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Investment incentives of rent controls and gentrification - Evidence from German micro data*

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Abstract

We empirically document that the effectiveness of the German rent control introduced in 2015 in achieving rental housing affordability is limited. Exploring the reasons for this limited effectiveness we focus on the impact of the rent control on the yield on rental housing investments proxied by rent-price ratios which we derive by matching micro-level quotes on similar objects offered for rent and for sale. Exploiting the temporal, regional, and object-specific variation generated by the design of the rent control we identify a causal negative effect of the rent control on the yield of rental objects subject to the regulation. Further, we zoom into the spillovers across regulated objects and objects in the affected markets that were exempt from the regulation and find rising yields for the exempted objects, suggesting that the regulation contributed to gentrification via a shift of rental housing supply away from the regulated segment.

Keywords: rent control, micro data, rent-price ratio, housing affordability, housing supply

JEL Classification: R38, R31, E65, R21, R23, R10

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1 Introduction

Rising rents and sale prices for residential properties cause serious affordability problems in the housing markets in different countries. This situation developed after years of a severe demand overhang combined with inelastic supply, low interest rates, and population growth in most large cities. Interventions that promote affordable housing in tense markets are part of the current policy debate in many countries. To protect tenants and secure affordable housing, regulations like rent controls that put an upper ceiling on rent prices are introduced.[1] However, as rent price restrictions might negatively affect the supply of housing by reducing the incentives to invest in real estate, it is disputed if such measures can indeed improve housing affordability. A few studies have found evidence that rent controls inhibit the housing supply (Asquith, 2019; Diamond et al., 2019a; Sims, 2007). These studies however do not relate the inhibited housing supply to the effectiveness of the policy introduction in terms of achieving affordable rental housing.

In this paper, we document the limited effectiveness of the rent controls in achieving housing affordability and relate this limited effectiveness to the negative impact of these policies on the supply of rental housing units. Our focus is on the German rent control regulation introduced in 2015 that authorizes German federal states to limit the increases of rental prices in new contracts by a ceiling of 10% above the local comparative rent index. The rent control regulations are only applicable in municipalities with tight housing markets which are defined as markets where: (i) rents increase faster than the national average, or (ii) the rent-income ratio is significantly higher than the national average, or (iii) the vacancy rate is low, or (iv) the population is growing with a rate higher than the growth rate of new constructions (§556d BGB - Mietrechtsnovellierungsgesetz, 2015). Newbuilds and extensively modernized housing units

[1] While some countries regulate existing rental contracts most recent examples of newly introduced regulations (e.g. in Ireland, Sweden and Germany) only affect new tenancy rents.

are excluded from this regulation. Even though the federal law authorized the states to start with the introduction of rent control in June 2015, there was a substantial variation across states with regard to the timing of the de facto introduction of the policy.

Several features of the German rental market and the 2015 rent control regulation make it an excellent laboratory for studying the impact of this type of policy intervention. First, Germany has a large share of tenant households and a comparably small homeownership rate of 46.5% (German Federal Statistical Office, 2021b) which makes the rental market particularly relevant both in terms of the stock of rental housing and in terms of the relevance of rental payments for the total of household expenditures. Second, the affordability of housing costs has increasingly become a significant issue in Germany with more than 14% of German households overburdened by housing costs in 2019, i.e. they spent more than 40% of their disposable income on housing. Among the EU27, this proportion is higher only in Greece, Bulgaria, and Denmark (German Federal Statistical Office, 2021a). Third, for Germany, very detailed micro data on both offered rental and sale prices of real estate are available. This data availability allows us to compute the yield of investments in housing by matching rental and sale properties based on a similarity index computed on the basis of object-specific characteristics and object condition. Fourth, the design of the rent control policy and in particular the staggered implementation of the rent control over the federal states allows the empirical analysis of causal effects where the identification is based on the temporal and regional variation in the introduction of the rent control while controlling for many factors at the regional level. Further, the fact that some objects in markets with rent control are exempt from the policy allows us to trace the spillovers between the unregulated and the regulated segment of the regional rental market.

Our empirical analysis proceeds as follows. We begin by presenting some stylized evidence on the general effectiveness of the regulation in terms of controlling the affordability of rental housing. For this initial step, we use aggregate district-level data and measure affordability by the ratio of median rent to average disposable household income. Scaling rental prices by household income allows us to control for the fact that rising households' income might be associated with higher demand for upscale housing standards and thus concentrate only on affordability. The results of our analysis comparing the dynamics of the rent-income ratio in the regulated markets to that ratio in markets without rent controls illustrate the very limited effectiveness of the rent controls in terms of reducing or even stabilizing the rent-income ratio. More specifically, we find that the proportion of household income spent on rental payments not only does not decrease but even increases in tight housing markets after the implementation of the rent control.

Next, we dig deeper into explaining this observed limited improvement of rental housing affordability after the introduction of the rent control. More specifically, we explore the richness of our granular data to put forward a potential explanation for the limited effectiveness of the rent control policy. Our focus is on exploring the aforementioned argument that rent controls inhibit rental housing supply. We presume that the incentives to supply rental housing will be positively related to the yield on rental housing that can be imputed by the ratio of annual rents to the sale price. The fact that we observe a large number of objects offered for rent and sale in most regions allows us to derive the yield by matching highly similar rental and sale objects. We then perform a two-way fixed effects analysis of the dynamics of the yield (rent-price ratio) of regulated and not-regulated objects in tight (regulated) and normal (not-regulated) markets around the introduction of the rent control in the respective federal state. The results of our analysis indicate that after the introduction of the rent control, the rent-price ratio of regulated objects lies on average 6.8 percentage points lower than in the control group while the rent-price ratio of unregulated objects in a regulated municipality is 14.0 percentage points higher. The higher yield on unregulated objects suggests that there are incentives for housing investments to shift to the unregulated segment. These results also explain why the aggregate impact of the policy measure in regulated markets is a relative increase rather than a decrease in rent-income ratios.

In sum, we find that the rent control regulation affects the yield not only of regulated but also of unregulated objects. Berg et al. (2021) propose an explicit methodology for the estimation of such spillover effects to non-treated units and we next apply this methodology to derive the treatment, non-treatment, and average effects contingent on the share of treated objects in the respective district. The results show that a higher proportion of regulated objects in a municipality is associated with higher rent-price ratios of unregulated objects in this municipality. Thus, the goal of the German rent control to foster the provision of affordable living space is undermined by the increasing incentives for new construction and renovations. It promotes gentrification and amplifies the supply shortage of moderately priced living space in tense housing markets.

By presenting new insights into the effectiveness of rent controls and the determinants of this effectiveness our results contribute to several strands of the literature. First, we speak to the growing empirical literature that shows various negative effects of limiting rents below market prices on rental housing supply and construction activities. Sims (2007) and Asquith (2019) find reductions in the controlled rental housing supply. Diamond et al. (2019a) highlight that these studies suffer some identification challenges as there is little exogenous variation in the regulatory events they explore. These authors then improve the identification by studying a fairly unexpected change introduced in 1994 of the San Francisco rent control regulation that includes (previously exempt) dwellings in smaller multi-family homes but only if the home was built before 1979 leaving newer dwellings outside the scope of the regulation. Based on this quasi-experimental variation across dwellings Diamond et al. (2019a) causally demonstrate that the number of tenants who live in regulated objects decreased due to property redevelopments aiming to circumvent the regulation. This conversion of existing rental properties ultimately led to a higher-end less affordable housing stock. Following this, the authors conclude that the primary goal of the rent controls is missed because of gentrification (this finding is consistent with Gyourko & Linneman (1990) and Sims (2011) who find effects on the socioeconomic composition in regulated areas) and the decreased rental housing supply which is likely to foster rent increases in the long-run. Further, Diamond et al. (2019b) find that the development is driven by the reduced supply of objects managed by corporate landlords. While the supply of rent-controlled housing owned by individuals decreases by 14 percent, corporate landlords are more likely to evade rent controls and replace rent-controlled housing by 64 percent by selling to owner-occupants and increasing their supply of non-regulated objects. We contribute to this strand of the literature that shows that rent controls adversely affect the supply of rental housing in at least four dimensions. First, while most existing studies examine the effects only in selected cities or metropolitan areas, our data allows us to explore nationwide dynamics in one of the largest European countries. The nationwide coverage of the policy measure combined with the time variation of its introduction across districts allows us to also derive identification from adopting a quasi-experimental approach but in an empirical setup that substantially differs from the ones explored so far. Second, while existing studies mostly directly measure the changes in affordable rental housing supply by tracing tenants' evictions and property redevelopments, we adopt a less direct approach that looks at the yield of investments in regulated vs unregulated rental housing as an indicator for the incentives to invest in each of these property categories. Although the rental housing yield is likely to affect rental housing supply and thus the general outcome of the rent control policies, it has so far received little attention in the existing literature on rent regulation. The use of the rental housing yield allows a different perspective of the analysis and enables the exploration of rent control’s impact in settings where detailed data on evictions and redevelopments is not available. Third, we explicitly control for spillover effects to non-regulated objects which as our results show are not negligible. And last but not least, we show that the gentrification effect is present even in markets – as the German one- where corporate landlords have a smaller market share (i.e. around 40% according to Kofner, 2014) indicating that the concern that gentrification might arise as a rent control' side effect has a broader validity and is not limited to corporate landlords.

