantially after subsidy introduction in 2008 Q3. Munich, Stuttgart, and Heidelberg (first three rows) belong to the least affordable decile of cities, while the bottom three cities (Rostock, Weimar, and Cottbus) are among the most affordable decile of cities in the sample. The postulated differing central rent premium development by city affordability is almost visible to the naked eye: While expensive cities' apartments in close distance the CBD increased their rent advantage over their more peripheral peers pretty much unperturbed, affordable cities' centers saw their lead over the periphery dampened with subsidy introduction. In the following section, I examine this central hypothesis of the paper: the subsidy *dampened* the growth of the central rent premium, i.e. the rent differential between central and peripheral city parts, in those cities in which it could be used most effectively.

[17] A possible explanation for the rise in peripheral rents is that rent controls were introduced in many German cities around 2015. As a result of limiting the increase in existing rents (in the city center), one can expect rents for new construction (on the outskirts) to rise more sharply.

[18] And this is why the following regression analyses consequently include city fixed effects.

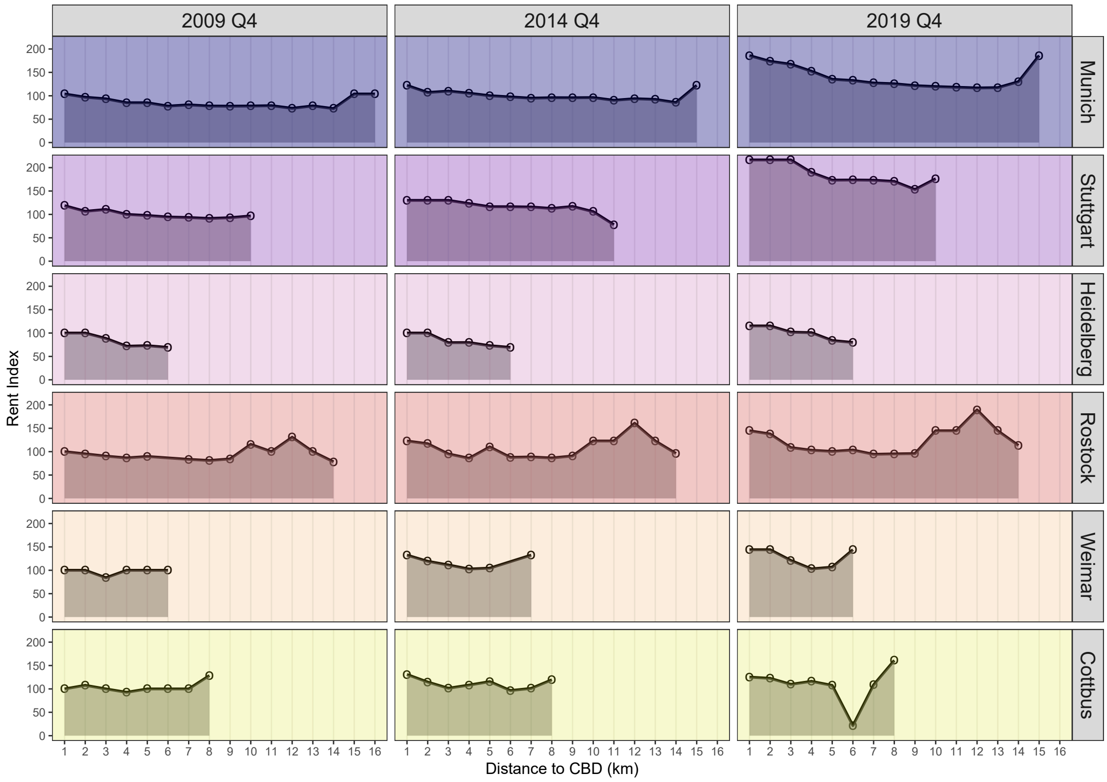


Figure 4: Intra-city rent structure for three points in time

Note: This figure has the intra-city rent structure for six cities (rows) and three points in time (columns). The top three rows show three of the most expensive cities in the sample, while the bottom three rows show three of the most affordable cities. The central rent premium grew in all six cities, going from 2009 (first column) to 2014 (second column). But going from 2014 to 2019 (third column), enveloping subsidy introduction, affordable cities' central rent premiums did not grow as strongly as their expensive cities' peers. Data: Author's calculations.

4 Empirical Framework

4.1 Identification

To isolate causal effects of introducing BK on intra city rent structure, I set up a suitable regression model to study the subsidy's effects by exploiting variation in intra-city locations and inter-city variation in real estate affordability, and thus conditional on the true effectiveness of BK. Cities with high real estate price levels can be expected to be less affected by subsidy introduction, as argued before. In cities where the subsidy encourages the switch in tenure from rent to owner-occupancy, one expects population to live less centrally. Corresponding price effects should therefore lower central rents in affordable cities more sharply than in expensive cities. This link enables the use of a Triple Difference style approach, an extension to double differences first introduced to the economic literature by Gruber (1994), in which differences in treatment intensity (prior-introduction real estate price levels and spatial intra-city ring location) across cities give the cross-sectional variation needed to identify the effects of the treatment.

In any DD(D)-framework, the coefficient of the interaction term has a causal interpretation under three assumptions: First, the assumption that no other policy interventions or events coincided with the intervention and affected treatment and control groups unequally. Second, the assumption that there are no spillover effects between treatment and control groups. And third and most important, the common trend assumption, which states that in the absence of treatment, outcomes in treatment and control groups would have developed similarly (Lechner 2011).

As a first difference, I compare ring rents in the time period before the subsidy was introduced with the time period after. Although an introduction of a homeownership subsidy for families was already discussed during the federal election campaign before the October 2017 election, I consider anticipation effects unlikely. It was not until July 2018 that government announced the introduction of the Baukindergeld in its present form, and unexpectedly also retroactively for owner-occupied homes that were bought or granted a building permit from January 1, 2018. So before July 2018, it was not clear from which date purchases would be subsidized by the Baukindergeld, which marks the third quarter of 2018 as the start of the unanticipated intervention.

As argued, rental housing is predominantly found near the city center, so comparing central rents (i.e. rental housing with high treatment intensity) with peripheral rents (i.e. rental housing with lower treatment intensity) gives an opportunity to control for all other factors that affect the rental housing market[19] As a second difference, I thus compare central rings' rents with rents of peripheral rings.

However, the link between building type and tenure is not absolute. Rather, it depends on the relative costs of tenure types, which can be expressed, for example, via the price-

[19] "Treated" in this context does not mean that central rental housing is in any way directly targeted with the homeownership subsidy. But still it is treated indirectly, as first-time homeowners are renters that switch from rental housing to owner-occupied housing. The subsidization of their owner-occupied housing units ("directly treated" by the subsidy) does have an immediate effect on rental units ("indirectly treated" by the subsidy).

to-rent ratio. If the homeownership subsidy increases the demand for owner-occupied housing and the supply does not respond perfectly elastic, prices for owner-occupied housing will also rise, and so will the price-to-rent ratio. Owners of apartments then have an incentive to convert their rental apartments into condominiums. Thus, not only would the subsidy increase the demand for owner-occupied housing in the periphery while simultaneously decreasing the demand for rental housing in the center, but the conversion from rental apartments to condominiums would also decrease the supply of rental housing in the center. It is unclear, which of the effects would predominate and what the net effect would be.

In the case of Germany, however, this channel is very unlikely: provisions in the Civil Code give special protection to current tenants in the event of conversion from rental to owner-occupied apartments. When an occupied rental apartment is converted, the current tenant has a right of first refusal. If the tenant waives his or her right of first refusal, there is nevertheless a blocking period of at least 3 years before the lease can be terminated. In cities with "tight housing markets" (determined by the state government), this blocking period can be further extended from three to up to ten years. In 40 of my 105 cities, such an extension is in force.[20] So for landlords, it does not seem viable to exploit price increases in the owner-occupied market through conversion of rental apartments to condominiums.

I further argue that the introduction of the subsidy only played a role in the decision to switch from renting to owning in affordable cities. The subsidy was based on the number of children in the household and not on local housing price levels. In a more expensive city, the subsidy had too small a share of the total investment amount to really financially incentivize people to change tenure. Thus, the more affordable the city, the greater the (indirect) treatment intensity of the subsidy on apartment rents. In my main specification, I introduce groups of affordable cities' rings and expensive cities' rings to distinguish between the treatment intensity by real estate affordability, but also provide results for a continously varying treatment intenstity by city affordability.

One option with my data would be to estimate a Difference-in-Differences model with the difference in time and the difference in ring location separately for both affordability groups of cities, and to identify the subsidy's effect through the difference in the parameters of the interaction terms. The drawback of this approach is that (i) there is no t-statistic

[20]In detail, 16 cities have an extended blocking period of five years, 4 prohibit lease determination for eight years while 20 cities have a blocking period of ten years.

to assess whether differences between affordability groups have statistical significance and (ii) two parallel trend assumptions, one for each group, have to hold. The better suited approach thus is the estimation of a triple difference (TD) model that accounts for these group differences by including an additional treatment (group) indicator in the regression.

