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

Vera Baye[1] | **Valeriya Dinger**[1,2]

[1]Institute of Empirical Economic Research, School of Business Administration and Economics, University of Osnabrueck, Osnabrueck, Germany

[2]Accounting and Finance Department, Leeds University Business School, Leeds, England

Correspondence
Vera Baye, University of Osnabrueck, Osnabrueck, Germany.
Email: vera.baye@uni-osnabrueck.de

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 predicting sale prices to rental objects based on a hedonic model using micro-level quotes on rental and sale listing. 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. Furthermore, 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
housing affordability, housing supply, micro data, rent control, rent-price ratio

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 article, we document the limited effectiveness of rent control 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 regulation is 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 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; that is, 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 predicting sale prices for rental dwellings based on a hedonic model

[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.

including object-specific characteristics, object condition, and location. 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. Furthermore, 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 segments 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 the mean of rental prices to 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 in rental housing affordability after the introduction of 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 use the sale listings to calibrate a hedonic price model, then employ the estimated model to predict out-of-sample sale prices on the rental listings and derive the yield. We then perform a two-way fixed effects analysis of the dynamics of the yield proxied by the rent-price ratio of regulated and unregulated objects in tight (regulated) and normal (unregulated) markets around the introduction of 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 0.133 percentage points lower than in the municipalities from the control group, where rent control is not introduced, while the rent-price ratio of unregulated objects in a regulated municipality is 0.252 percentage points higher. The higher yield on unregulated objects suggests that there are incentives for housing investments to shift to the unregulated segment. The separate examination of the effect of the rent control on both rental and sale prices shows that the negative effect on the yield of regulated objects is driven by the larger increase of sale prices than rental prices, while the higher yield of unregulated dwellings in regulated municipalities occurs due to a significant increase in rents while sale prices of this segment do not seem to be affected by the intervention into the housing market. 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 nontreated units and we next apply this methodology to derive the treatment, nontreatment, and average effects contingent on the share of treated objects in the respective municipality. 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.

Furthermore, our results point to an increase in the proportion of offered new (unregulated) dwellings in tense (regulated) housing markets after the implementation of rent control. Thus, at least in the short run, 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 which boost the proportion of high-value properties that are less affordable for low-income households. Our results indicate that the German rent control 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.[2] 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 and 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. Furthermore, 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%, corporate landlords are more likely to evade rent controls and replace rent-controlled housing by 64% by selling to owner-occupants and increasing their supply of unregulated 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 states 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 versus 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 unregulated objects which as our results show are not negligible. And last but

[2] For a comprehensive overview of the effects of rent control, see for example Kholodilin (2022).

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's 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 (Arnott, 1995; Bulow & Klemperer, 2012; Chapelle et al., 2019; Glaeser & Luttmer, 2003; Skak & Bloze, 2013). More specifically, Oust (2018) points to reduced mobility in the rental market. Kholodilin and 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 noncontrolled 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; for example, 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, Eilers 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 policymakers from other countries, for example, from France, Spain, and Belgium,[3] 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, Eilers et al. (2022) study the temporal dynamics and medium-term effects of 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. Furthermore, 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.

[3] To create more affordable housing, France introduced a new law to regulate rents in 2018 (Loi ELAN, November 23, 2018). The Spanish rent control introduced in Catalonia in September 2020 (Ley 11/2020 of September 18, 2020) was revoked by Constitutional Court in March 2022. The implementation of rent control in Belgium announced for Brussels in October 2021 (Ordonnance visant a instaurer une commission paritaire locative et a lutter contre les loyers abusifs) is still being discussed.

The remainder of this article 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, Eilers 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 April 2015, which empowers every federal state in Germany to regulate new rental contracts in tense housing markets ("*Mietpreisbremse*").[4] 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 5 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.[5] So, for example, it was first introduced in Berlin in June 2015, followed by North Rhine-Westphalia in July 2015, which is Germany's most populous federal state. 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

[4] Tenancy Law Amendment Act, 2015 (Gesetz zur Dämpfung des Mietanstiegs auf angespannten Wohnungsmärkten und zur Stärkung des Bestellerprinzips bei der Wohnungsvermittlung (Mietrechtsnovellierungsgesetz—MietNovG), April 21, 2015, Bundesgesetzblatt Jahrgang 2015 Teil I Nr. 16, Bonn, 27.04.2015).