By showing that the rent control policy fails short of reaching the goal of reducing rent burdens we also speak to the literature that argues that rent controls might generate misallocation and welfare losses and are, therefore, inefficient tools in fighting housing market shortages (Bulow & Klemperer, 2012; Chapelle et al., 2019; Skak & Bloze, 2013; Arnott, 1995; Glaeser & Luttmer, 2003). More specifically, Oust (2018) points to reduced mobility in the rental market. Kholodilin & Kohl (2021) evaluate the effect of rent controls as a tool of redistribution on inequality. Autor et al. (2014) show that the regulation leads to spillover effects on non-controlled units since after the abolition of rent controls in Massachusetts, price appreciations were observable for both regulated and unregulated objects. These results support the findings of Early (2000) examining the effects of rent controls on the distribution of benefits to tenants in controlled and uncontrolled rental units in New York. In addition to several empirical studies, theoretical models are used to explore the impact of rent controls, too, e.g. (Favilukis et al., (2023) develop a dynamic stochastic spatial equilibrium model to evaluate the effectiveness of different political measures that are put in place to foster the affordability of housing.

And last but not least, we contribute to the growing literature focused on the German housing market. The general effectiveness of the German rent control has been the focus of recent analyses (Breidenbach et al., 2022; Deschermeier et al., 2016; Kholodilin et al., 2016; Mense et al., 2019, 2023; Thomschke, 2019). As the design of rent controls already applied in other countries slightly differs from the German one, the above-mentioned findings might only be partly transferable to the German housing market. As policy makers from other countries, like e.g. from France and Spain, proposed rent control schemes that are similar to the German regulation, the examination of the effects is relevant not only to Germany. The above-mentioned studies find varying price effects in different regions. They also indicate unintended side effects like market segmentation and misallocations. More specifically, Breidenbach et al. (2022) study the temporal dynamics and medium-term effects of the rent control using a similar to our dataset. They find a decrease in rental prices of up to 5%, however, the effect seems to vanish about one year after the implementation. They also conclude that the measure does not meet the original policy goal because the rent control mostly benefits areas inhabited by high-income households. Further, Mense et al. (2023) present a standard comparative-static model of a divided housing market which explains that the market segmentation induced by the price regulation causes misallocation. These authors show empirical evidence of supply-side spillovers to unregulated rents as a consequence of misallocation. This fits our results as the rent-price ratios in regulated, tense housing markets are higher for unregulated newbuilds after the introduction of the rent control. None of the above studies, however, addresses the questions of how the rent control scores in terms of stabilizing the proportion of income spent on rental payments and how it affects the housing yield proxied by the rent-price ratio.

The remainder of this paper is organized as follows. Section 2 describes the institutional background of the rent control and the German housing market. Section 3 presents the dataset and its sources. In Section 4 we explore the impact of the rent control on rental housing affordability as measured by the rent-income ratio. Section 5 elaborates on how the rent control affects rent-price ratios. Section 6 concludes.

2 Institutional background and the German housing market

In Germany, prices of new rental contracts are more than 40% higher in 2022 than in 2010, and in booming cities like Munich, Berlin, or Stuttgart, rent price indexes indicate price increases of 70% to more than 100% (Breidenbach et al., 2022). To ensure affordable housing and stop the rapid rise of rents, especially in metropolitan areas, a tenancy law reform was introduced in June 2015 which empowers every federal state in Germany to regulate new rental contracts (*Mietpreisbremse*). As in the established literature focusing on this topic, we use the term 'rent control' to refer to this law. The law adds to the protection regime in the German tenancy law which prevents substantial rental price increases of existing contracts. More specifically, the law limits the increases in inventory rents in tight housing markets by capping these to a level linked to the local rent index.

The tenancy law reform allows the federal states to introduce rent controls in regions where the housing markets are tight. A tight housing market is characterized by rents that increase faster than the national average, a rent burden ratio that is significantly higher than the national average, a low vacancy rate combined with high demand, and a residential population growing faster than the new construction activity. To identify a housing market as "tight", at least one of the mentioned conditions has to be fulfilled (Kholodilin, 2016; Simons et al., 2020).

The law stipulates that new rents are not allowed to exceed the standard local comparative level given by the local rental index by 10% in the following five years. The local rent index represents the typical local private market rents for comparable objects given similar characteristics and location, however, its composition and suitability are disputed in this context (Thomschke, 2019). The level at which these local rent indices are computed is the municipality, so we will be focusing on observing variations across municipalities in the regional dimension. In terms of the timing of the staggered introduction of the rent control, the variation comes from the different points in time when the different federal states endorsed and adopted the policy[2]. So, for example, it was first introduced in Berlin, followed by North Rhine-Westphalia, which is Germany's most populous federal state (Breidenbach et al., 2022). There is one important exception to the regulation, which also gives rise to variation that we explore: Condition-specific exceptions of the regulation apply to new buildings, completed in the year 2014 or later, and extensively modernized apartments to support investments in building activities[3]. As modernized units are not regulated, variation at the level of rental objects arises on top of the regional and temporal ones.

As rising housing costs are a problem that is often more severe in cities, the regulation is mostly concentrated in urban and metropolitan areas. Overall, after the law became effective, 13 out of 16 federal states implemented the rent control in 313 municipalities. In this context, the law affects around 40% of all rental objects in Germany (Breidenbach et al., 2022). To analyze the effect of the rent control, we take advantage of its variation on temporal, regional, and individual levels since it is applied in a selected number of municipalities at different points in time and new and modernized units are not regulated.

The German housing market is characterized by a large share of tenants and constantly low homeownership rates (46.5% in 2019, (German Federal Statistical Office, 2021b)). The well-developed rental market has evolved after a severe housing shortage after the Second World War when heavy subsidies and regulations made renting economically attractive relative to living in residential property (Bentzien et al., 2012). Still today, several factors like credit

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[2] Germany is structured into 16 federal states (*Länder*). These consist of districts (*Kreise*) which are at an intermediate level of administration between the German federal states and the municipalities' governments. Municipalities are cities or towns with their own local government, they define the lowest level of territorial divisions in Germany. In Germany, more than 11,000 municipalities exist in 401 districts. Cities with more than 100,000 inhabitants usually do not belong to a district but form their own district.

[3] Three further exceptions that we cannot control for due to data limitations are: (i) objects are excluded from the rent control if the previous tenant paid a rent beyond 10% of the local rental index, in this case the same rent level can be asked for in new contracts, (ii) objects are excluded if the rental contract is for a limited period of time, and (iii) if the object is furnished.

rationing and missing advantages in taxation disfavor owner-occupied housing (Schmidt, 2019). The rental sector is supported by a large stock of adequate rental housing which serves a broad range of target groups by offering several quality choices and renting is socially accepted. The well-maintained rental housing stock prevents also richer households from moving into owner-occupied dwellings. Moreover, the large private rental sector is special in the German housing market where over 60% of all rental apartments are owned by private households (Kofner, 2014).

3 Data

For the analysis, we merge data from different sources, including micro-level rental and sale price data for flats, self-collected data on the rent control introduction in Germany as well as regional characteristics and regional socioeconomic variables from the regional database of German Federal statistical offices.

The micro-level housing data are provided by the research data center FDZ Ruhr at the RWI (RWI-GEO-RED, 2020a, 2020b). They are based on German residential real estate advertisements from the internet platform ImmobilienScout24[4]. The data are a systematic collection of all objects that were offered for rent and for sale on this internet platform with a monthly frequency covering the period from January 2007 to March 2020. The data cover information on the *asking price*, several object-specific value-determining characteristics, like the *number of rooms*, *living space*, *object condition*, and details concerning the location on the municipality-level (Boelmann & Schaffner, 2019). The *object condition* can take the values of (1) first occupancy, (2) first occupancy after reconstruction, (3) reconstructed, (4) modernized, (5) like new, (6) completely renovated, (7) well kept, (8) needs renovation, (9) dilapidated but negotiable and (10) dilapidated. These detailed data are used in the micro-level analysis (Chapter 5) to identify if a specific object is subject to rental controls or not.

For the empirical analysis, we use data on apartments for sale and apartments for rent. The raw data provide a high number of observations. To ensure the quality of the analyzed dataset, incomplete advertisements that do not contain a net rent could not be included in the analysis. Moreover, we only consider objects with a listed postcode area,[5] that were built in 1800 or later,

[4] ImmobilienScout24 is one of the largest internet platforms for real estate advertisements in Germany and can be used by both private and commercial users. Of all real estate objects offered for rent or sale, it has a self-reported market share of about 50% and is used by 74,3% professionals to offer their objects (Statista, 2020). For a detailed description, see Boelmann & Schaffner (2019).

[5] The German postcode system is a pure number system consisting of five digits. By only considering objects in five-digit postcode areas, the quality of the observations considered should be ensured. Studies using the same data set use similar procedures for quality assurance (Breidenbach et al., 2022; Deschermeier et al., 2016; Eilers, 2017).

with a minimum number of rooms of one, reported living space of at least ten square meters, and that do not belong to the cheapest or most expensive 1% in terms of price per square meter. The average apartment for rent in our dataset is located in a building that was built in 1973, has three rooms and a living space of 72.5 square meters. The monthly net rent of this object would be 583.25 Euros, as the rent per square meter is 8.04 Euros (Table 1). The average apartment for sale has three rooms as well, is slightly newer, larger, and has an average sale price per square meter of 2,251.17 Euros (Table 2). Recent studies based on these data were for example published by Breidenbach et al. (2022), analyzing the temporal dynamics of rent prices due to the rent control, Deschermeier et al. (2016), Klick & Schaffner (2019), and Eilers (2017) who focus on recent developments in the housing market for rentals and sales.

Variable	Mean	Std. Dev.	Min	p25	p50	p75	Max	N
Year of construction	1972.657	29.858	1800	1960	1974	1995	2020	3,925,713
Living space	72.534	24.337	10.6	57	70	85	527.44	3,925,713
Number of rooms	2.617	.854	1	2	3	3	10	3,925,713
Rent per square meter	8.041	2.827	3.654	5.921	7.477	9.524	20.522	3,925,713

Table 1: Descriptive statistics of rental objects
Table 1 shows descriptive statistics of the quotes on rental objects from the micro-level housing dataset based on German residential real estate advertisements. The data are a systematic collection of all objects that were offered for rent on the internet platform ImmobilienScout24 with a monthly frequency covering the period from January 2007 to December 2019.