Common trends Olden and Møen (2020) show that the parameter on the triple interaction term is mathematically equivalent to the difference between the two separate group-specific difference-in-difference estimators, but (i) allows for statistical testing of the difference between groups while on the other hand (ii) does not require two parallel trend assumptions to hold in order to have a causal interpretation. The one parallel trend assumption that has to hold is that the relative outcome between treatment and control group in one group trends in the same way as the relative outcome of treatment and control group in the other group, in the absence of treatment. So in my setup, the differential (the "gap") in rents between central and peripheral rings in affordable cities does have to trend similarly to the differential in central and peripheral rents in expensive cities. To test for parallel trends in the pre-treatment period, I conduct a placebo intervention in 2015 Q3 and run separate DD-estimations for each group. Results indicate that central and peripheral rents do indeed not trend the same way when looking on affordable and expensive cities in DD-setups separately. But using this same placebo intervention, results in Table 3 show that the coefficient on the triple interaction is not statistically significant, indicating that the TD assumption of common trends in differentials between groups is not rejected.

Coinciding policies My identification strategy is based on the assumption that the introduction of the homeownership subsidy is not correlated with any other events or policies that affect central and peripheral rents differently. A variety of possible influences can be projected out through the third "difference" in city affordability. However, policies that dissimilarly affect central and peripheral rents and in addition do so dissimilarly in affordable and expensive cities may pose a threat to the identification strategy.

One policy measure that meets these conditions is the "Mietpreisbremse" (translated literally "rent brake"), a second-generation-type rent control introduced in some German cities with tight housing markets starting in 2015. The key feature of the "Mietpreisbremse" is that it prohibits rents in tight housing markets from being raised above the rent index

Table 3: Testing the parallel trends assumption

Intercept	93.87***
	(1.92)
Center	6.92***
	(1.35)
Placebo	15.59***
	(1.17)
Center × Placebo	3.58***
	(0.68)
Aff × Placebo	−1.40
	(1.44)
Aff × Center × Placebo	−1.06
	(0.88)
Adj. R^2	0.22
Num. obs.	40431
N Clusters	105

OLS regressions with quarterly ring rent index as the response variable. Clustered standard errors (at city level) in parentheses. Placebo is a dummy for a placebo intervention turning 1 (zero), if the quarter is equal or post 2015 Q3. Observations used are from 2008 Q1–2018 Q2.
$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

rent when apartments are re-letted. There is an exception in the case of re-letting, if the rent of the previous tenant was already above the rent index. In this case, the landlord does not have to reduce the rent in the new tenancy to the level of the rent index, but rather enjoys protection of the status quo. The main exemption from the "Mietpreisbremse" applies for first-time leases of new properties or first-time leases after extensive renovation; in these cases, the brake does not apply and the rent level may be freely negotiated.[21]

While landlords did not have to formally prove that an exception to the "Mietpreisbremse" existed due to a higher rent paid by the previous tenant, this changed in January 2019. From then on, landlords had to inform tenants in writing and unsolicited prior to signing the lease, whether an exception to the "Mietpreisbremse" exists. While the regulations of the rent control itself thus did not change, they became more transparent for tenants and thus easier to enforce. Although I do not suspect that the mere increase in transparency

[21] The effects of rent brakes are well documented in the literature, see for example Glaeser and Luttmer (2003) and Diamond et al. (2019), or specifically for the German case Mense et al. (2017, 2019) or Breidenbach et al. (2019).

had much impact on asking or agreed rents, it was nevertheless introduced after the introduction of the homeownership subsidy, and thus within the treatment period, possibly leading to biased results. Additionally, the “Mietpreisbremse” itself probably fulfills the requirements of a coinciding policy posing a risk to my identification strategy, as I suspect it to be more relevant in expensive cities, and within these cities probably rather binding in central than peripheral locations. As I can not rule out that the new transparency rules of the rent control in 2019 or delayed effects of its introduction in 2015 dissimilarly affect rents in central and peripheral locations in cities of different affordability levels, I will–as a robustness check–exclude all cities from my sample that at any point between 2008–2020 introduced the “Mietpreisbremse” and were thus affected by its regulations and changes in it.

SUTVA In any causal study, the stable unit treatment value assumption (SUTVA) requires that the (i) composition of treatment and control groups is stable over time and that there are no (ii) spillover effects from treatment to control groups (Rubin 1977). Two spillover effects could occur in the specific setup of this paper: In response to the homeownership subsidy, households change their tenure. Since tenure is closely related to location, spillover effects might occur (i) *between* cities, from expensive cities (control) to affordable cities (treatment), and (ii) *within* cities, from central (treatment) areas to peripheral (control) areas. Since moving between cities involves substantial relocation costs, e.g. changing jobs, a severe spillover effect between cities as response to the subsidy seems unlikely.

The link between tenure and residential location this paper advocates consists of households moving from central to peripheral areas; if these peripheral locations households move to are indeed *within* the same city, estimates would be biased. I cannot completely rule out that the SUTVA assumption is violated and thus the possibility that the estimates for the average treatment effect are biased. However, this need not be the case: First, new single-family housing developments often occur just outside the city gates in the urban hinterland. But then, new owners moving from rental housing to owner-occupied housing causing the negative demand shock, do not move into the locations that comprise the control group.[22] And second, my treatment and control groups are *rents* in central and peripheral locations. However, when subsidy recipients become homeowners, they leave the rental market, hence, their move reduces the demand for central rental housing

[22] And this is what anecdotal evidence, e.g. for the case of Berlin’s renters moving into owner-occupied homes in counties in Brandenburg, the urban hinterlands outside of Berlin, seems to confirm

in apartments but does not directly alter the demand for peripheral rental housing in apartments. So although *population* spillover effects between treatment and control locations might occur, there is no (direct) spillover on peripheral rents.

4.2 Estimating Equations

The following triple difference model forms the core of my analysis:

$$
\begin{aligned}
E(\mathrm{P}_{ij}^{t}|\mathrm{x}_{ij}^{t}) = \alpha &+ \mu_i + \beta_1\,\mathrm{CENTER}_{ij} + \beta_2\,\mathrm{BK}^t \\
&+ \beta_3\,\mathrm{CENTER}_{ij} \times \mathrm{BK}^t + \beta_4\,\mathrm{AFF}_i \times \mathrm{BK}^t + \beta_5\,\mathrm{AFF}_i \times \mathrm{CENTER}_{ij} \\
&+ \beta_6\,\mathrm{AFF}_i \times \mathrm{CENTER}_{ij} \times \mathrm{BK}^t\,. \qquad (2)
\end{aligned}
$$

Here, the conditional expectation of rent index P in city i, ring j at time t is dependent on all variables on the right side, in short x_{ij}^t. μ_i is a city fixed effect, CENTER is a city center dummy (which is 1 if ring j is located in the first third of city rings), BK is a treatment period dummy (1 if time t is at or after the introduction of BK in 2018 Q3), and AFF is a city affordability dummy turning 1, if ring j belongs to a city that is more affordable than the median city in my sample. Cities are ranked by their average price per square meter of developable land in 2007, and thus predating the time period under observation to avoid endogeneity.[23]

It might be helpful to disentangle effects on city rent structure from Equation 2. First, consider the case of all dummy variables set to 0. This leaves us with the intercept α (and city fixed effect μ_i), representing the average rent index of expensive cities' peripheral thirds of rings before the subsidy's introduction.[24] Next, consider dummy CENTER and BK separately set to 1. In the first case, β_1 shows the rent premium in the central

[23]The construction and material costs of real estate hardly vary between cities. What makes up a large part of real estate prices in many cities and thus determines city affordability, however, is the price of land (see Braun and Lee (2021).

[24]Note that, in this setup with city fixed effects, affordable as well as expensive cities are modeled to have the same peripheral development prior to BK's introduction. I do not make use of a fully saturated model in the classic sense, i.e. a full set of dummy variables and their interactions, as the set of fixed effects of affordable cities is collinear with treatment dummy AFF. However, the influence of AFF is now captured in the city fixed effects and so this DDD-setup with fixed effects neither alters the identification strategy of subsidy introduction nor renders the DD/DDD-coefficients.

third of rings of expensive cities prior to BK while in the second case, β_2 shows the rise in average rent after subsidy introduction but also only in expensive cities' peripheries. Switching both dummies to 1, β_3 represents the rent premium increase of expensive cities' centers after subsidy introduction.

Now, let only treatment period dummy BK stay 1 and additionally set the affordable cities' dummy AFF to 1. β_4 now shows the rent increase in affordable cities' peripheries in the wake of subsidy introduction, over that of expensive cities. For the last case, let all three dummies, AFF, CENTER and BK be 1. While β_5 represents the extra in rent affordable cities' centers had over their expensive counterparts prior to BK, β_6 shows how this differential changed after BK was introduced. And exactly this coefficient is what identifies the role of the subsidy introduction: The change in affordable cities' central rent premium prior and post treatment, in comparison to all other developments in other city parts and in less-treated (expensive) cities.