[5] 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.

support investments in building activities.[6] 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 rent control in 313 municipalities. In this context, the law affects around 40% of all rental objects in Germany (Breidenbach, Eilers 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 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 also prevents 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, 2020, 2020a,b). They are based on residential real estate advertisements from the internet platform ImmobilienScout24, which is one of the largest internet platforms for real estate advertisements in Germany and has a user share of 74.3% (Statista, 2023). 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 (Section 5) to identify if a specific object is subject to rental controls or not.

[6] Three further exceptions that we cannot control for due to data limitations are: (i) objects are excluded from 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.

TABLE 1 Descriptive statistics of rental and sale objects.

Variable	Mean	Std. Dev.	Min	p25	p50	p75	Max	*N*
A. Rental objects								
Year of construction	1971	34.80	1800	1957	1975	1997	2020	5,662,358
Living space	76.72	31.578	10	56.16	72	91	1000	5,662,358
Number of rooms	2.68	0.99	1	2	3	3	10	5,662,358
Rent per square meter	8.42	3.03	3.66	6.10	7.80	10	20.45	5,662,358
B. Sale objects								
Year of construction	1978	33.55	1800	1965	1984	2003	2020	5,609,255
Living space	85.37	38.38	10	61	79	101	1000	5,609,255
Number of rooms	2.94	1.11	1	2	3	3.5	10	5,609,255
Price per square meter	2269	1284	396	1316	1970	2909	7715	5,609,255

Note: This table shows descriptive statistics of the quotes on rental objects and 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 rent on the internet platform ImmobilienScout24 with a monthly frequency covering the period from January 2010 to December 2019.

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,[7] that were built in 1800 or later, 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 1971, has three rooms, and a living space of 76.72 square meters. The monthly net rent of this object would be 645.98 Euros, as the rent per square meter is 8.42 Euros (Table 1, Panel A). The average apartment for sale has three rooms as well, is slightly newer, larger, and has an average sale price per square meter of 2269 Euros (Table 1, Panel B).

To ensure the representativeness of our dataset, we compare the distribution of the key property characteristics *living space* and *year of construction* in the latest available German census data (German Federal Statistical Office, 2023) from the year 2011 to our rental and sale data from the same year. Figure A1 shows that our data compare to the census data, thus, indicating that our dataset includes a representative sample of the German housing market.[8] Recent studies based on these data were, for example, published by Breidenbach, Eilers et al. (2022) analyzing the temporal dynamics of rent prices due to the rent control, Breidenbach, Cohen et al. (2022), Pommeranz and

[7] 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, Eilers, et al., 2022; Deschermeier et al., 2016; Eilers, 2017).

[8] One deviation appears in the share of newer dwellings built after 2006 whose share is larger in the ImmobilienScout24 dataset than in the census data. These deviations could be expected as the census depicts the characteristics of the stock of existing housing, while the ImmobilienScout24's data are representative of the dwellings currently offered for sale or rent. As newer and more standard properties are more likely to be sold and standard properties more likely to be rented out, the fact that we observe these differences relative to the census data is not surprising. In addition, the ImmobilienScout24 dataset does not perfectly mirror the stock of housing units in very small municipalities where only a few dwellings are offered for rent or sale. This applies especially to larger apartments.

Steininger (2021), Klick and Schaffner (2019), Eilers (2017), and Deschermeier et al. (2016) who focus on recent developments in the housing market for rentals and sales.

We are aware that the asking prices might deviate from actual transaction prices, but as Dinkel and 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. This is particularly true for Germany, where it is not common to negotiate apartment rental prices (Breidenbach, Eilers et al., 2022), and landlords generally obtain their asking prices (Deschermeier et al., 2016). Of course, although we use a large and representative data set on micro-level, we might still miss some rental agreements that may be used to bypass the regulation, as for example shadow rental agreements and subletting.

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[9] 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*). Broad summary statistics for regulated and unregulated municipalities of those variables used as controls in our empirical analyses are provided in Table 2.

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 mean of the yearly net rent of the newly offered flats per district.[10] Our data show that despite the implementation of the rent

[9] Municipalities are cities or towns with an own local government, they define the lowest level of territorial division in Germany. In Germany exists 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.

[10] 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

TABLE 2 Descriptive statistics of socioeconomic characteristics of regulated municipalities.