Variable	Mean	Std. Dev.	Min	p25	p50	p75	Max	N
Year of construction	1977.66	33.66	1800	1965	1984	2003	2020	5,659,449
Living space	85.35	38.61	10	60.9	79	100.79	1000	5,659,449
Number of rooms	2.94	1.1141	1	2	3	3.5	10	5,659,449
Price per square meter	2,251.17	1,291.57	5	1,300	1,956	2,900	7,718	5,659,449

Table 2: Descriptive statistics of sale objects
Table 2 shows descriptive statistics of the quotes on objects for sale from the micro-level housing dataset based on German residential real estate advertisements. The data are a systematic collection of all objects that were offered for sale on the internet platform ImmobilienScout24 with a monthly frequency covering the period from January 2007 to December 2019.

We are aware that the asking prices might deviate from actual transaction prices, but as Dinkel & Kurzrock (2012), Kholodilin et al. (2016) and Lyons (2013) emphasize, asking price data show reliable price trends. Especially for the advertised rent prices, significant deviations from the transactions do not need to be assumed because, as Zhu (2005) emphasizes, bargaining over rent prices is relatively rare, especially in regions with a demand overhang. Thus, landlords will generally obtain their asking prices (Deschermeier et al., 2016). However, although we use a large data set on micro-level, the housing market might be not perfectly represented, as for example shadow rental agreements and subletting may be used to bypass the regulation.

We match the micro-level real estate data to self-collected data from the Federal State's laws on the application of rent controls, which were introduced on the municipality-level at various points in time by the Federal States. Further data on regional characteristics, local economic activity, and socioeconomic variables at the municipality- and district-level[6] are collected from the "Genesis" regional data platform maintained by the German Federal Statistical Institute (*Statistisches Bundesamt*) and the German Federal Institute for Research on Building, Urban Affairs and Spatial Development which offers indicators of spatial and urban development (*INKAR*).

[6] Municipalities are cities or towns with an own local government, they define the lowest level of territorial division in Germany. In Germany exist more than 11,000 municipalities in 401 districts. The German districts are at an intermediate level of administration between the German federal states and the municipality governments. Cities with more than 100,000 inhabitants do not usually belong to a district, but form their own district.

4 The effects of rent control on rental housing affordability

As a point of departure, we first evaluate the effectiveness of the German rent control by analyzing the effect of the introduction of this policy instrument on the rent-income ratio, which we use to proxy the affordability of rental housing. We explicitly do not focus on the development of the rent prices but rather on the rent-income ratio, because we intend to rule out an increased demand for higher living space and housing standards which might occur due to growing income, and focus on the intended target of improving housing affordability. The variable displays the proportion of the household income that is spent on rental payments proxied by the yearly median net rent of the newly offered flats per district.[7] Our data show that despite the implementation of the rent control after 2015, the gap between the average rent-income ratios of regulated and unregulated regions increased from 2014 to 2019.[8] Due to data availability for the household income variable, we work on a district-year level for this analysis, as this is the most granular level at which household income data are reported in Germany.[9] We compress the micro-level rental prices by taking the mean per district and year and implement a panel structure. We study the effect of the introduction of the rent control on the rent-income

[7] As described above, this indicator is also used to identify tight housing markets (Simons et al., 2020).When using the rent-income ratio in our analysis, we are aware of the concerns of Favilukis et al. (2023) who underline that this ratio must be interpreted carefully because rent-income ratios reflect equilibrium rents and the income of those people who have sorted themselves into each area in the spatial equilibrium. In their dynamic stochastic spatial equilibrium model, an increasing rent-income ratio can be a sign of an effective regulation as misallocation decreases and low-income households can move to more expensive areas, like city centers, where they could not get an apartment before a specific regulation was implemented. However, there are various reasons why the use of the rent-income ratio is still reasonable in our analysis. First, the rent control in Germany is not targeted and does not include an income qualification of tenants which is crucial in the framework of Favilukis et al. (2023). Second, the rent control is introduced in tense housing markets with a severe demand overhang where landlords typically chose the financially strongest tenant. An upward bias through the immigration of tenants with smaller incomes into municipalities with rental control is therefore rather unlikely.

[8] In 2014, prior to the introduction of the rent control, households in tense housing markets, where the rent control is introduced in the following months, spend on average 33.18% of their income on rental payments. These payments lie on average 7.37 percentage points higher than in areas where the rent control is never introduced, as on average 25.81% of the household income is spent on rent here. However, in 2019, four years after the first federal states introduced the rent control, the gap between the average rent-income ratios of regulated (37.44%) and unregulated areas (29.02%) increased.

[9] We do not impose substantial restrictions on the granularity of the data because for urban areas, where we observed most of the regulation, the overlap between the administrative units *municipality* and *district* is high. Most districts consisting of multiple municipalities are located in rural areas.

ratio using a linear model with fixed effects and exploit the staggered introduction of the regulation in the different federal states by applying the following regression framework:

$$rent\_income\_ratio_{dy} = \alpha + \gamma\, district\_reg_d + \delta\, district\_reg_d \times period\_reg_y + \beta\, X_{dy} + B_y + \varepsilon \quad (1)$$

The dummy variable $district\_reg_d$ divides the sample into a treatment and a control group and equals 1 if at least one municipality in a district is regulated. [10] Thus, γ reveals the average difference of the rent-income ratio between regulated and unregulated districts. As a higher than national average rent-income ratio is one of the criteria to implement the rent control in a municipality, we expect a positive sign of the estimated coefficient for γ.[11] The dummy variable $period\_reg_y$ identifies the treatment period and equals 1 if the rent control is applied in one or more municipalities in the district in a certain year. Thus, the coefficient δ estimates the effect of the introduction of the rent control in a regulated district on the rent-income ratio. If the regulation is effective in lowering the rent-income ratio or at least in maintaining the level of income spent on rental payments, the estimator for δ will be significantly negative or insignificant. Moreover, we include several control variables in the vector X_{dy} and year fixed effects.[12] Robust standard errors are clustered for districts.

The estimation results (Table 3) reveal that the rent-income ratio in the treatment group lies 4.64 percentage points higher than in municipalities from the control group which reflects the fact that the rent control is introduced in municipalities where the rent-income ratio is higher.

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[10] Although the rent control is introduced on the municipality level, the aggregation to the district-level leads to little information losses because the regulation mostly applies to cities that are classified as individual districts in the data set.

[11] Indeed, the rent control is introduced in 78% of those districts that belong to the quartile with the highest rent-income ratios in 2014.

[12] We include *yield* which is proxied by the rent-price ratio (mean of all rental offers divided by the mean of the sale prices of all offered objects for each district per year). In addition, region-specific dummy variables to define if a district is considered as an urban or metropolitan area and is located in Western or Eastern Germany, as well as socioeconomic factors including the number of students, the unemployment rate, and construction completions are included. Year fixed effects cover changes in the real interest rates and credit conditions as well as in the overall economic situation.

However, the estimated coefficient for δ shows that introduction of the rent control increases the rent-income ratio on average by a further 1.45 percentage points in regulated districts. Thus, rental payments seem to increase faster than household incomes in these tight markets after the implementation of the rent control and housing affordability is not improved. We next zoom into the potential reasons for this failure of the regulation and exploit the micro dimension of our dataset to investigate how the rent control affects the supply side of the housing market by affecting the yields on rental housing.

Table 3 y = rent-income ratio VARIABLES	(1)
District_reg	**0.0464***** (0.00512)
District_reg x Period_reg	**0.0145***** (0.00257)
Yield	-0.0135*** (0.00142)
Urban area (Dummy) (regional centers)	0.00154 (0.00688)
City / Metropolitan area (Dummy)	-0.0186** (0.00928)
Western / Eastern GER (Dummy) (1 = West, 0 = East)	0.0143* (0.00800)
Population density	0 (0)
Students	0.122** (0.0616)
Unemployment rate	1.093*** (0.186)
Construction completions	0.113*** (0.0290)
Constant	0.281*** (0.0164)
Observations	3,585
Number of districts	380
R-squared	0.522
Year FE	Yes
Observation period	2010-2019

Table 3: The effect of rent control on the rent-income ratio
Table 3 presents the results of the fixed effects regression to estimate the effect of the introduction of rent controls on the rent-income ratio. We estimate the model of equation (1) using district-year-level panel data. The dependent variable is the rent-income ratio which displays the proportion of the household income that is spent on rental payments proxied by the yearly median net rent of the newly offered flats per district.
The explanatory variables contain several dummy variables: District_reg_d divides the sample into a treatment- and a control-group depending on the introduction of the regulation, Period_reg_y identifies the treatment period and equals 1 if the rent control is applied in one or more municipalities in the district in a certain year. Year fixed

effects are included. The sample covers the observation period from 2010 to 2019. Robust standard errors clustered for districts are displayed in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1%-level, respectively.

5 Rent control and the rent-price ratio

Our results so far indicate that the effectiveness of rent control in terms of achieving affordability of rental housing is limited. In this section, we explore the granularity of our real estate data and identify a channel through which the rent control might affect the supply side of the housing market: the reduction of the yield of investments in regulated rental housing. As the provision of affordable housing naturally depends on the supply of living space, we put the yield on rental housing, proxied by the rent-price ratio, in the center of the analysis. As it indicates the attractiveness of investing in rental housing, the rent-price ratio reflects the investment incentives which are needed to address supply shortages in the long term. Using this ratio allows us a more holistic view of the dynamics of the incentives to supply rental housing relative to a simple focus on rent levels. This is particularly the case as we look at periods when not only rents but also house price levels are changing substantially.