As a second model, I also estimate a variation of Equation 2 using a continuous variable to measure affordability rather than relying on dummy variable AFF. Let $\overline{\text{PRICE}}$ be the price of the most expensive city in the sample, Munich.[25] Substract now the price of city i from this maximum, such that $\left(\overline{\text{PRICE}} - \text{PRICE}_i\right)$ gives a kind of reversed price rank, with the most expensive city having the lowest value (Munich, 0) and the most affordable city having the highest (Suhl, 950).[26]

The regression equation transforms to

$$
\begin{aligned}
E(\text{P}^t_{ij}|\text{x}^t_{ij}) = \alpha + \mu_i + \beta_1\,\text{CENTER}_{ij} + \beta_2\,\text{BK}^t \\
+ \beta_3\,\text{CENTER}_{ij} \times \text{BK}^t + \beta_4\left(\overline{\text{PRICE}} - \text{PRICE}_i\right) \times \text{BK}^t \\
+ \beta_5\left(\overline{\text{PRICE}} - \text{PRICE}_i\right) \times \text{CENTER}_{ij} \\
+ \beta_6\left(\overline{\text{PRICE}} - \text{PRICE}_i\right) \times \text{CENTER}_{ij} \times \text{BK}^t\,. \qquad (3)
\end{aligned}
$$

Using $\left(\overline{\text{PRICE}} - \text{PRICE}_i\right)$ instead of treatment dummy AFF has the advantage, that the particular definition as affordable or expensive city does not play a role. Rather, results indicate whether the findings are robust throughout the distribution of cities' land price affordability in the sample.

[25]Munich's average price per square meter of land ready for development in 2007 already exceeded €1,000 (2018: 2,638 Euros/sqm).

[26]In the regressions, this price is divided by 1000 for better readability of the coefficients.

Table 4: Rent Index and Affordability

	All Cities				Only West	No "Bremse"
	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	147.09***	161.44***	172.99***	172.62***	178.45***	165.85***
	(0.69)	(3.94)	(4.02)	(3.97)	(3.83)	(3.90)
Center	6.87***	6.83***	6.84***	6.85***	6.53***	0.71
	(1.35)	(1.35)	(1.34)	(1.34)	(1.44)	(2.34)
BK	22.98***	17.61***	13.59***	26.61***	26.59***	28.53***
	(1.45)	(1.45)	(1.34)	(0.93)	(1.03)	(1.12)
Center × BK	5.87***	5.81***	4.89***	4.67***	4.23***	3.42***
	(0.93)	(0.97)	(0.81)	(1.00)	(0.98)	(0.85)
Aff × BK	−2.88	−4.82**	−4.58**			
	(1.85)	(1.87)	(1.85)			
Aff × Center	−4.78***	−4.77***	−5.19***	−5.16***	−5.14***	−0.42
	(1.79)	(1.81)	(1.82)	(1.81)	(1.93)	(2.59)
Aff × Center × BK	−4.79***	−4.66***	−3.50***	−4.38***	−4.51***	−2.93**
	(1.18)	(1.22)	(1.29)	(1.45)	(1.66)	(1.34)
Log(New Houses)		−6.66***	−5.53***	−5.58***	−5.10***	−4.38***
		(1.05)	(0.85)	(0.85)	(0.91)	(0.93)
Log(New Apartments)		9.03***	6.44***	6.53***	6.32***	5.18***
		(0.83)	(0.65)	(0.65)	(0.74)	(0.69)
Vacancy Rate			−721.06***	−737.25***	−1115.60***	−503.64***
			(149.26)	(142.96)	(168.22)	(85.74)
City FE	Yes	Yes	Yes	Yes	Yes	Yes
City FE × BK	No	No	No	Yes	Yes	Yes
Adj. R^2	0.45	0.50	0.48	0.49	0.52	0.41
Num. obs.	47030	45289	40915	40915	33786	21610
N Clusters	105	105	103	103	86	61

OLS regressions with quarterly ring rent index as the response variable. Clustered standard errors (at city level) in parentheses. Col (5) excludes all cities on territory of former GDR, Col (6) excludes all cities that (at any point in time) introduced a rent control. Data on building completions is from the federal and state statistical offices, data on the vacancy rate from empirica AG.
$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

5 Results

Table 4 has the OLS estimates of Equation 2 for all cities in the sample (column (1)–(4)), while column (5) excludes all cities located on territory of former German Democratic Republic to rule out the possibility that east German cities and their special rental market circumstances influence results.[27] Column (6) finally excludes all cities from the sample in which, at any time in the period of observation 2008–2020, the "Mietpreisbremse" applied. The estimated coefficient of interest, showing the effects of the subsidy introduction on central rent premium, $\widehat{\beta_6}$, equals −4.79 in column (1) and is statistically highly significant. Gradually adding additional controls for the number of house and apartment building completions and the vacancy rate (col (2) and (3)) does not alter this DDD-coefficient

[27] During the 2000's a lot of East Germany's (rental) housing was demolished, see for example Dascher (2014), Deilmann et al. (2009)) or Radzimski (2016).

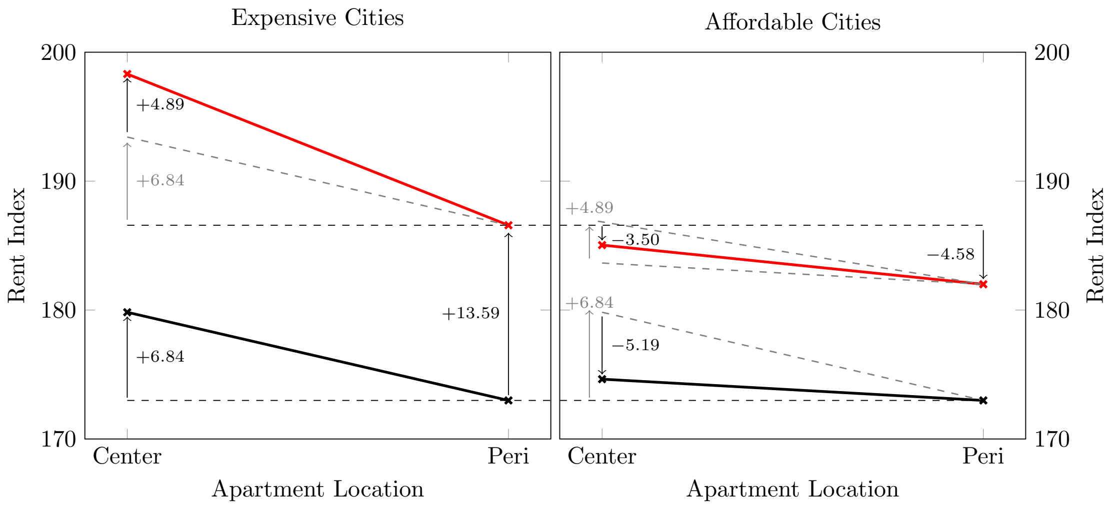


Figure 5: Estimated Effect of Homeowner Subsidy's Introduction

Note: This figure shows "rent gradients" for expensive cities (left panel) and affordable cities (right panel) using estimated coefficients from Table 4. Black solid lines depict these gradients pre-treatment while red solid lines show them post-treatment. While in both city groups, central rents have risen, affordable cities' central rents did so by 3.5 index points less. Data: Author's calculations.

significantly. Even in models in columns (4)–(6), where I include City × BK fixed effects to control for unobserved effects in the treatment period, the estimated coefficient of β_6 retains its sign and high statistical significance. While central rent premiums in both, expensive and affordable cities' centers, continue to rise after the introduction of BK, it is the affordable cities' premium that does so *less* sharply. The homeownership subsidy thus dampens central rent surge in those cities where it can be effectively used - the affordable ones.

Figure 5 graphically depicts the unequal effects of the subsidy introduction on expensive and affordable cities, using estimated coefficients from col (3). The black line in both panels depicts city rent structure before introduction of BK, while the red line shows this structure post subsidy introduction. Expensive cities' (left panel) central rents were 6.84 index points ($\widehat{\beta}_1$) higher than its' peripheral rents, pre subsidy introduction. In affordable cities (right panel), this pre-subsidy central rent premium accounted for only 1.65 index points ($\widehat{\beta}_1 + \widehat{\beta}_5$). With subsidy introduction, expensive cities' peripheral rental housing experienced a rent increase of 13.59 index points ($\widehat{\beta}_2$) while this increase in affordable cities amounts to 4.58 index points ($\widehat{\beta}_4$) less and thus to 9.01 index points in total. I now focus on apartment rents in central locations: With subsidy introduction, central rent premium on average grows in both, expensive and affordable cities. But it does so by 4.89 index points ($\widehat{\beta}_3$) in expensive cities and only by 1.39 index points in affordable ones, with the difference represented by $\widehat{\beta_6}$ equal to -3.50. This is what can be identified as, and equated with, the dampening effect of subsidy introduction.

I will also briefly comment on the estimated coefficients of the additional controls, the log number of "home completions" i.e. the number of newly built apartments and one- and two-family houses, and the vacancy rate. All are statistically highly significant and imply that (i) a one log-point increase in the number of new apartments results in an increase of ring rent index of 5.18–9.03 index points, (ii) a one log-point increase in the number of new houses results in a ring rent index decrease of 4.38–6.66 index points, and (iii) a one percentage point increase of a city's vacancy rate leads to a ring rent index decrease of 5.04–11.16 index points. The negative estimated coefficient on the vacancy rate matches the standard economic reasoning that—holding demand fixed—higher supply of a good (more vacant apartments to rent out) should ceteris paribus result in lower prices of that good, i.e. rents. Also, according to the models in Table 4, building more detached and semi-detached houses (i.e having more owner-occupiers and fewer renters) results in a decrease of apartments rents, and this smoothly coincides with the mechanism of tenure choice and housing segment prices postulated in the introduction. Finally, the positive estimated coefficient on the number of new apartments may mirror the fact that newly built apartments are generally more expensive than older ones and developers are—taking the anecdotally present shortage of rental housing in many German cities as granted—able to capitalize that premium in rents.[28]

Besides that, attention should also be paid to the results in column (6) for cities where the "Mietpreisbremse" did not apply. No central rent premium (for the ten year period before BK) is found here, neither in expensive, nor in affordable cities (as $\widehat{\beta_1}$ and $\widehat{\beta_4}$ are not statistical significant from zero). This might at least be suggestive evidence that these cities also did not have the kind of "overheated" rental market with which politicians usually justify introducing rent controls.