Variable	Mean	Std. Dev.	Min	P25	P50	P75	Max	*N*
A. Regulated municipalities								
Urban area (dummy)	0.83	0.374	0	1	1	1	1	2,406,210
City/metropolitan area (dummy)	0.81	0.395	0	1	1	1	1	2,406,210
West/East Germany (dummy)	0.75	0.437	0	0	1	1	1	2,406,210
Population density	2.49	1.22	0.03	1.35	2.56	3.79	4.71	2,406,210
Population growth	0.01	0.01	−0.39	0.01	0.01	0.01	0.39	2,406,210
Primary income per capita	27.60	5.66	16.08	22.98	27.38	30.81	48.08	2,406,210
Students	0.06	0.05	0	0.04	0.05	0.09	0.31	2,406,210
Unemployment rate	0.04	0.01	0.01	0.03	0.04	0.05	0.07	2,406,210
Social assistance recipients	163.37	213.66	1.0	18.50	61.87	178.98	576.33	2,406,210
Construction completions	0.26	0.26	0	0.04	0.14	0.40	0.93	2,406,210
B. Unregulated municipalities								
Urban area (dummy)	0.277	0.447	0	0	0	1	1	2,213,517
City/metropolitan area (dummy)	0.286	0.452	0	0	0	1	1	2,213,517
West/East Germany (dummy)	0.914	0.28	0	1	1	1	1	2,213,517
Population density	0.94	0.77	0.004	0.31	0.69	1.46	3.20	2,213,517
Population growth	0.002	0.018	−0.399	−0.0024	0.0023	0.0085	2.457	2,213,517
Primary income per capita	24.68	4.203	13.77	21.91	24.47	27.62	48.04	2,213,517
Students	0.03	0.05	0	0	0.01	0.04	0.45	2,213,517
Unemployment rate	0.037	0.016	0.007	0.0237	0.0337	0.0503	0.0923	2,213,517
Social assistance recipients	25.11	23.17	1.0	9.93	17.62	32.53	118.52	2,213,517
Construction completions	0.02	0.02	0	0	0.01	0.02	0.19	2,213,517

Note: This table shows descriptive statistics of major characteristics of regulated municipalities where the rent control was introduced in June 2015 or later (Panel A) and of unregulated municipalities where the rent control was never implemented from January 2010 to December 2019. The data are collected from 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). The included variables are dummy variables that take the value of 1 if an object is located in an urban area, a city, or in Western Germany. On municipality level, we consider the population density (in 1000 inhabitants per square kilometer), population growth, and construction completions (in sqm per 1000 inhabitants). On district-level primary income per capita (in 1000 Euros), the number of students per capita, the unemployment rate, and the number of social assistance recipients per 1000 inhabitants are covered.

control after 2015, the gap between the average rent-income ratios of regulated and unregulated regions increased from 2014 to 2019.[11] 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

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.

[11] 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 34.71% of their income on rental payments. These payments lie on average 7.62 percentage points higher than in areas where the rent control is never introduced, as on average 26.97% of the household income is spent on rent here. However, in 2019, 4 years after the first federal states introduced the rent control, the gap between the average rent-income ratios of regulated (40.44%) and unregulated areas (29.92%) increased.

household income data are reported in Germany.[12] We compress the micro-level rental prices by taking the mean per district and year and implement a panel structure. 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.

We study the effect of the introduction of rent control on the rent-income ratio using a staggered difference-in-differences analysis. We use the estimator proposed by Callaway and Sant'Anna (2021) which exploits the staggered introduction of the regulation in the different federal states.[13] To estimate the average treatment effect on the treated (ATT), that is, the effect of the introduction of rent control on the rent-income ratio in regulated districts, we apply the following multiple-period estimator (Callaway & Sant'Anna, 2021):

$$ATT\,(g,y) = \left[RIR(g|X)_y - RIR(NT|X)_y\right] - \left[RIR(g|X)_{y-1} - RIR(NT|X)_{y-1}\right] \quad (1)$$

with

$$X = \left(UA_d,\ CMA_d,\ West_d,\ PDens_{dy}, Stud_{dy},\ BuildCompl_{dy}\right).$$

Here, the group indicator g is assigned to the observations depending on the year y when rent control was introduced in the district d for the first time, $RIR(g)_t$ is the expected value of the rent-income ratio of group g at time t. NT marks the "never-treated" districts, which are used as the control group. X is a vector of observable region-specific variables.