5.1 Variables and descriptive analysis

5.1.1 The rent-price ratio

The rental housing yield is measured by the rent-price ratio which is calculated for each rental object from the reported yearly net rent and the potential sale price which we derive from matching the rental objects to similar objects advertised for sale. Each dwelling in our dataset is advertised either as a rental or as a sale offer. To match the sale and rental offers and compute the rent-price ratio we proceed as follows: we match all sales objects in the same postcode area in the same quarter to each rental object and identify the most similar matches. As a similarity measure, the Euclidean Distance (ED) is calculated based on object-specific characteristics. The matching variables are the *year of construction*, the *living space*, the *number of rooms*, and the *object condition* which are used to compute the square root of the sum of the squared standardized differences. The consideration of the *object condition* in the calculation of the similarity measure allows a quality-adjusted matching. This allows us to address a challenge faced by the earlier literature which claims that rented and sold objects may not be of equal quality and recommends quality adjustments to approximate the actual ratio (Hill & Syed, 2015). For our matching approach, we take advantage of the well-maintained rental housing stock in Germany. Since the quality of German rental objects is indistinguishable from the quality of objects for sale, our approach is reasonable to generate a reliable rent-price ratio.

The smaller the ED of a match, the more similar the rental and the sale object, according to the underlying characteristics used as matching variables. To proxy a suitable potential sale price for each rental object, we take the mean of the matches that have one of the three lowest EDs and whose ED lies under a minimum similarity level of 3[13], which is set to prevent the creation of unsuitable matches. The rent-price ratio is calculated for each rental object from the reported net rent and the matched potential sale price.

This results in a dataset covering 3,925,713 observations. As presented in Figure 1, the average rent-price ratio in Germany decreases since 2010 because sale prices for residential properties grow faster than rents[14]. To reduce the risk of a biased measure for the rent-price ratio, in the following analysis, we only consider observations whose rent-price ratio does not belong to the highest or lowest 0.1%, thus, the rent-price ratio varies between 1.603% and 17.571% with a mean of 5.478% (see distribution of the rent-price ratio in Figure 2).

Among other things, the rent-price ratio depends on the living space, the number of rooms, and the year of construction. Summary statistics (Table 4) show that smaller apartments, determined by the living space as well as by the number of rooms, have a higher rent-price ratio. Moreover, in newer buildings, the rents are smaller in proportion to the sale prices, thus, their yield on

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[13] The results are robust to different thresholds between an ED of 2 - 3.5 that specify the minimum similarity of the matched rental and sale offers.

[14] The decreasing yield on rental housing investments is also consistent with the fact that we cover a period of low and decreasing interest rates which are reflected in decreasing yields in mast major assets' categories.

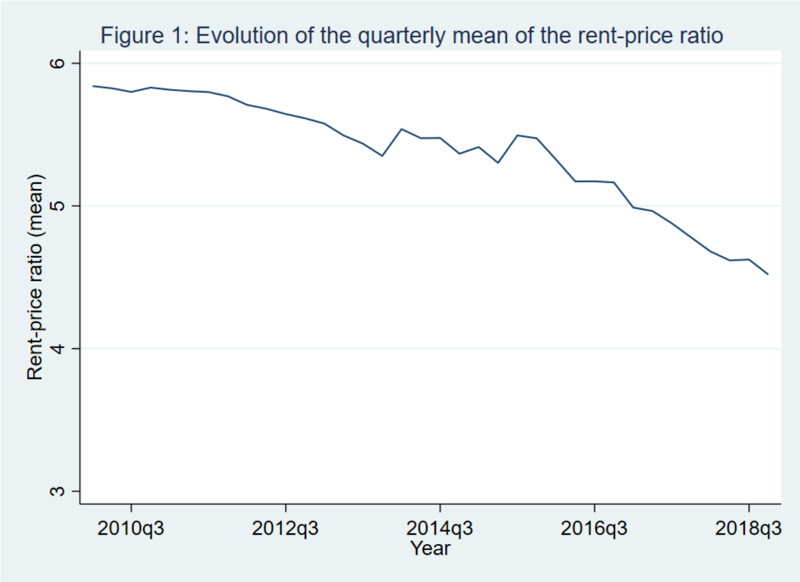

Figure 1: Evolution of the quarterly mean of the rent-price ratio in Germany between 2010 and 2019
Figure 1 shows the decreasing average rent-price ratio between 2010 and 2019. The rent-price ratio is calculated for each rental object by the yearly net rent divided by the potential sale price which is proxied by matching the most similar rental and sale objects based on object-specific characteristics.

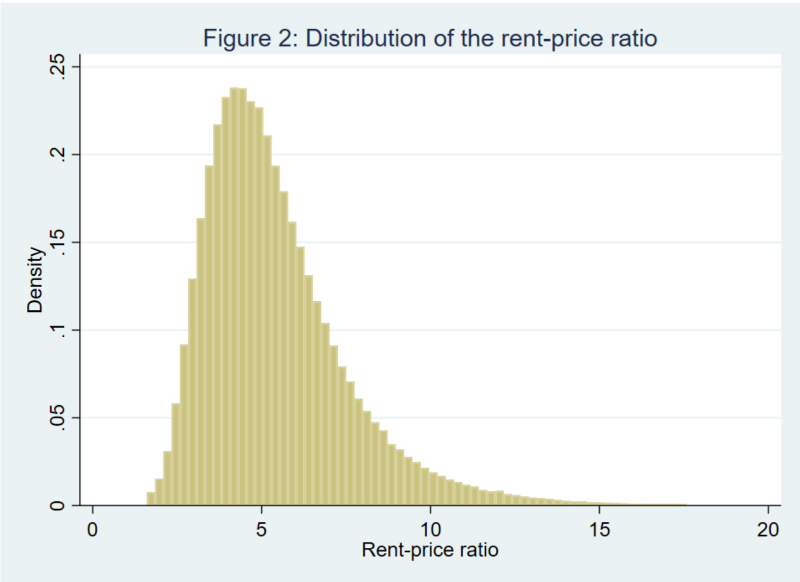

Figure 2: Distribution of rent-price ratio in Germany between 2010 and 2019
Figure 2 shows the distribution of the rent-price ratio in Germany between 2010 and 2019. The rent-price ratio is calculated for each rental object by the yearly net rent divided by the potential sale price which is proxied by matching the most similar rental and sale objects based on object-specific characteristics.

average is smaller. The characteristics of our dataset fit the findings of recent papers that investigate the determinants of rent-price ratios (Ambrose et al., 2013; Bracke, 2015; Case & Shiller, 1990; Clark & Lomax, 2019; Cui et al., 2018; Engsted & Pedersen, 2015; Gallin, 2008;

Garner & Verbrugge, 2009; Halket et al., 2020; Halket & Pignatti Morano di Custoza, 2015; Huang et al., 2018; Hwang et al., 2006; Ito & Hirono, 1993; Smith & Smith, 2006). In cities, the rent-price ratio is smaller which is consistent with the results of (Hilber & Mense, 2021) who find that price-rent ratios increased more in cities than in rural areas due to persistent demand shocks in combination with an inelastic supply of living space. The unique features of the dataset, covering rents and the estimated sale prices, are exploited in the following analysis (see Chapters 5.2 and 5.3).

Summary statistics: Rent-price ratio

	Obs.	mean	min	p25	Median	p75	max
Rent-price ratio	3,925,713	5.428	1.603	3.931	5.000	6.429	17.571

Summary statistics: Rent-price ratio by living space

Living space (sqm)	Obs.	mean	min	p25	Median	p75	max
x < 57	968,451	5.888	1.603	4.214	5.442	7.055	17.566
57 ≤ x < 70	962,920	5.743	1.604	4.174	5.339	6.833	17.571
70 ≤ x < 85	1,008,812	5.363	1.604	3.980	4.992	6.308	17.571
x ≥ 85	985,530	4.734	1.604	3.560	4.389	5.488	17.571

Summary statistics: Rent-price ratio by number of rooms

Number of rooms	Obs.	mean	min	p25	Median	p75	max
1	755,149	5.688	1.605	4.111	5.261	6.762	17.568
2	1,292,071	5.46	1.603	3.949	5.028	6.477	17.571
3	1,448,089	5.401	1.604	3.938	4.983	6.381	17.571
4 or more	430,404	4.965	1.604	3.623	4.554	5.828	17.571

Summary statistics: Rent-price ratio by year of construction

Year of construction	Obs.	mean	min	p25	Median	p75	max
x < 1960	966,801	5.936	1.604	4.134	5.479	7.2	17.571
1960 ≤ x < 1974	977,845	6.07	1.606	4.598	5.732	7.12	17.571
1974 ≤ x < 1995	924,531	5.372	1.604	4.083	5.021	6.245	17.568
x ≥ 1995	1,056,536	4.418	1.603	3.424	4.143	5.063	17.556

Summary statistics: Rent-price ratio by district type

Year of construction	Obs.	mean	min	p25	Median	p75	max
City	2,250,413	5.406	1.603	3.812	4.935	6.479	17.571
Urban district	1,319,234	5.391	1.604	4.096	5.038	6.262	17.571
Rural district (urbanized)	204,775	5.604	1.606	3.956	5.111	6.698	17.569
Rural district (sparsely inhabited)	144,492	5.772	1.605	4.126	5.38	6.906	17.561

Table 4: Summary statistics of the rent-price ratio

Table 4 shows descriptive statistics of the rent-price ratio which is calculated for each rental object by the yearly net rent divided by the potential sale price which is proxied by matching the most similar sale objects based on object-specific characteristics. Smaller apartments, determined by the living space as well as by the number of rooms, have a higher rent-price ratio. In newer buildings and more rural districts, the rents are smaller in proportion to the sale prices, thus, their yield on average is smaller. The considered dataset covers the period from 2007 to 2019.

5.1.2 Rent control variables

To explore the effect of the rent control we define a set of dummy variables for each rental object. To mark if the object is located in a regulated area, we introduce the dummy variable $municip\_reg_m$ which varies at the municipality level and divides municipalities into a treatment group, where the rent control is introduced in 2015 or later by the corresponding Federal State, and a control group, where the regulation is never applied. Precisely, this means the variable equals 1 for the treatment group for the whole observation period if there are any periods when the rent control applies and it equals 0 if the regulation is never passed for this area and the municipality belongs to the control group.