Table 5 has the OLS results for equation Equation 3, again gradually introducing controls

[28]Of course, I am aware of the potential problems with including these control variables: On the one hand, omitting important variables from the regression leads to omitted variable bias. On the other hand, these control variables are likely to be endogenous and thus "bad controls" that should be (i) left out of the regression or (ii) instrumented. Note that an IV-approach is not feasible here, as I would need at least three time-varying instruments. I decided to describe these (probably) biased estimated coefficients anyway because my results regarding the causal effects of the subsidy introduction on rents do not depend on their inclusion in the regression (see col (1)).

Table 5: Rent Index and Landprice

	All Cities				Only West	No "Bremse"
	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	146.92***	160.88***	172.75***	172.34***	178.26***	165.80***
	(0.56)	(3.71)	(3.97)	(3.94)	(3.85)	(3.81)
Center	21.69**	21.75**	22.31**	22.23**	21.84**	2.87
	(6.02)	(6.10)	(6.34)	(6.30)	(6.87)	(17.78)
BK	38.37***	36.89***	30.88***	26.33***	26.45***	28.09***
	(5.58)	(5.57)	(4.83)	(0.80)	(0.82)	(1.08)
Center × BK	20.55***	19.64***	15.33**	17.21**	17.78**	11.20
	(3.75)	(3.74)	(4.14)	(5.10)	(5.72)	(8.31)
($\overline{\text{Price}}$ - Price) × BK	−21.77**	−28.08***	−25.31***			
	(6.81)	(6.94)	(5.98)			
($\overline{\text{Price}}$ - Price) × Center	−22.15**	−22.28**	−23.20**	−23.05**	−23.20**	−2.86
	(7.43)	(7.54)	(7.85)	(7.80)	(8.63)	(20.55)
($\overline{\text{Price}}$ - Price) × Center × BK	−21.45***	−20.34***	−15.23**	−18.93**	−20.52**	−11.44
	(4.53)	(4.54)	(5.20)	(6.38)	(7.38)	(10.11)
Log(New Houses)		−6.60***	−5.55***	−5.58***	−5.10***	−4.38***
		(0.99)	(0.83)	(0.85)	(0.91)	(0.93)
Log(New Apartments)		9.16***	6.45***	6.54***	6.33***	5.18***
		(0.82)	(0.65)	(0.65)	(0.74)	(0.69)
Vacancy Rate			−721.28***	−737.17***	−1114.82***	−503.70***
			(147.86)	(142.86)	(168.20)	(85.89)
City FE	Yes	Yes	Yes	Yes	Yes	Yes
City FE × BK	No	No	No	Yes	Yes	Yes
Adj. R^2	0.46	0.51	0.49	0.50	0.53	0.41
Num. obs.	47030	45289	40915	40915	33786	21610
N Clusters	105	105	103	103	86	61

OLS regressions with quarterly ring rent index as the response variable. Clustered standard errors (at city level) in parentheses.
Col (5) excludes all cities on territory of former GDR, Col (6) excludes all cities that (at any point in time) introduced a rent control.
Data on building completions is from the federal and state statistical offices, data on the vacancy rate from empirica AG.
$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

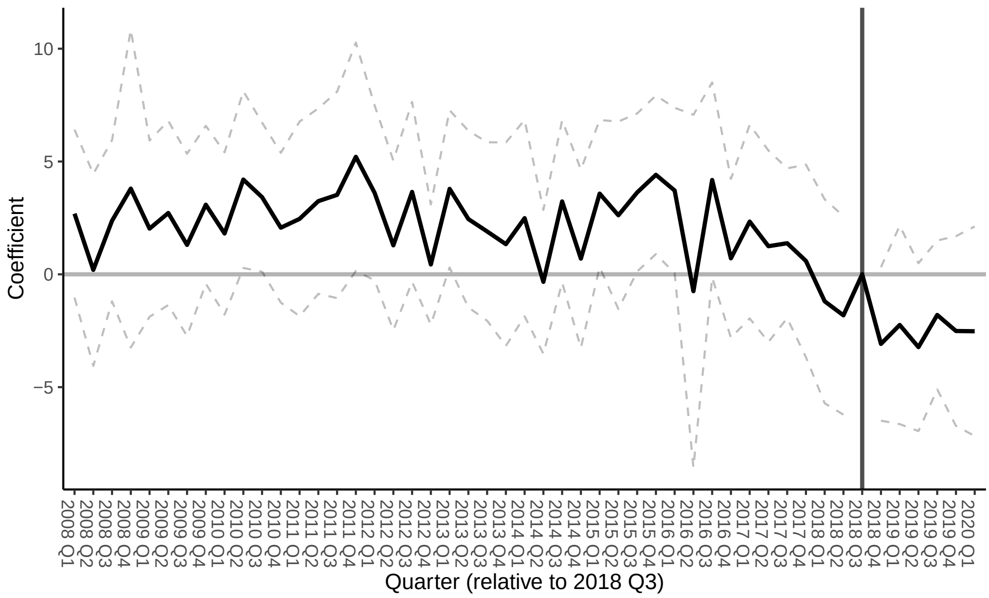
for building completions and the vacancy rate (col. (2) and (3)). Columns (4), (5) and (6) additionally include City × BK fixed effects using the whole sample of cities, only west German cities, and only cities without the "Mietpreisbremse", respectively. Again, equate the estimated coefficient of $\left(\overline{\text{PRICE}} - \text{PRICE}\right) \times \text{CENTER} \times \text{BK}$ with the subsidy's effect on central rent premium, while the estimated coefficient of CENTER × BK represents the changes for the most expensive city (Munich), where subsidy introduction has had least effect and may thus be equated with all other (unobservable) trends on that premium. $\widehat{\beta_6}$ carries the expected (negative) sign and is statistically highly significant, which means that the more affordable the city (the more sensitive to subsidy introduction), the weaker its central rent premium surge. To ease interpretation, consider now two cities with a difference in 2007 land prices of €100 per square meter. The more affordable of the two cities, according to column (1), would find its central rent premium rise by 2.15 index points *less* post subsidy introduction.

These results also have economic significance. Consider two specific cities, Munich (the most expensive city in the sample) and Regensburg (falling €675 short of Munich's price) and, to ease interpretation, results without the additional controls (i.e. col (1)). For Munich, $\left(\overline{\text{PRICE}} - \text{PRICE}\right)$ equals 0. Rent development of Munich's rings can thus be directly inferred from the estimated coefficients $\widehat{\beta}_2$ and $\widehat{\beta}_3$. The average rent of Munich's baseline ($P_1^0 = 100$) is €1072 and its estimated city fixed effect $\widehat{\mu}_M$ equals -61.23. Predicted average rent of apartments in the second and last third of rings pre-subsidy introduction is thus €919 ($\widehat{\alpha} + \widehat{\mu}_M$) while predicted central rents average €1151 ($\widehat{\alpha} + \widehat{\mu}_M + \widehat{\beta}_1$). The difference between both rents equals the predicted central rent premium before BK, €233. Post subsidy introduction, Munich's peripheral apartments experienced a rent increase of 38.37 ($\widehat{\beta}_2$) index points while its central rings saw an even larger increase of 58.92 ($\widehat{\beta}_2 + \widehat{\beta}_3$) index points. This translates into a predicted average peripheral rent post subsidy introduction of €1330 while the average central apartment rents out for €1783. Central rent premium has increased to €453, which means, in absolute terms, it almost doubled in the wake of subsidy introduction.