As the regulation was not introduced randomly but in tense housing markets, the plausibility of parallel trends might be questioned. However, the Callaway & Sant'Anna estimator assumes conditional parallel trends; thus, it allows to identify average treatment effects if the parallel trends assumption holds conditional on covariates. As in our setting conditional parallel trends are more plausible than unconditional parallel trends, we include various covariates to control for the observable differences between treatment and control districts. The estimator already implicitly controls for district, year, and cohort fixed effects. Additionally, we add time-invariant covariates in the regression, as in X, we cover region-specific dummy variables to detect if a district is an urban area (UA_d), categorized as city and metropolitan area (CMA_d), and located in Western Germany ($West_d$), as well as some time-varying characteristics such as the population density ($PDens_{dy}$), the number of students ($Stud_{dy}$), and the number of building completions ($BuildCompl_{dy}$). Thus, we control for the observable characteristics that could correlate with the treatment status of a district and therefore address the fact that the rent control is not implemented randomized but in housing markets where the rent-income ratio is higher than the national average.[14] If the regulation is effective in lowering the rent-income ratio or at least in maintaining the

[12] 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.

[13] This estimator allows us to avoid potential biases resulting from a two-way fixed effects approach (Baker et al., 2022) and is currently used by Alexander and Karger (2023), Johnson et al. (2023), and Ang (2021) among others. Since we are using yearly data here, we assume that there is no anticipation of the treatment.

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

TABLE 3 The effect of rent control on the rent-income.

	(1) Rent-income ratio	(2) Rent-income ratio
ATT	0.0122***	0.0515***
	(0.0028)	(0.0075)
Treatment variable	Discrete	Continuous

Note: This table presents the results of the staggered difference-in-differences analyses to estimate the effect of the introduction of rent controls on the rent-income ratio. 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 mean net rent of the newly offered flats per district. The included covariates cover region-specific dummy variables on urbanization and location in Western Germany, as well as the population density, the number of students, and the number of building completions. The overall treatment effect in Column 1 is estimated using the doubly robust difference-in-differences estimator based on inverse probability and weighted least squares estimator from Sant'Anna and Zhao (2020). In Column 2, we extend the staggered design from Column 1 with the treatment intensity, which is modeled by the share of regulated objects per district. The sample covers the observation period from 2010 to 2019. Standard errors are displayed in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

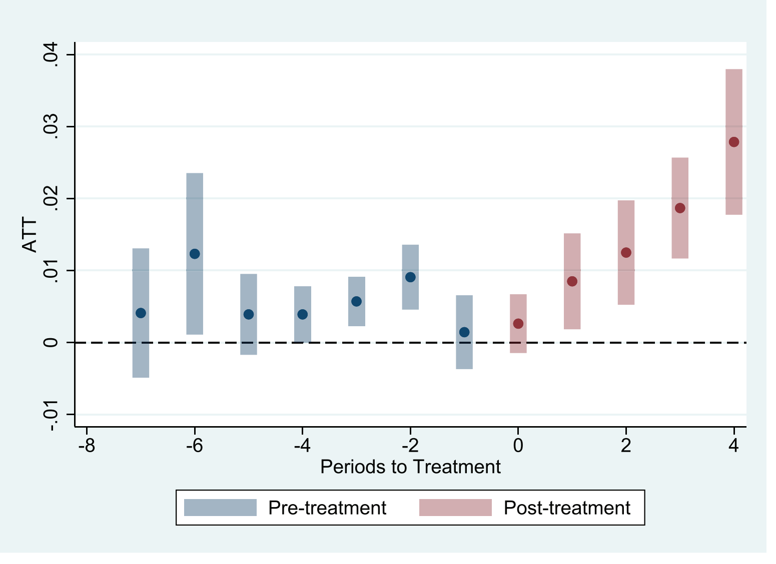

FIGURE 1 Dynamic effects of rent control on rent-income ratio. [Color figure can be viewed at wileyonlinelibrary.com]

level of income spent on rental payments, the estimator for the ATT will be significantly negative or insignificant.

In Table 3, Column 1, the overall treatment effect of the introduction of rent control on the rent-income ratio is reported, which is calculated as the average of all ATTs weighted by group size. It shows that after the introduction of rent control, the rent-income ratio in regulated areas increases on average by 1.22 percentage points. 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.