The dummy variable $municip\_reg\_applied_{mq}$ varies in the cross-section on the municipality-level and across time on a quarterly basis. It takes the value 1 if the rent control applies in a certain municipality during a particular quarter. Since there are condition-specific exceptions from the rent control to new objects, not all rental objects in treated municipalities are subject to the rent control. To consider this fact in our analysis, we introduce the additional dummy variables $object\_reg_i$ and $object\_unreg_i$ by exploiting the detailed information from the micro-level dataset. The dummy variable $object\_reg_i$ equals 1 if the specific dwelling is regulated due to its year of construction and condition and 0 otherwise. To control for the unregulated objects in regulated municipalities as well, the dummy variable $object\_unreg_i$ equals 1 if the rent control does not apply for this object because it was built after 2014 or its condition is categorized as *first occupancy*, *first occupancy after reconstruction*, or *like new*.

Overall, the rent control was introduced in 313 out of over 11,000 municipalities. Although the regulation is only implemented in a small fraction of municipalities, these represent more than one quarter of the whole population. Figure 3 shows the proportion of regulated and unregulated objects in regulated municipalities of all objects listed for each year since the rent control has been introduced. In 2018, about 50% of all offered apartments were located in regulated municipalities, as 35.6% of all advertised apartments were subject to the regulation of the rent control and 14.9% were offered in a regulated municipality but excluded from the rent control due to its year of construction and object condition.

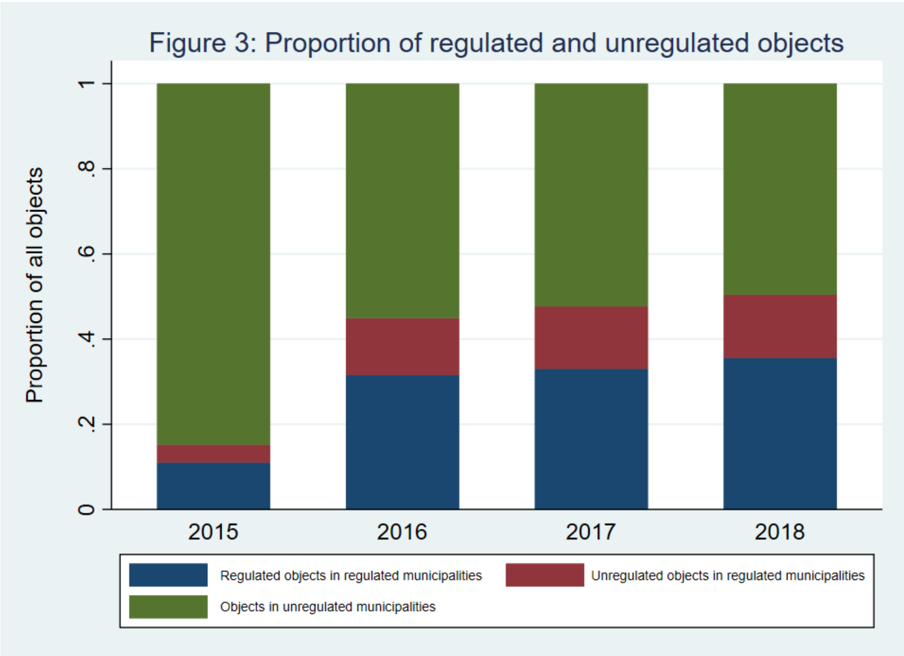

Figure 3: Proportion of regulated and unregulated objects after the introduction of rent controls in 2015
Figure 3 shows the proportion of regulated and unregulated objects in our sample after the introduction of rent controls in 2015. After 2015, rent control is introduced in a rising number of municipalities. The offered apartments can be divided into three groups: *regulated objects in regulated municipalities, unregulated objects in regulated municipalities*, and *objects in unregulated municipalities*. In regulated municipalities, exemptions from rent control apply depending on the year of construction and the object condition.

5.2 The effects of rent control on the rent-price ratio

5.2.1 Empirical approach

To estimate the effect of the rent control on the rent-price ratio, we use a two-way fixed effects linear regression, which is inspired by a multiple-period difference-in-differences framework. Our baseline regression is specified as follows:

$$rent\_price\_ratio_i = \alpha + \gamma\, municip\_reg_m + \delta_1\, municip\_reg\_applied_{mq} \times object\_reg_i + \delta_2\, municip\_reg\_applied_{mq} \times object\_unreg_i + \beta X + A_d + B_q + \varepsilon \quad (2)$$

The coefficient γ accounts for general differences between the treated and the untreated areas as $municip\_reg_m$ divides the sample into a treatment and a control group. The coefficient for δ_1 displays the effect of the introduction of the rent control on the rent-price ratio of regulated objects. The effect of the treatment on untreated, i.e. unregulated, objects in municipalities where the rent control is introduced, is shown by δ_2. Thus, we can exploit variation on the micro-level in our regression framework.

Moreover, X contains several object-specific and region-specific influences inspired by existing research on the determinants of the rent-price ratio (e.g. Clark & Lomax, 2019; Halket et al., 2020). The included object-specific variables are the *year of construction*, the *living space*, the *number of rooms*, dummy variables for the existence of a basement, balcony, terrace, or garden, and the *object condition*. On the regional level, we control for the quarterly average yield per municipality, if the object is located in an urban or metropolitan area in Western or Eastern Germany, the population density and growth, the completion of living space, the primary income per capita, the number of students in the district, the unemployment rate and the proportion of social assistance recipients.

Furthermore, we add cross-sectional fixed effects at the district level (A_d) and time fixed effects on quarterly basis (B_q). The use of time fixed effects absorbs the variation in the risk-free return, which is important because, as Campbell et al. (2009) emphasize, housing returns correlate with the expected future risk-free rates which as mentioned before had a substantial downward change in the period we focused on. Based on this setup, we can identify the effects of the rent control while controlling for different levels and dynamics of the rent-price ratio in controlled areas even if the introduction of the regulation is endogenous as it is contingent on previous price dynamics in the local rental housing market. Our model is estimated using an OLS regression with standard errors clustered for districts.

5.2.2 Results

To identify the effect of the introduction of the rent control on the rent-price ratio, we estimate several specifications based on equation (2). The main results are illustrated in Table 5. The estimation results show that the average impact of the rent control on the yield of regulated dwellings is negative, thus, their rents increase less than their sale prices after the introduction of the regulation. Although the level and dynamic of rent prices are subject to rent control, the sale price of comparable objects in these areas does not adapt to the regulation in a similar proportion. The estimated coefficient δ_1 suggests that their rent-price ratio lies 6.8 percentage points lower than the rent-price ratio of comparable objects in not regulated areas. The yield of regulated objects decreases due to the introduction of the rent control because either the rent prices decrease faster or increase slower than the sale prices for similar objects. For unregulated objects in regulated areas, the opposite appears to hold. On average, the rent prices of these objects rise 14.0 percentage points faster than the sale prices after the implementation of the regulation. The coefficients of the covariates as determinants of the rent-price ratio take the expected signs and sizes.

All in all, these results suggest a reduced yield on investments in regulated rental housing objects. For investors, these results indicate a decreased incentive to invest in regulated objects and relatively better incentives to invest in new apartments (non-regulated) in regulated areas. In sum, this may lead to the buildup of more expensive living space which does not help to generate a higher amount of affordable housing in the short term. These results may be one possible explanation for the documented increase in the rent-income ratios in regulated areas. An additional analysis indeed shows that the number of building completions in regulated municipalities increases in the three years after the implementation of the rent control (Appendix, Table A1). Thus, although the regulation fails to improve affordability in the short-run, the buildup of additional living space might relax the situation in tense housing markets in the future. However, due to the short time period since the introduction of the regulation, it is currently not possible to credibly empirically document these longer-term effects hence our focus on the shorter-term observations.

We review the results in several robustness analyses (Appendix, Tables A2, A3 and A4). The direction and significance of the results are robust to including the year of construction and the object condition as categorical variables. The results are reported in the Appendix in Table A2. Moreover, we show that the estimates are robust to an extension of the observation period from 2010-2019 to 2008-2019 (Appendix, Table A3, col. 2). We also ensure that the results are not driven by a specific regional subsample, as we run the regression for several subsamples (e.g. the largest cities). The effect of the rent control on the rent-price ratio seems not to be driven by developments in the seven biggest cities (Berlin, Hamburg, Munich, Cologne, Frankfurt, Stuttgart, Düsseldorf) as the introduction of the rent control does not influence the rent-price ratio of regulated objects there. Moreover, the rent-price ratio of new, untreated objects lays only 3.6 percentage points higher in these cities (Appendix, Table A3, col. 3).

Furthermore, we find that the results are not driven by the intensity of construction activity in different housing markets, as the sample division by building completions suggests (Appendix, Table A3, col. 4 and 5). However, we find a huge difference in the estimators if we divide the sample by the building permits (Appendix, Table A4, col. 1 and 2). In regions where fewer building permits are granted, the introduction of rent controls decreases the rent-income ratio of regulated dwellings, however, unregulated dwellings seem to be not affected by the regulation. In municipalities where comparably many building permits were granted, the biggest effects of the rent control on the rent-price ratio can be observed: the rent-price ratio of regulated objects decreases by 9.6 percentage points, whereas the one of unregulated objects increases by 17.6 percentage points. If the sample division is conducted with the median of the building permits lagged by one (Appendix, Table A4, col. 3 and 4) or two (Appendix, Table

A4, col. 5 and 6) years, the high coefficients of the areas with high building permits prove to be robust. Thus, for regulated municipalities, the results suggest a positive correlation of rental housing yield of unregulated newbuilds and the number of building permits.