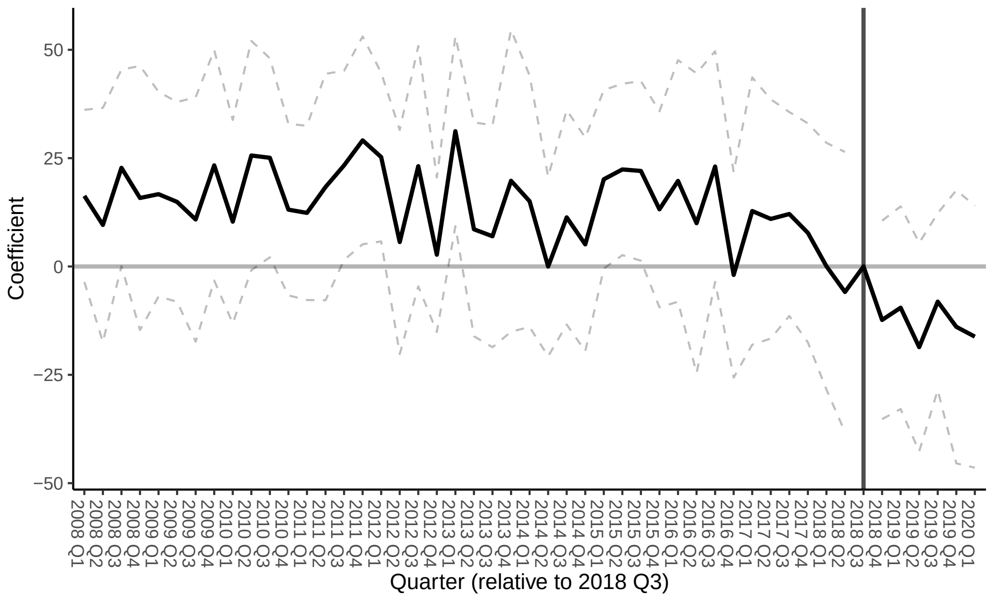
Regensburg's average baseline rent equals €684 and its corresponding regression city fixed effect $\widehat{\mu}_R$ equals -63.53. Predicted peripheral and central rent equals €570 and €616 respectively, so central rent premium is just 6.7 ($\widehat{\beta}_1 + (0.675 \cdot \widehat{\beta}_5)$) index points or €46. Peripheral rents are predicted to rise with subsidy introduction by 23.67 index points ($\widehat{\beta}_2 + (0.675 \cdot \widehat{\beta}_4)$), so the average peripheral apartment rents out for €732. Lastly, the predicted central rent after subsidy introduction equals €820.[29] Predicted central rent premium after subsidy introduction hence equals 12.8 index points or €87. In summary, both cities' central rent premiums have risen with subsidy introduction, but Munich's did so by 20.6 index points while Regensburg's rose only by 6.1. The difference of 14.5 index points between the two can be attributed to the BK drawing residents out of Regensburg's rental apartments in the city center into owner-occupancy.

To show the dynamics of the dampening effect on (more) affordable cities' central rent premiums, I re-estimate Equation 2 and Equation 3 in an "event study-style" by replacing the treatment dummy BK with a set of dummies, one for each quarter. Figure 6 shows the estimated coefficient on the triple difference parameters AFF × CENTER × QUARTER and $\left(\overline{\text{PRICE}} - \text{PRICE}\right)$ × CENTER × QUARTER as black solid lines along with 95% confidence intervals. Clearly, there is a longer-term effect of subsidy introduction, rather than just a short term effect of a few quarters, and it is only after subsidy introduction

[29]Obtained by evaluating the full set of estimated coefficients: $\widehat{\alpha} + \widehat{\mu}_R + \widehat{\beta}_1 + \widehat{\beta}_2 + \widehat{\beta}_3 + (0.675 \cdot \widehat{\beta}_4) + (0.675 \cdot \widehat{\beta}_5) + (0.675 \cdot \widehat{\beta}_6))$



(a) Estimated event-study style coefficients on AFF × CENTER × QUARTER



(b) Estimated event-study style coefficients on $\left(\overline{\text{PRICE}} - \text{PRICE}\right) \times \text{CENTER} \times \text{QUARTER}$

Figure 6: Dynamics of (more) affordable cities' central rent premium markdown

Note: This figure plots estimated coefficients along with 95 % confidence intervals of the estimated coefficients on the TD-parameters AFF × CENTER × QUARTER (Figure 6a) and $\left(\overline{\text{PRICE}} - \text{PRICE}\right) \times \text{CENTER} \times \text{QUARTER}$ (Figure 6b) from (adapted) Equation 2 and Equation 3. Standard errors are clustered at the city level.

that there is a reversal in the coefficients' signs. Only after subsidy introduction, (more) affordable cities' central rent premium exhibited a permanent markdown. Unfortunately, I do not observe a longer post-treatment period in my data, but I suspect that the longer-term effect would be even more pronounced, i.e. negative, as more and more owner-occupiers that built new housing rather than moving into existing housing move out of their rental apartments.

Several robustness checks are reported in the appendix. My results are robust against (i) using another method of index construction (a "double imputation" index), (ii) the grouping of cities as "affordable" (demonstrated by stable results in the continuous treatment) and (iii) other definitions of the the city center. These checks conclusively strengthen the validity of this paper's identification strategy.

6 Conclusions

This paper empirically analyzed the effects of a new homeownership subsidy on rents within cities. Its main finding is that subsidy introduction induced falling central city rent premiums, likely caused by population sorting from rental into owner-occupied housing. With this analysis, I offer a complementary building block for analyzing housing subsidies' effects on housing prices. While other authors solely focus on subsidies for a certain tenure type on prices of the same tenure type, this paper complements how subsidies to *homeownership* influence *rents*.

Using triple difference frameworks, I suggest that subsidy introduction had a dampening effect on affordable cities' central rent premium growth. In a setup with a continuously varying treatment intensity by cities' land price, I show that this dampening effect is prevalent throughout the distribution of city affordability, measured by cities' prices of building land.

These results have important policy implications. Subsidies to homeownership are usually justified on the grounds of making the move to owner-occupancy more affordable. The literature, however, suggests that they often fail to achieve this goal. Subsidies get capitalized in house prices, benefiting the selling developer rather than the prospective owner-occupant. Interestingly and novel, this paper reveals that renters benefit most, as the homeownership subsidy's introduction dampens growth in central rents.[30]

Germany is in many regards rather unique in terms of its housing sector: It has a rather low homeownership rate and, in comparison to high ownership countries like the United States, an extensive social housing sector, high transfer taxes when buying real estate, and no tax deductions for mortgage interest payments for owner-occupiers (Kaas et al. 2021). And Germany also had a rather unique program setup for promoting homeownership: the subsidy was based on the number of children in the household and not, e.g., on the home loan amount, as it is the case with the mortgage interest deduction in the U.S. The MID in many cases does not lead the marginal resident to form homeownership. Rather, future homeowners use the savings from the tax breaks to increase the intensive margin, i.e. consume more living space (Glaeser and Shapiro 2003; Hanson 2012; Hilber and Turner 2014). This paper however is silent on the direct effects of lump-sum type homeownership subsidies on the extensive or intensive margins. It may very well be that different types of homeownership subsidies have different effects. But then also the indirect effects on the rental market carved out by this paper might be ambiguous in other settings with nominally varying subsidy rates, and one should exercise caution in generalizing the findings to other countries and subsidy programs.

This is a paper of eminent importance as, in the particular case of Germany, the subsidy was set to expire after a three years term and thus within current government's legislative period. This fall, after the elections, a new government must decide about its stance on housing policies. This contribution offers advice in the sense that it carved out the subsidy's dampening effect on central rent premium growth. It is likely that terminating the subsidy also means terminating this central city rent relief. Government must be clear that, when deciding to not reviving the program, it will likely hit both types of housing tenure: homeowners *and* renters.

[30] I leave aside in this exaggeration many other aspects the subsidy might cause, e.g., a higher tax burden, a reduction in government spending elsewhere, or that in areas of inelastic supply, part of the subsidy will lead to higher prices of existing properties, which might very well increase the wealth of existing owners.

7 Appendix

7.1 Index Construction (Hedonic Dummy Method)

For the construction of the rental index, I rely on the following hedonic regression, which is estimated for each city in the sample (n=109) separately. As the index' goal is to represent the main section of the rental market, I clean the sample from observations likely to be luxury apartments, following Klick and Schaffner (2019). I exclude observations with the following: a net rent above €5,000, a living space larger 400 square meters or more than seven rooms.

The conditional expectation of the log net rent (i.e. rent excluding utilities) NET RENT of apartment advertisement h in city ring j at time t is a function all the covariates on the right-hand side, for simplicity denoted by x_{ij}^t:

$$\begin{aligned}
E(\ln(\text{NET RENT}_{hj}^t)|x_{hj}^t) = \alpha &+ \beta_1 \text{LIVING SPACE}_{hj}^t + \beta_2 \text{ROOMS}_{hj}^t \\
&+ \beta_3 \text{QUALITY}_{hj}^t + \beta_4 \text{BUILT}_{hj}^t \\
&+ \beta_5 \text{FIRST OCCUPANCY}_{hj}^t + \beta_6 \text{GARDEN}_{hj}^t \\
&+ \beta_7 \text{GUEST BATH}_{hj}^t + \beta_8 \text{CELLAR}_{hj}^t \\
&+ \beta_9 \text{FITTED KITCHEN}_{hj}^t + \beta_{10} \text{BALCONY}_{hj}^t \\
&+ \sum_{j=2}^{J} \gamma_j \text{RING}_{hj} + \sum_{t=1}^{T} \theta^t \text{TIME}_h^t \\
&+ \sum_{j=2,t=1}^{J,T} \lambda_j^t \text{RING}_{hj} \times \text{TIME}_h^t
\end{aligned} \tag{4}$$

Variables LIVING SPACE and ROOMS are metric variables, indicating the amount of living space and the number of rooms in the apartment, respectively. QUALITY is a categorical variable measuring the quality of materials and equipment used in the apartment.[31] BUILT is a dummy variable specifying the year of construction,[32] FIRST OCCUPANCY turning 1 if the perspective move-in is the first occupancy of a

[31] Conditions are: 0 = information missing, 1 = simple, 2 = normal, 3 = sophisticated, 4 = exclusive

[32] 1 = missing, 2 = before 1900, 3 = 1900-1945, 4 = 1946-1959, 5 = 1960-1969, 6 = 1970-1979, 7 = 1980-1989, 8 = 1990-1999, 9 = 2000-2009, 10 = after 2009

newly built or substantially renovated apartment, GARDEN indicating if the apartment has access to a private garden, GUEST BATH if object includes a guest toilet, CELLAR if a cellar room is available, FITTED KITCHEN if the object comes with a fitted kitchen and BALCONY if the property has a balcony.