In sum, our micro-level results so far are consistent with the district level-results reported in the previous section and suggest a supply-driven within-market shift towards high-priced newbuilds or renovated objects in tense, regulated housing markets resulting in no improvement (at least in the short-run) of rental housing affordability. These results highlight the potential relevance of the spillover effects of the rent-control regulation from regulated to non-regulated objects that we will next explicitly account for in the estimation.

Table 5 VARIABLES	Rent-price ratio
$\mathbf{municip\_reg_m}$	-0.0207
(Treatment municipality)	(0.0153)
$\mathbf{municip\_reg\_applied_{mq} * object\_reg_i}$	**-0.0676*** **
(Regulated objects in regulated area)	(0.0111)
$\mathbf{municip\_reg\_applied_{mq} * object\_unreg_i}$	**0.140*** **
(Unregulated objects in regulated area)	(0.0165)
Object-specific variables:	
Base yield	0.847***
	(0.0160)
Year of construction	-0.00761***
	(0.00211)
Living space	-0.00887***
	(0.000630)
Number of rooms	-0.000862
	(0.0101)
Basement (Dummy)	0.00513
	(0.0105)
Balcony (Dummy)	0.161***
	(0.00938)
Object condition	0.0151***
(1 = new; 10 = demolition)	(0.00395)
Region-specific variables:	
Urban area (Dummy)	-0.0553**
(Regional centers)	(0.0270)
City / Metropolitan area (Dummy)	-0.00758
	(0.0409)
West / East Germany (Dummy)	0.771***
(1 = West, 0 = East)	(0.131)
Socioeconomic variables:	
Population density	-0.0271**
	(0.0126)
Population growth	0.0543
	(0.134)
Primary income per capita	-0.00497
	(0.00494)
Students	-1.619*
	(0.862)
Unemployment rate	4.805**
	(2.037)
Construction completions	0.000821
	(0.000854)
Social assistance recipients	0.0498
	(0.0414)
Constant	15.51***
	(4.124)
Observations	2,768,555
R-squared	0.436
Observation period	2010-2019
Year FE	Yes
DISTRICT FE	Yes

Table 5: The effect of the rent control on the rent price ratio

Table 5 presents the results of the OLS regression modeling the determinants of housing yield described in equation (2) using micro data. The dependent variable is the rent-price ratio, i.e. the yearly net rent divided by the objects'

potential sale price. The first explanatory variable is the dummy variable ($\text{municip\_reg}_{\text{m}}$) which divides the sample into a treatment and a control group depending on the application of the rent control. The interaction terms of the dummy variable $\text{municip\_reg\_applied}_{\text{mq}}$, which equals 1 if the rent control applies in the municipality at the point of time of the observation, and the dummy variables $\text{object\_reg}_{\text{i}}$ and $\text{object\_unreg}_{\mathbf{i}}$, which indicate if the object itself is regulated due to its year of construction and condition, display the effects of the introduction of the rent control on the rent-price ratio depending on the individual objects' regulation status.
The control variables can be categorized as object-specific, region-specific, and socioeconomic variables. The object-specific control variables include the base yield, i.e. the quarterly mean of the rent-price ratio in the objects' municipality, the object's year of construction, the living space, the number of rooms, dummy variables considering if the object has a basement and a balcony or terrace and the object condition which can vary between 1 = new and 10 = demolition.
The region-specific variables indicate if an object is located in an urban area, a city, or a metropolitan area and in West or East Germany. The considered socioeconomic variables include population density, population growth, primary income per capita, the number of students, the unemployment rate, construction completions, and the number of social assistance recipients. Year fixed effects are included.
The sample covers the observation period from 2010 to 2019. Robust standard errors clustered for districts are displayed in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1%-level, respectively.

5.3 Spillover effects

5.3.1 Model

To confirm the results from the previous analysis and examine how these effects depend on the share of regulated objects, we test for spillover effects between regulated and unregulated objects in areas where the rent control is introduced. More specifically, we examine how the rent control on regulated objects affects also the yield on unregulated ones and what is the joint impact on the yields of rental housing in the regulated municipalities as a whole. Therefore, we only consider regions where the rent control is introduced and use an approach inspired by the full spillover model of Berg et al. (2021) to confirm a within-market shift in regulated municipalities:

$$rent\_price\_ratio_i = \alpha + \beta_1\, object\_reg_i + \beta_2\, object\_reg_i \times \overline{object\_reg_{my}} + \beta_3(1 - object\_reg_i) \times \overline{object\_reg_{my}} + \gamma' X_{my} + A_d + B_y + \varepsilon \quad (3)$$

To extract the potential spillover effects on the treated units, we use the dummy variable $object\_reg_i$, which displays the direct treatment effect and equals 1 if a specific object is subject to the rent control due to its year of construction and object condition. With β_2 we estimate the spillover effect to treated units by interacting the treatment effect variable with the group-level average treatment intensity ($\overline{object\_reg_{my}}$) which is given by the proportion of regulated apartments in a municipality. The estimate for β_2 displays if a higher proportion of regulated rental housing in a municipality has an impact on the rent-price ratio of regulated objects. To extract the spillover effects to the untreated units in β_3, we interact the unregulated objects in the regulated area with the group-level average treatment intensity. If the results of the previous analysis can be confirmed, we will find a significant positive estimate for β_3 because a higher proportion of regulated objects in a municipality will be assigned to higher rent-price ratios of unregulated objects in the regulated municipality.

5.3.2 Results

The results of the spillover analysis (Table 6) confirm that there is a direct treatment effect of the introduction of rent controls, as the estimate for β_1 suggests that the rent-income ratio of regulated objects is significantly lower than the one of not treated dwellings. The analysis does not point towards spillover effects to treated units, thus, the proportion of regulated units in a municipality where the regulation applies does not affect the yield of regulated objects. However, the positive, significant coefficient of β_3 confirms our conclusion from the previous analysis that the introduction of the rent control leads to an increase in the rent-price ratio of unregulated objects in regulated areas. The spillover analysis shows that the effect on unregulated objects increases with the proportion of regulated objects. In a municipality with a high proportion of regulated dwellings, the investment incentive for unregulated objects is higher than in municipalities with a smaller proportion of regulated dwellings where already many new objects have been built. This result is again consistent with our district-level findings of the limited effectiveness of the rent control as they indicate that the incentives to invest in regulated rental housing are decreasing after the introduction of the policy and this is particularly the case in municipalities where the rent control measure was ex-ante having a high coverage.

Our results go along with recently studies like Diamond et al. (2019a) who using US data show that the number of tenants living in rent-controlled units decreased because of property redevelopment. The incentivized redevelopment of buildings to exempt them from rent control shifts the housing supply toward less affordable living space. Our study shows that these developments, identified for the San Francisco housing market by Diamond et al. (2019a), can be found in the German market as well.

Table 6 VARIABLES	(1) Rent-price ratio
$\mathbf{object\_reg_i}$	**-0.118*** **
(Direct treatment effect)	(0.0223)
$\mathbf{object\_reg_i} \times \overline{\mathbf{object\_reg_{my}}}$	**0.0201**
(Spillover effects to treated units)	(0.0303)
$(\mathbf{1 - object\_reg_i}) \times \overline{\mathbf{object\_reg_{my}}}$	**0.0574*** **
(Spillover effects to control units)	(0.0104)
Object-specific variables:	
Year of construction	-0.00448***
	(4.14e-05)
Living space	-0.0137***
	(8.10e-05)
Number of rooms	0.0834***
	(0.00233)
Basement (Dummy)	-0.0275***
	(0.00276)
Balcony (Dummy)	0.172***
	(0.00333)
Object condition	0.0460***
(1 = new; 10 = demolition)	(0.000610)
Region-specific variables:	
Urban area (Dummy)	-0.361***
(Regional centers)	(0.0142)
City / Metropolitan area (Dummy)	0.314***
	(0.0192)
West / East Germany (Dummy)	0.0504
(1 = West, 0 = East)	(0.0376)
Socioeconomic variables:	
Population density	0.0579***
	(0.00458)
Population growth	-1.064***
	(0.143)
Primary income per capita	-0.0323***
	(0.00129)
Students	-7.446***
	(0.225)
Unemployment rate	14.63***
	(0.708)
Construction completions	-0.186***
	(0.0199)
Constant	15.91***
	(0.0936)
Observations	1,829,649
R-squared	0.219
Year FE	Yes
District FE	Yes

Table 6: Spillover effects of rent controls in regulated areas to regulated and excluded objects
Table 6 presents the results of the spillover analysis based on equation 3 using micro data. The dependent variable is the rent-price ratio, i.e. the yearly net rent divided by the objects' potential sale price. The dummy variable $\mathrm{object\_reg_i}$ displays the direct treatment effect. The variable $\overline{\mathrm{object\_reg_{my}}}$ is the group-level average treatment intensity, i.e. the proportion of apartments in a municipality that is regulated, thus, not new or renovated. The interaction term with the treatment effect reveals the spillover effects of rent control on regulated objects. To extract the spillover effects to the control units, we interact the unregulated objects $(1 - \mathrm{object\_reg_i})$ in the

regulated area with the group-level average treatment intensity $\overline{\text{object\_reg}_{\text{my}}}$.
The control variables can be categorized as object-specific, region-specific, and socioeconomic variables. The object-specific control variables include the base yield, i.e. the quarterly mean of the rent-price ratio in the objects' municipality, the object's year of construction, the living space, the number of rooms, dummy variables considering if the object has a basement and a balcony or terrace and the object condition which can vary between 1 = new and 10 = demolition.
The region-specific variables indicate if an object is located in an urban area, a city, or a metropolitan area and in West or East Germany. The considered socioeconomic variables include population density, population growth, primary income per capita, the number of students, the unemployment rate, construction completions, and the number of social assistance recipients. Year and district fixed effects are included.
The sample covers the observation period from 2010 to 2019. Only observations from regulated municipalities are included. Robust standard errors are displayed in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1%-level, respectively.