RING is a spatial dummy variable showing in which city ring the property is located. TIME constitutes a quarter-year dummy for the quarter and year the advertisement on the web page ended, indicating a successful transaction/lease. Lastly, RING $\times$ TIME is an interaction term between RING and TIME.

Methodology-wise, consider for now the case of a simple Dummy Time Hedonic (DTH) index to construct a city-wide rent index (i.e. skipping rings as the subject of indexes for now). Hill (2011, 13 ff.) describes the semi-log formulation as

$$y = Z\beta + D\delta + \epsilon, \tag{5}$$

where y is an $H \times 1$ vector with elements $y_h = \ln p_h$, Z is an $H \times K$ matrix of property characteristics, β is a $K \times 1$ vector of characteristic shadow prices, D is an $H \times T - 1$ matrix of period dummy variables, δ is a $T - 1 \times 1$ vector of period prices and ϵ is an $H \times 1$ vector of random errors. H, K and T denote, respectively, the number of observations, characteristics and time periods, and p_h denotes the rent of property h. The base period rent index is normalized to 100.

To construct a quality-adjusted rent index, the primary interest lies in the δ parameters, which measure the period specific fixed effects on the logarithm of the price level after controlling for the effects of the differences in the attributes of the dwellings. To obtain rent index P^t for period t, one simply exponentiates the estimated $\widehat{\delta}^t$ obtained from the hedonic model and multiples that by 100, such that

$$\widehat{P^t} = \exp\left(\widehat{\delta}^t\right) \cdot 100. \tag{6}$$

I will briefly note for completeness Hill (2011) and Silver (2016) pointing out that, in theory, this rent index P^t is a biased estimate since it entails taking a nonlinear transformation of a random variable, i.e. $E[\exp(\hat{\delta})] \neq \exp(\delta)$. One should correct for

Coefficient	Estimate	Standard Error	t statistic
γ_2	-0.1508	0.01679	-8.98
γ_3	-0.1767	0.01662	-10.63
$\theta^{08\text{-}2}$	0.0063	0.01597	0.40
$\theta^{08\text{-}3}$	-0.0504	0.01550	-3.25
$\theta^{08\text{-}4}$	-0.0415	0.01744	-2.38
$\lambda_2^{08\text{-}2}$	-0.0313	0.02463	-1.27
$\lambda_2^{08\text{-}3}$	0.0488	0.02268	2.15
$\lambda_2^{08\text{-}4}$	0.0499	0.02567	1.95
$\lambda_3^{08\text{-}2}$	-0.0234	0.02464	-0.95
$\lambda_3^{08\text{-}3}$	0.0362	0.02293	1.58
$\lambda_3^{08\text{-}4}$	0.0198	0.02632	0.75

Table 6: Estimated coefficients for Regensburg

that by adding half of the variance of the estimated coefficient when calculating the rent index, such that the corrected rent index for period t is

$$\overset{*}{\widehat{P}^t} = \exp\left[\widehat{\delta}^t + \frac{1}{2}\left(\widehat{\sigma}^t\right)^2\right] \cdot 100 \tag{7}$$

while $\left(\widehat{\sigma}^t\right)^2$ is an estimate of the variance of $\hat{\delta}_t$. Importantly note that both authors point out that the difference between $\widehat{P^t}$ and $\overset{*}{\widehat{P}^t}$ is in practice typically negligible as $\widehat{\sigma}^t$ is usually very small. I carry out this index correction but also find that it leads to changes only in the fourth decimal of $\widehat{P}_j^t$ and hence is of no great importance in this application.

For this paper's purposes, I generalize this Dummy Time Hedonic (DTH) method to a Hedonic Dummy (HD) method as I have not only period dummy variables (TIME) but also ring dummy variables (RING) and their interactions (RING × TIME). For illustration purposes, I estimate Equation 4 for the city of Regensburg but report only the resulting estimated coefficients $\widehat{\gamma}_j$, $\widehat{\theta}^t$ and $\widehat{\lambda}_j^t$ for time periods t = 2008 Q2, . . . , 2008 Q4 and rings j = 2,3. Quarter t^0 = 2008 Q1 and ring j = 1 are the base period and base ring, respectively.

Table 6 has the regression results for this set of estimated coefficients; Table 7 uses them to illustrate the construction of ring indexes $\widehat{P}_j^t$. Importantly note that, although all coefficients are reported in the tables, all those that were estimated with a p-value > 0.1

Table 7: Calculation of $\widehat{P}_j^t$ for Regensburg

Ring	Time	Calculation	$\widehat{P}_j^t$
1	08-Q1	$\exp(0)$	100.0
1	08-Q2	$\exp(\theta^{08\text{-}2})$	100.0
1	08-Q3	$\exp(\theta^{08\text{-}3})$	95.1
1	08-Q4	$\exp(\theta^{08\text{-}4})$	95.9
2	08-Q1	$\exp(\gamma_2)$	86.0
2	08-Q2	$\exp(\gamma_2 + \theta^{08\text{-}2} + \lambda_2^{08\text{-}2})$	86.0
2	08-Q3	$\exp(\gamma_2 + \theta^{08\text{-}3} + \lambda_2^{08\text{-}3})$	85.9
2	08-Q4	$\exp(\gamma_2 + \theta^{08\text{-}4} + \lambda_2^{08\text{-}4})$	86.7
3	08-Q1	$\exp(\gamma_3)$	83.8
3	08-Q2	$\exp(\gamma_3 + \theta^{08\text{-}2} + \lambda_3^{08\text{-}2})$	83.8
3	08-Q3	$\exp(\gamma_3 + \theta^{08\text{-}3} + \lambda_3^{08\text{-}3})$	79.7
3	08-Q4	$\exp(\gamma_3 + \theta^{08\text{-}4} + \lambda_3^{08\text{-}4})$	80.4

Note: Bias correction (eq (8)) skipped for illustration purposes.

are not used for index construction or are set to 0.

7.2 Robustness

Alternative Rent Index (Hedonic Double Imputation Index)

The results of subsidy introduction effects could depend on the way cities' ring rent indexes are constructed. I therefore check whether the results obtained by using the Hedonic Dummy Method for index construction change if the index is instead constructed by the Hedonic Double Imputation Method (HDI). HDI relaxes the assumption that housing characteristics' valuations are time-invariant. In particular, it combines features of an index number (e.g. Laspeyres, Paasche or Dutot) and uses hedonic methods to estimate predicted values for missing prices. First, I estimate separate hedonic models of the form

$$y_h^t = Z_h^t \beta + \epsilon_h^t, \tag{8}$$

for each city i in each period t. The dependent variable y is, an $H \times 1$ vector with elements $y_h = \ln p_h$, Z is an $H \times K$ matrix of property characteristics, β is a $K \times 1$ vector of characteristic shadow prices and ϵ is an $H \times 1$ vector of random errors. Again, H, K and T denote, respectively, the number of observations, characteristics and time periods, and p_h denotes the rent of property h.

The estimated coefficients from the hedonic models are then used to impute net rents for individual apartments. Following Hill and Scholz (2018) and Silver (2016) let $\ln\left(\widehat{p^t_{h|z^0_h}}\right)$ be the imputed log-rent (the predicted value) in period t of an apartment rented out in period 0. This log-rent is imputed by substituting the characteristics of apartment h rented out in period 0, z_h^0, into the estimated hedonic model of period t as

$$\ln\left(\widehat{p^t_{h|z^0_h}}\right) = \sum_{k=1}^{K} \widehat{\beta^t_k}\, z^0_{k,h}. \tag{9}$$

These imputed prices can be inserted into standard price formulas. I group observations ring j and time t and use a Dutot/Laspeyres-type imputation index of the form

$$P_j^t = \frac{\exp\left(1/H_j^0 \sum_{h \in H_j^0} \ln \widehat{p^t_{h|z_h^0}}\right)}{\exp\left(1/H_j^0 \sum_{h \in H_j^0} \ln \widehat{p^0_{h|z_h^0}}\right)} \times 100 \tag{10}$$

Hence, the price index of ring j at time t (in city i) is the mean of the predicted prices of apartments offered in ring j in t^0 valued at prices at t divided by the mean of these same apartments' predicted prices at t^0. Practically, I take all rental observations in ring j and time t^0 and, predicting prices from quarterly hedonic regression results, look at how much these same rental observations would have cost in other periods. Also note that I use a double imputation method, which means that rents both in t and in base period t^0 are imputed/predicted from the quarterly regressions. This index' baseline is different from the dummy hedonic method, as here every ring j is treated separately and hence each ring j's index value at t^0 serves as baseline = 100 (and not, as in the Hedonic Dummy Method, j_1 at t^0).[33]

Let me again show this index technique using one of my sample's cities, Regensburg, as an example. Table 8 shows estimated coefficients for a rent estimation like Equation 8, where property characteristics vector z only consists of variables listed in the table (and hence shortening the original rent regression for ease of presentation). Further, assume that both of these rings in t^0 only consist of three rental observations each. Table 9 illustrates the imputation of the rent index for two rings of Regensburg, j = 1,5. For each observation, I calculate the predicted log-rent in t using its housing characteristics (in t=0) from Table 9 and valuations of property characteristics in t from Table 8.

For example, the calculation of the log of predicted rent of the first apartment (first row of Table Table 9) in t^0 is

$$\begin{aligned} \ln \widehat{p^{08\text{-}1}}(z^{08\text{-}1}_{h=1}) &= 5.5421 + (0.0113 \times 77.5) + (0.0268 \times 3) + (-0.0698 \times 1) \\ &= 6.42866 \end{aligned}$$

[33] For "hands-on" explanations of a variety of index constructions, see Aizcorbe (2014).

Table 8: Hedonic regression results for Regensburg (shortend set of variables)

	Quarter-by-Quarter-Regressions		
	2008 Q1	2015 Q1	2020 Q1
Intercept	5.5421	5.4125	5.7629
living space	0.0113	0.0091	0.0113
rooms	0.0268	0.1427	0.0511
garden	0.0175	0.0571	0.0431
ring	-0.0698	-0.0216	-0.0435
adj rsq	0.748	0.764	0.817

Note: All reported estimated coefficients have p-values < 0.1.

Table 9: Calculation of imputed price indexes for Regensburg

Illustration of predicted rents					(log) Actual and predicted rents			P_j^t
Raw data for apartment rents in 2008 Q1					Actual	Predicted		
net rent	living space	rooms	garden	ring	2008 Q1	2008 Q1	2015 Q1	
700	**77.5**	**3**	**0**	**1**	**6.55108**	**6.42866**	**6.52250**	
570	76	2	0	1	6.34564	6.38488	6.36620	
720	80	3	1	1	6.57925	6.49610	6.60230	
Averages j = 1					6.49199	6.43655	6.50390	**106.97**
390	56	2	1	5	5.96615	5.91874	6.15534	
402	74	3	0	5	5.99645	6.11015	6.40459	
630	90	3	0	5	6.44572	6.29064	6.54957	
Averages j = 5					6.13611	6.10651	6.36983	**104.12**

Calculation for the numbers of the 2015 Q1 predicted column proceed the same way, except they use the estimated coefficients from the hedonic regression for 2015 Q1. Next, I take the average of the predicted log-rents for each ring j and proceed to calculate index P_j^t. In my example, the HDI-Index value for the first ring at 2015 Q1 is

$$P_1^{15\text{-}1} = [\exp(6.50390)/\exp(6.43655)] \times 100 = 106.97.$$

Table 10 has the regression results for the re-estimation of Equation 2 and Equation 3, but this time with the HDI-Index as response variable. The estimated DDD-coefficient does change in amplitude but - more importantly - retains its sign and statistical significance. Consequently, the paper's main result, lower central rent premiums post subsidy introduction in affordable cities, is not driven by how apartment rent and rent growth is measured.

Table 10: Estimations with the Hedonic Double Imputation Index

	All Cities								Only West		No Rent Control	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Intercept	112.81***	128.07***	142.19***	142.93***	113.33***	128.05***	142.70***	143.36***	149.52***	143.36***	133.59***	133.98***
	(0.57)	(5.40)	(5.50)	(5.42)	(0.53)	(4.97)	(5.38)	(5.35)	(5.22)	(5.35)	(4.66)	(4.59)
Center	2.24*	2.23*	2.22*	2.21*	0.98	0.95	1.25	1.28	1.11	1.28	1.19	−12.78
	(1.18)	(1.18)	(1.17)	(1.17)	(3.32)	(3.30)	(3.22)	(3.20)	(0.72)	(3.20)	(0.79)	(7.77)
BK	24.99***	19.30***	14.79***	11.87***	52.28***	49.95***	40.71***	11.86***	11.85***	11.86***	14.51***	14.03***
	(2.08)	(2.00)	(1.84)	(1.19)	(9.96)	(9.74)	(8.92)	(1.16)	(1.27)	(1.16)	(1.26)	(1.23)
Center × BK	7.37***	7.22***	6.09***	6.24***	25.49***	25.19***	22.26***	21.53***	5.18***	21.53***	5.00***	15.65**
	(1.36)	(1.39)	(1.24)	(1.30)	(3.36)	(3.35)	(3.64)	(3.00)	(1.07)	(3.00)	(0.97)	(7.37)
Aff × BK	−5.94**	−7.77***	−6.95***									
	(2.40)	(2.49)	(2.54)									
Aff × Center	1.72	1.81	1.62	1.63					2.05*		2.75**	
	(1.43)	(1.42)	(1.42)	(1.42)					(1.12)		(1.25)	
($\overline{\text{Price}}$ - Price) × Center					2.64	2.71	2.24	2.21		2.21		18.57*
					(3.93)	(3.90)	(3.81)	(3.79)		(3.79)		(9.45)
Log(New Houses)		−6.83***	−5.47***	−5.65***		−6.75***	−5.49***	−5.65***	−4.94***	−5.65***	−4.15***	−4.15***
		(1.44)	(1.13)	(1.14)		(1.35)	(1.11)	(1.14)	(1.15)	(1.14)	(1.09)	(1.09)
Log(New Apartments)		9.32***	6.41***	6.48***		9.52***	6.41***	6.48***	6.30***	6.48***	4.60***	4.60***
		(1.10)	(0.83)	(0.81)		(1.09)	(0.82)	(0.81)	(0.81)	(0.81)	(0.79)	(0.79)
Vacancy Rate			−818.00***	−835.16***			−818.55***	−835.16***	−1286.42***	−835.16***	−536.99***	−536.99***
			(205.37)	(198.80)			(203.22)	(198.80)	(185.39)	(198.80)	(127.79)	(127.79)
DDD-estimates												
Aff × Center × BK	−4.47***	−4.52***	−3.76**	−4.01**					−3.38**		−2.97**	
	(1.53)	(1.55)	(1.60)	(1.60)					(1.57)		(1.31)	
($\overline{\text{Price}}$ - Price) × Center × BK					−25.61***	−25.50***	−22.76***	−22.19***		−22.19***		−14.83
					(3.94)	(3.90)	(4.50)	(3.71)		(3.71)		(8.97)
City FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City FE × BK	No	No	No	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes
Adj. R^2	0.42	0.48	0.47	0.49	0.44	0.50	0.47	0.49	0.51	0.49	0.39	0.39
Num. obs.	46550	44724	40348	40348	46550	44724	40348	40348	33276	40348	21472	21472
N Clusters	105	105	103	103	105	105	103	103	86	103	61	61

OLS regressions with ring rent index as the response variable. Clustered standard errors (at city level) in parentheses.
Cols (9) & (10) exclude all cities on territory of former GDR, Col (11) & (12) exclude all cities that (at any point in time) introduced a rent control.
Data on building completions is from the federal and state statistical offices, data on the vacancy rate from empirica AG.
$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

Different Definitions of the City Center

Results of central rings' rent developments of course, may also heavily depend on which rings one defines as "central". The paper's results are obtained with ring j being central, i.e. dummy CENTER turning 1, if j lies within the first third of a cities' set of rings or $j \leq J_i/3$.

Table 11 serves as a robustness check and presents results from a re-estimation of Equation 2 and Equation 3 but with different definitions of CENTER. Col (1) and (4) use an *absolute* definition of the city center, as in every city—irrespective of its size—Dummy CENTER is 1 only for the first two rings from the CBD, i.e. $j = 1{,}2$. Col (2) and (5) use again a *relative* measure, as ring j is considered central when it lies within the first quarter of a city's set of rings or $j \leq J_i/4$. Finally, Col (3) and (6) show results when Dummy CENTER turns 1, if j lies within the first half of a city's set of rings.

Results of central rent premium development do not depend on the exact definition of central rings. Significant different central rent premium development by city affordability can be seen up to "mid-town", i.e. $j \leq J_i/2$ and this may closely coincide with the spatial cut-off of the predominance of apartment development in most cities.