6 Conclusion

In this paper, we provide new evidence on rental housing market dynamics caused by rent regulation. Using residential real estate data on the micro level, we analyze the effects of the introduction of rent controls in Germany from 2015 onwards. In our empirical analyses, we exploit the temporal, regional, and object-specific variation caused by the implementation of the rent control by the federal states in tight rental markets at different points in time. We study the effectiveness of the rent control by examining the effect on the rental payments in proportion to average household incomes and analyze supply-side effects and spillovers as an explanation for the limited efficiency of the regulation.

We show that a rent regulation designed like the rent control in Germany is not a suitable instrument to solve the problem of rising housing costs in the short run because it amplifies the supply shortage of moderately priced living space in tense housing markets. We find that, on average, the rent-income ratios in controlled areas rise after the introduction of the rent control by 1.45 percentage points. One reason for this development can be found in the effect on the rental housing yield. We show that the rent control incentivizes new construction and renovations in tight markets as the yield on unregulated new apartments on average lie 14.0 percentage points higher after the implementation of the regulation and the yield on controlled inventory objects decreases by 6.8 percentage points after the introduction of the law. The results of the spillover analysis confirm this development as it shows that in municipalities with a higher proportion of regulated objects, the rent-price ratios of unregulated dwellings are higher than in municipalities with a smaller proportion of regulated dwellings. Therefore, we conclude that the rent control causes a supply-driven within-market shift toward an increased supply of high-priced newbuilds in tense housing markets. Thus, the goal to foster the provision of affordable living space is undermined by investment incentives for higher priced newbuilds in the short run. This may lead to increasing gentrification and does not improve the situation for low-income tenants in tight markets. However, as the number of building completions in regulated municipalities increases in the three years after the implementation of the rent control, the buildup of additional living space might relax the situation in tense housing markets in the future. Analyzing this development could be the subject of future studies.

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Appendix

Table A1: Number of building completions after introduction of rent control

Table A1 presents the results of the OLS regression modeling the determinants of the number of building completions described by the equation $building\ completions_{m,y} = municip\_reg_m + municip\_reg_m \times\ period\_reg_{t-L} + X_{m,y} + B_y + \varepsilon$.
Building completions show the yearly number of building completions per municipality. The dummy variable $municip\_reg_m$ divides the sample into a treatment (regulated) and a control group (unregulated) depending on the application of the rent control. The dummy variable $period\_reg_{t-L}$ indicates the treatment period when the rent control was implemented in a specific municipality. The columns of the table vary by the considered lags (one, two and three years) of the rent control implementation. Thus, the interaction term displays the effects of the introduction of the rent control on the number of building completions one, two and three years after the application of the regulation.
We control for inhabitants per municipality and region-specific variables which indicate if an object is located in an urban area, a city, or a metropolitan area and in West or East Germany. Year fixed effects and municipality-type fixed effects (city, large town, small town, mid-sized, rural municipality) are included in all specifications.
The sample covers the observation period from 2010 to 2019. Robust standard errors clustered for districts are displayed in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1%-level, respectively.

Table A1 VARIABLES y = number of building completions	(1) Lag of implementation = 1 (L = 1)	(2) Lag of implementation = 2 (L = 2)	(3) Lag of implementation = 3 (L = 3)
$municip\_reg_m$	25.12**	32.32***	38.01***
(Treatment municipality)	(10.83)	(9.067)	(7.653)
$\boldsymbol{municip\_reg_m \times period\_reg_{t-L}}$	**80.10****	**79.87****	**91.61***
(Implementation of rent control)	**(35.91)**	**(39.91)**	**(48.37)**
Inhabitants	0.00276***	0.00276***	0.00276***
	(0.000319)	(0.000319)	(0.000319)
Urban area (Dummy)	22.90*	22.90*	22.90*
(regional centers)	(11.88)	(11.89)	(11.89)
City / Metropolitan area	-149.9**	-150.1**	-150.5**
(Dummy)	(65.47)	(65.52)	(65.48)
Western / Eastern GER	12.05**	12.38**	12.56**
(1 = West, 0 = East)	(6.145)	(6.218)	(6.278)
Constant	-26.96***	-28.13***	-28.90***
	(6.435)	(6.742)	(7.014)
Observations	28,359	28,359	28,359
Number of municipalities	4,033	4,033	4,033
Year FE	Yes	Yes	Yes
Municipality type FE	Yes	Yes	Yes

Table A2: Robustness test with categorical variables

Table A2 presents the results of the OLS regression modeling the determinants of housing yield described in equation (2) using micro data. The dependent variable is the rent-price ratio, i.e. the yearly net rent divided by the objects' potential sale price. The first explanatory variable is the dummy variable (municip_reg_{m}) which divides the sample into a treatment and a control group depending on the application of the rent control. The interaction terms of the dummy variable $\text{municip\_reg\_applied}_{mq}$, which equals 1 if the rent control applies in the municipality at the point of time of the observation, and the dummy variables object_reg_{i} and object_unreg_{i}, which indicate if the object itself is regulated due to its year of construction and condition, display the effects of the introduction of the rent control on the rent-price ratio depending on the individual objects' regulation status.

The control variables can be categorized as object-specific, region-specific, and socioeconomic variables. The object-specific control variables include the base yield, i.e. the quarterly mean of the rent-price ratio in the objects' municipality, the object's year of construction, the living space, the number of rooms, and dummy variables considering if the object has a basement and a balcony or terrace. In this specification, we include the object condition, which can vary in ten categories between new and demolition, as a categorical variable. Moreover, in column 1, the year of construction is included as a continuous variable and in column 2 as a categorical variable (grouped by ten years, i.e. 1800-1810).

The region-specific variables indicate if an object is located in an urban area, a city, or a metropolitan area and in West or East Germany. The considered socioeconomic variables include population density, population growth, primary income per capita, the number of students, the unemployment rate, construction completions, and the number of social assistance recipients. Year fixed effects are included in all specifications.

The sample covers the observation period from 2010 to 2019. Robust standard errors are displayed in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1%-level, respectively.

Table A2 VARIABLES y = rent-price ratio	(1) Categorical variables for object condition	(2) Categorical variables for object condition and year of construction
municip_reg_{m}	-0.0174	-0.0289*
(Treatment municipality)	(0.0150)	(0.0151)
$\mathbf{municip\_reg\_applied_{mq} * object\_reg_{i}}$	**-0.0850*** **	**-0.0942*** **
(Regulated objects in regulated area)	(0.0113)	(0.0121)
$\mathbf{municip\_reg\_applied_{mq} * object\_unreg_{i}}$	**0.185*** **	**0.183*** **
(Unregulated objects in regulated area)	(0.0169)	(0.0176)
Object-specific variables:		
Base yield	0.868***	0.845***
	(0.0150)	(0.0139)
Year of construction	-0.00621***	
	(0.00193)	
Living space	-0.00833***	-0.00550***
	(0.000645)	(0.000554)
Number of rooms	-0.00971	-0.0591***
	(0.00913)	(0.00751)
Basement (Dummy)	-0.000152	-0.0110
	(0.0112)	(0.00849)
Balcony (Dummy)	0.155***	0.119***
	(0.00960)	(0.00956)
Region-specific variables:		
Urban area (Dummy)	-0.0474*	-0.0461*
(Regional centers)	(0.0258)	(0.0253)
City / Metropolitan area (Dummy)	-0.00898	0.00841
	(0.0421)	(0.0437)
West / East Germany (Dummy)	0.674***	0.474***
(1 = West, 0 = East)	(0.122)	(0.116)
Socioeconomic variables:		
Population density	-0.0295**	-0.0542***
	(0.0124)	(0.0134)
Population growth	0.0716	0.116
	(0.144)	(0.144)
Primary income per capita	-0.00464	-0.00327
	(0.00495)	(0.00502)
Students	-1.779**	-1.753**

	(0.864)	(0.821)
Unemployment rate	4.981**	5.553**
	(2.063)	(2.317)
Construction completions	0.0644	0.0763
	(0.0461)	(0.0486)
Social assistance recipients	0.000640	0.000932
	(0.000940)	(0.00101)
Constant	12.60***	1.132***
	(3.781)	(0.333)
Observations	2,774,267	2,774,267
R-squared	0.435	0.450
Object condition	Categorical	Categorical
Year of construction		Categorical
Year FE	Yes	Yes
District FE	Yes	Yes

Table A3: Robustness analysis with different subsamples

Table A3 presents the results of the OLS regression modeling the determinants of housing yields described in equation (2) using micro data. The dependent variable is the rent-price ratio. Column 1 shows the baseline specification as described in Chapter 5.2. Column 2 displays the results of the estimation with an extended observation period, already beginning in 2008. Column 3 shows the subsample analysis of the seven biggest cities (Hamburg, Berlin, Duesseldorf, Frankfurt, Stuttgart Cologne, Munich). Because of the reduction of the sample, all municipalities are subject to the rent control, thus, the dummy to differentiate between treatment and control groups cannot be included. The variables that determine if an object is located in an urban area, a city, or a metropolitan area are not included as well. For the results in Columns 4 and 5, the sample is split by the median of the yearly construction completions measured by square meters of newbuild living space per capita on municipality level.
Year and district fixed effects are included in all specifications. The sample covers the observation period from 2010 (2008) to 2019. Robust standard errors clustered for districts are displayed in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1%-level, respectively.

Table A3 VARIABLES	(1) Baseline	(2) Baseline	(3) TOP 7 cities	(4) Little construction completions	(5) Many construction completions
municip_reg_m	-0.0207	-0.0237		-0.0160	-0.0296**
(Treatment municipality)	(0.0153)	(0.0148)		(0.0200)	(0.0131)
$\mathbf{municip\_reg\_applied_{mq} * object\_reg_i}$	**-0.0676*** **	**-0.0696*** **	**-0.0318**	**-0.0635*** **	**-0.0651*** **
(Regulated objects in regulated area)	(0.0111)	(0.0116)	(0.0184)	(0.0146)	(0.0187)
$\mathbf{municip\_reg\_applied_{mq} * object\_unreg_i}$	**0.140*** **	**0.146*** **	**0.0359** **	**0.137*** **	**0.144*** **
(Unregulated objects in regulated area)	(0.0165)	(0.0163)	(0.0118)	(0.0237)	(0.0283)
Object-specific variables:					
Base yield	0.847***	0.851***	0.896***	0.836***	0.882***
	(0.0160)	(0.0161)	(0.0108)	(0.0218)	(0.0112)
Year of construction	-0.00761***	-0.00733***	-0.00263**	-0.00714***	-0.00909***
	(0.00211)	(0.00208)	(0.000873)	(0.00251)	(0.00212)
Living space	-0.00887***	-0.00918***	-0.00566***	-0.00983***	-0.00667***
	(0.000630)	(0.000607)	(0.000632)	(0.000980)	(0.000730)
Number of rooms	-0.000862	-0.00299	-0.0446***	-0.00320	-0.00139
	(0.0101)	(0.00936)	(0.00867)	(0.00991)	(0.0124)
Basement (Dummy)	0.00513	0.00253	-0.0266	0.00863	-0.00560
	(0.0105)	(0.0103)	(0.0211)	(0.00975)	(0.0172)
Balcony (Dummy)	0.161***	0.169***	0.155***	0.175***	0.125***
	(0.00938)	(0.00922)	(0.0115)	(0.0112)	(0.0179)
Object condition	0.0151***	0.0173***	-0.00626	0.00525	0.0282***
(1 = new; 10 = demolition)	(0.00395)	(0.00373)	(0.00801)	(0.00420)	(0.00462)
Region-specific variables:					
Urban area (Dummy)	-0.0553**	-0.0494*		-0.0507	-0.0509***
(Regional centers)	(0.0270)	(0.0264)		(0.0420)	(0.0181)
City / Metropolitan area (Dummy)	-0.00758	-0.0113		-0.00129	0.0313**
	(0.0409)	(0.0416)		(0.0494)	(0.0153)
West / East Germany (Dummy)	0.771***	-0.0471**	0.932***	-0.266***	-2.576***
(1 = West, 0 = East)	(0.131)	(0.0221)	(0.237)	(0.0975)	(0.222)
Socioeconomic variables:					
Population density	-0.0271**	-0.0234*	0.184	-0.0323*	-0.0147
	(0.0126)	(0.0126)	(0.142)	(0.0175)	(0.0149)
Population growth	0.0543	0.0271	-0.107	-0.0482	0.247
	(0.134)	(0.132)	(0.340)	(0.155)	(0.242)
Primary income per capita	-0.00497	-0.00514	-0.0548**	-0.0159***	-0.00127
	(0.00494)	(0.00438)	(0.0166)	(0.00563)	(0.00406)
Students	-1.619*	-1.466*	0.444	-1.718	-0.600
	(0.862)	(0.763)	(0.842)	(1.147)	(1.054)
Unemployment rate	4.805**	4.079***	9.050**	4.431	3.400
	(2.037)	(1.567)	(2.767)	(2.722)	(2.768)
Construction completions	0.000821		2.33e-05	0.00105	0.000117
	(0.000854)		(0.000645)	(0.00104)	(0.00320)
Social assistance recipients	0.0498	-0.0305	0.0517	0.0496	0.0387
	(0.0414)	(0.0431)	(0.0657)	(0.0633)	(0.138)
Constant	15.51***	15.79***	5.816**	16.06***	21.12***
	(4.124)	(4.193)	(1.885)	(5.026)	(4.346)
Observations	2,768,555	3,110,427	761,539	1,862,906	905,649

R-squared	0.436	0.427	0.364	0.421	0.421
Observation period	2010-2019	2008-2019	2010-2019	2010-2019	2010-2019
Year FE	Yes	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes	Yes

Table A4: Robustness analysis with subsamples divided by building permits

Table A4 presents the results of the OLS regression modeling the determinants of housing yields described in equation (2) using micro data. The dependent variable is the rent-price ratio. The sample is divided into different subsamples depending on the median of building permits, measured by authorized living space (thousand square meters) per capita on municipality level, with no lag (Col. 1, 2), one-year lag (Col. 3, 4) and a two-year lag (Col. 5, 6).
Year and district fixed effects are included in all specifications. The sample covers the observation period from 2010 (2008) to 2019. Robust standard errors clustered for districts are displayed in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1%-level, respectively.

Table A4 VARIABLES y = rent-price ratio	(1) Little building permits	(2) Many building permits	(3) Little building permits **Lag = 1 year**	(4) Many building permits **Lag = 1 year**	(5) Little building permits **Lag = 2 years**	(6) Many building permits **Lag = 2 years**
municip_reg_m	-0.0108	-0.0315**	-0.0153	-0.0265*	-0.0157	-0.0208
(Treatment municipality)	(0.0223)	(0.0125)	(0.0212)	(0.0143)	(0.0207)	(0.0137)
$\mathbf{municip\_reg\_applied_{mq} * object\_reg_i}$	**-0.0450***	**-0.0964*** **	**-0.0423**	**-0.0973*** **	**-0.0556*** **	**-0.108*** **
(Regulated objects in regulated area)	(0.0249)	(0.0174)	(0.0261)	(0.0256)	(0.0154)	(0.0259)
$\mathbf{municip\_reg\_applied_{mq} * object\_unreg_i}$	**0.0523**	**0.176*** **	**0.0772**	**0.179*** **	**0.0984*** **	**0.166*** **
(Unregulated objects in regulated area)	(0.0393)	(0.0228)	(0.0508)	(0.0267)	(0.0235)	(0.0273)
Object-specific variables:						
Base yield	0.829***	0.881***	0.834***	0.882***	0.839***	0.881***
	(0.0226)	(0.00863)	(0.0218)	(0.00771)	(0.0214)	(0.00874)
Year of construction	-0.00907***	-0.00551***	-0.00828***	-0.00633***	-0.00772***	-0.00733***
	(0.00231)	(0.00179)	(0.00248)	(0.00175)	(0.00256)	(0.00164)
Living space	-0.0106***	-0.00669***	-0.0102***	-0.00683***	-0.00980***	-0.00727***
	(0.000736)	(0.000596)	(0.000813)	(0.000680)	(0.000909)	(0.000754)
Number of rooms	-0.00617	0.00987	-0.00703	0.0113	-0.00689	0.00993
	(0.0111)	(0.0147)	(0.0104)	(0.0154)	(0.0103)	(0.0154)
Basement (Dummy)	0.00224	0.000108	0.00330	0.00429	0.00315	0.00731
	(0.0119)	(0.0148)	(0.0119)	(0.0158)	(0.0116)	(0.0160)
Balcony (Dummy)	0.179***	0.141***	0.179***	0.134***	0.175***	0.134***
	(0.0112)	(0.0118)	(0.0114)	(0.0137)	(0.0114)	(0.0145)
Object condition	0.000846	0.0376***	0.00164	0.0376***	0.00394	0.0338***
(1 = new; 10 = demolition)	(0.00418)	(0.00482)	(0.00414)	(0.00582)	(0.00423)	(0.00471)
Region-specific variables:						
Urban area (Dummy)	-0.0612	-0.0427**	-0.0735*	-0.0274	-0.0513	-0.0568***
(Regional centers)	(0.0416)	(0.0167)	(0.0412)	(0.0175)	(0.0405)	(0.0199)
City / Metropolitan area (Dummy)	-0.0191	0.0403**	-0.000660	0.0126	-0.0126	0.0329
	(0.0526)	(0.0164)	(0.0514)	(0.0139)	(0.0534)	(0.0328)
West / East Germany (Dummy)	4.016	-0.928***	0.978***	-0.324***	17.21	-0.152
(1 = West, 0 = East)	(4.333)	(0.119)	(0.175)	(0.0902)	(13.46)	(0.155)
Socioeconomic variables:						
Population density	-0.0366**	0.00332	-0.0370**	-0.00566	-0.0417**	-0.0112
	(0.0167)	(0.0106)	(0.0166)	(0.0106)	(0.0171)	(0.0131)
Population growth	-0.00373	0.181	-0.0630	0.0789	0.00547	0.167
	(0.178)	(0.140)	(0.220)	(0.0867)	(0.164)	(0.130)
Primary income per capita	-0.0167***	-0.00457	-0.0174**	-0.00361	-0.0190***	-0.000208
	(0.00604)	(0.00450)	(0.00677)	(0.00444)	(0.00649)	(0.00415)
Students	-1.886	-0.155	-1.887	-0.0309	-2.007*	-0.303
	(1.166)	(0.741)	(1.237)	(0.781)	(1.118)	(0.762)
Unemployment rate	4.576	6.399***	4.597	5.617**	4.601	4.034
	(2.913)	(2.141)	(2.819)	(2.415)	(2.819)	(2.667)
Construction completions	0.00208	-0.00104	0.00224	-0.000669	0.00202	0.00310***
	(0.00175)	(0.000635)	(0.00159)	(0.000714)	(0.00162)	(0.000787)
Social assistance recipients	-0.111	0.0200	0.0202	-0.0587	0.0657	-0.181
	(0.140)	(0.0681)	(0.101)	(0.0625)	(0.0819)	(0.126)
Constant	15.83*	12.20***	17.20***	13.23***	-0.163	15.06***
	(8.275)	(3.553)	(4.890)	(3.488)	(17.62)	(3.394)
Observations	1,682,754	1,085,801	1,743,280	1,032,977	1,813,273	1,028,483
R-squared	0.400	0.416	0.403	0.425	0.406	0.445
Observation period	2010-2019	2010-2019	2010-2019	2010-2019	2010-2019	2010-2019

Year FE	Yes	Yes	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes	Yes	Yes