Table 11: Different Definitions of Central Rings

	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	171.70^{***}	172.34^{***}	176.34^{***}	171.54^{***}	172.24^{***}	174.85^{***}
	(4.02)	(4.03)	(4.74)	(3.94)	(3.97)	(4.45)
Center	7.82^{***}	7.45^{***}	4.32^{***}	20.84^{***}	23.31^{***}	17.75
	(1.32)	(1.41)	(1.55)	(4.57)	(5.84)	(8.44)
BK	14.42^{***}	13.90^{***}	14.30^{***}	32.92^{***}	31.32^{***}	37.72^{***}
	(1.33)	(1.34)	(2.03)	(5.24)	(5.07)	(5.41)
Center × BK	6.18^{***}	5.26^{***}	1.61	24.42^{***}	18.75^{***}	−1.00
	(0.92)	(0.89)	(1.39)	(5.45)	(4.18)	(6.70)
Aff × BK	-5.23^{***}	-4.68^{**}	−3.57			
	(1.87)	(1.85)	(2.84)			
Aff × Center	-3.86^{**}	-4.63^{**}	-6.83^{**}			
	(1.68)	(1.84)	(2.94)			
Aff × Center × BK	-4.28^{***}	-4.06^{***}	−2.82			
	(1.30)	(1.26)	(2.56)			
($\overline{\text{Price}}$ - Price) × Center				-19.05^{**}	-23.31^{**}	−21.53
				(5.60)	(7.18)	(10.99)
($\overline{\text{Price}}$ - Price) × Center × BK				-25.48^{***}	-19.42^{***}	2.54
				(6.60)	(5.17)	(9.00)
Log(New Houses)	-5.52^{***}	-5.53^{***}	-5.54^{***}	-5.53^{***}	-5.54^{***}	-5.55^{***}
	(0.85)	(0.85)	(0.85)	(0.83)	(0.83)	(0.83)
Log(New Apartments)	6.45^{***}	6.44^{***}	6.44^{***}	6.45^{***}	6.45^{***}	6.46^{***}
	(0.66)	(0.66)	(0.66)	(0.65)	(0.65)	(0.65)
Vacancy Rate	-721.36^{***}	-720.93^{***}	-721.62^{***}	-721.51^{***}	-721.24^{***}	-721.53^{***}
	(149.27)	(149.26)	(149.38)	(147.86)	(147.86)	(147.92)
City FE	Yes	Yes	Yes	Yes	Yes	Yes
Center	$j < 2$	$j \leq J_i/4$	$j \leq J_i/2$	$j < 2$	$j \leq J_i/4$	$j \leq J_i/2$
Adj. R^2	0.48	0.49	0.47	0.49	0.49	0.47
Num. obs.	40915	40915	40915	40915	40915	40915
N Clusters	103	103	103	103	103	103

OLS regressions with ring rent index as the response variable. Clustered standard errors (at city level) in parentheses.
Data on building completions is from the federal and state statistical offices, data on the vacancy rate from empirica AG.
$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

7.3 Further Descriptives

Table 12: Sample of Cities

No.	City	J	State	Former GDR	Affordable	$\overline{\text{Price}}$ - Price
1	Amberg	6	BY	0	1	0.869
2	Ansbach	8	BY	0	1	0.859
3	Aschaffenburg	7	BY	0	0	0.674
4	Augsburg	13	BY	0	0	0.696
5	Baden-Baden	9	BW	0	0	0.748
6	Bamberg	7	BY	0	0	0.768
7	Bayreuth	6	BY	0	1	0.854
8	Berlin	26	B	1	0	0.665
9	Bielefeld	12	NW	0	0	0.799
10	Bochum	10	NW	0	0	0.800
11	Bonn	13	NW	0	0	0.718
12	Bottrop	13	NW	0	0	0.758
13	Brandenburg an der Havel	18	BB	0	1	0.947
14	Braunschweig	11	NI	0	1	0.846
15	Bremen	27	HB	0	1	0.833
16	Bremerhaven	9	HB	0	1	0.932
17	Chemnitz	12	SN	1	1	0.959
18	Coburg	6	BY	0	1	0.901
19	Cottbus	11	BB	1	1	0.946
20	Darmstadt	9	HE	0	0	0.533
21	Delmenhorst	7	NI	0	1	0.915
22	Dessau-Roßlau	14	ST	0	1	0.958
23	Dortmund	13	NW	0	0	0.799
24	Dresden	16	SN	1	0	0.794
25	Duisburg	13	NW	0	0	0.797
26	Dusseldorf	15	NW	0	0	0.676
27	Eisenach	10	TH	1	1	0.938
28	Emden	11	NI	0	1	0.922
29	Erfurt	12	TH	1	1	0.924
30	Erlangen	8	BY	0	0	0.720
31	Essen	14	NW	0	0	0.671
32	Flensburg	5	SH	0	1	0.926
33	Frankenthal (Pfalz)	7	RP	0	1	0.820
34	Frankfurt (Oder)	12	BB	1	1	0.957
35	Frankfurt am Main	15	HE	0	0	0.527
36	Freiburg im Breisgau	14	BW	0	0	0.656
37	Fuerth	7	BY	0	0	0.753
38	Gelsenkirchen	11	NW	0	1	0.844
39	Gera	11	TH	1	1	0.945

Sample of Cities (continued)

No.	City	J	State	Former GDR	Affordable	$\overline{\text{Price}}$ - Price
40	Goettingen	8	NI	0	1	0.910
41	Hagen	11	NW	0	1	0.820
42	Halle (Saale)	9	ST	1	1	0.916
43	Hamburg	25	HH	0	0	0.494
44	Hamm	12	NW	0	1	0.885
45	Hannover	11	NI	0	1	0.850
46	Heidelberg	9	BW	0	0	0.462
47	Heilbronn	10	BW	0	0	0.749
48	Herne	6	NW	0	1	0.832
49	Ingolstadt	12	BY	0	0	0.706
50	Jena	8	TH	1	1	0.895
51	Kaiserslautern	9	RP	0	1	0.820
52	Karlsruhe	11	BW	0	0	0.671
53	Kassel	10	HE	0	1	0.880
54	Kaufbeuren	5	BY	0	1	0.851
55	Kempten (Allgäu)	8	BY	0	1	0.818
56	Kiel	13	SH	0	1	0.855
57	Köln (Cologne)	18	NW	0	0	0.729
58	Krefeld	10	NW	0	0	0.736
59	Landau in der Pfalz	10	RP	0	0	0.801
60	Landshut	11	BY	0	0	0.743
61	Leipzig	13	SN	1	1	0.921
62	Leverkusen	10	NW	0	1	0.848
63	Luebeck	18	SH	0	1	0.885
64	Ludwigshafen am Rhein	10	RP	0	0	0.772
65	Magdeburg	11	ST	1	1	0.936
66	Mainz	11	RP	0	0	0.662
67	Memmingen	8	BY	0	1	0.861
68	Moenchengladbach	13	NW	0	0	0.793
69	Muelheim an der Ruhr	8	NW	0	1	0.842
70	Munich	16	BY	0	0	0.000
71	Munster	12	NW	0	0	0.731
72	Neumunster	9	SH	0	1	0.910
73	Neustadt an der Weinstraße	12	RP	0	0	0.758
74	Nuremberg	12	BY	0	0	0.669
75	Oberhausen	12	NW	0	0	0.846
76	Offenbach am Main	6	HE	0	0	0.669
77	Osnabrueck	9	NI	0	1	0.820
78	Passau	11	BY	0	1	0.873
79	Pforzheim	9	BW	0	0	0.788
80	Pirmasens	6	RP	0	1	0.922

Sample of Cities (continued)

No.	City	J	State	Former GDR	Affordable	$\overline{\text{Price}}$ - Price
81	Potsdam	14	BB	1	1	0.854
82	Regensburg	8	BY	0	0	0.676
83	Remscheid	9	NW	0	1	0.818
84	Rosenheim	6	BY	0	0	0.652
85	Rostock	18	MV	1	1	0.937
86	Salzgitter	19	NI	0	1	0.919
87	Schwabach	6	BY	0	0	0.801
88	Schweinfurt	4	BY	0	1	0.810
89	Schwerin	9	MV	1	1	0.917
90	Solingen	9	NW	0	0	0.761
91	Speyer	6	RP	0	0	0.736
92	Straubing	7	BY	0	1	0.839
93	Stuttgart	11	BW	0	0	0.266
94	Suhl	10	TH	1	1	0.960
95	Trier	10	RP	0	0	0.804
96	Ulm	10	BW	0	0	0.795
97	Weiden i.d. OPf.	7	BY	0	1	0.862
98	Weimar	8	TH	1	1	0.944
99	Wiesbaden	11	HE	0	0	0.578
100	Wilhelmshaven	12	NI	0	1	0.926
101	Wolfsburg	13	NI	0	1	0.901
102	Worms	13	RP	0	1	0.810
103	Wuppertal	13	NW	0	0	0.792
104	Wuerzburg	9	BY	0	0	0.720
105	Zweibruecken	8	RP	0	1	0.926

Note: B = Berlin, BB = Brandenburg, BW = Baden-Wuerttemberg, BY = Bavaria, HB = Bremen, HE = Hesse, MV = Mecklenburg-Western Pomerania, NI = Lower Saxony, NW = North Rhine-Westphalia, RP = Rhineland-Palatinate, SH = Schleswig-Holstein, SN = Saxony, ST = Saxony-Anhalt, TH = Thuringia.

		Expensive (N=26479)		Affordable (N=27475)			
		Mean	Std. Dev.	Mean	Std. Dev.	Diff. in Means	Std. Error
Ring Rent Index		104.7	20.4	109.5	19.1	4.8	2.1
J		13.2	5.0	11.8	4.8	−1.3	1.3
($\overline{\text{Price}}$ - Price)		675.5	159.6	887.2	46.4	211.7	27.4
New Houses		296.0	392.0	126.3	161.1	−169.7	83.0
New Apartments		88.5	137.4	15.2	19.3	−73.3	23.4
		N	%	N	%		
Former GDR	No	24421	92.2	19737	71.8		
	Yes	2058	7.8	7738	28.2		
“Mietpreisbremse”	No	9361	35.4	19929	72.5		
	Yes	17118	64.6	7546	27.5		

Table 13: Balance table of of the data

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