To test for the conditional parallel trends, we estimate Equation (1) including the covariates captured in X across all cohorts for each period relative to the period first treated. Figure 1 shows the estimated ATTs. The coefficients suggest that in some pretreatment periods, the rent-income ratio already lies above the level in the never-treated municipalities, which can be explained by the fact that rent control was introduced in tense housing markets. However, these deviations are of small scale, compared to the growing difference in rent-income ratios that occurs 1 year after the implementation of the regulation and then increases from period to period. Thus, although the preexisting differences reflect the fact that the treatment is not introduced randomly, after the implementation of the treatment we see an increase in these differences in the rent-income ratios of treatment and control districts.

In addition to the standard staggered difference-in-differences estimation, we modify the estimation from Equation (1) and estimate the effect of the treatment intensity proxied by the rent-controlled share of apartments in treated districts. The results presented in Table 3, Column 2, reveal that the increase of the rent-income ratio in treated districts increases with the share of rent-controlled apartments in the district. We next zoom into the potential reasons for this failure of the regulation and exploit the micro dimension of our dataset to investigate how rent control affects the supply side of the housing market by affecting the yields on rental housing.

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 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. This is calculated for each rental object from the reported yearly net rent and the potential sale price which we derive from estimating a hedonic model since each dwelling in our dataset is advertised either as a rental or as a sale object:

$$price_i = \beta X_i + \delta \left(RC_i \times A_d \times B_y \right) + \varepsilon_i. \quad (2)$$

Here, $price_i$ is log of the purchase price per square meter of object i and X includes a rich set of property characteristics for each object in district d in year y. Specifically, we include the log of the dwellings' year of construction, the log of the number of rooms, a vector of dummy variables that indicate the object condition, and if a garden or balcony belongs to the apartment. δ estimates the

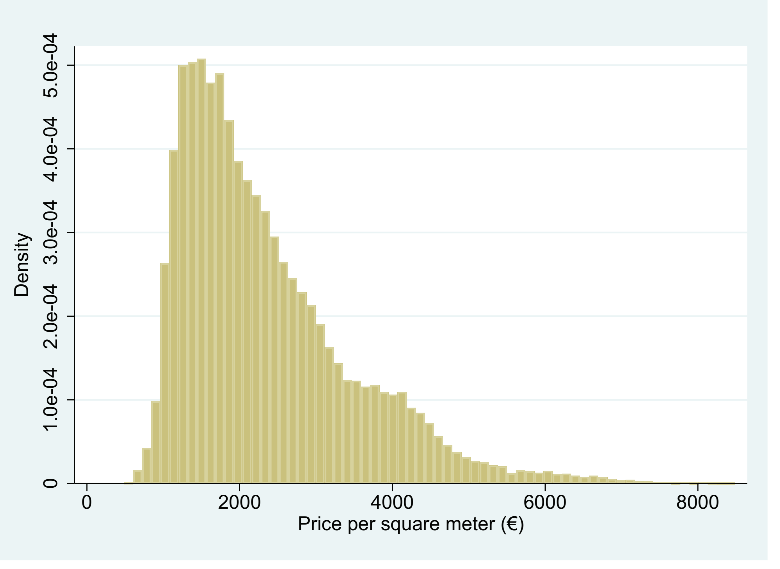

FIGURE 2 Distribution of the sale price per square meter. [Color figure can be viewed at wileyonlinelibrary.com]

coefficient that allows for local time-varying heterogeneities of regulated and unregulated objects, as the interaction term includes the dummy variable RC_i, which is 1 if the particular object would be subject to rent control (in case it was a rental object), and fixed effects for district (A_d) and year (B_y). Thereby, we allow the regulated objects to be priced differently and follow different price trends. Standard errors are clustered at municipality level. We estimate the coefficients using the sale price sample and predict the potential sale prices for each rental listing. Figure 2 presents the resulting distribution of rental objects' predicted sale prices per square meter.

The earlier literature has faced the challenge that rented and sold objects may not be of equal quality and recommends quality adjustments to approximate the actual ratio (Hill & Syed, 2015). The challenge is less pronounced in Germany where the rental housing stock is generally well-maintained and apartments on the markets for rental and owner-occupied dwellings are of similar quality so that households can find suitable housing not only as potential buyers but also as tenants (Voigtländer, 2014). However, for the sake of completeness, we also employ the *object condition* to generate a quality-adjusted prediction of the sale price and thus a reliable rent-price ratio. The rent-price ratio is calculated for each rental object from the reported yearly net rent and the predicted sale price from the hedonic model. Figure 3 presents the distribution of rent-price ratios over the sample.

This results in a dataset covering 5,662,358 observations. As presented in Figure 4, the average rent-price ratio in Germany has decreased since 2010 because sale prices for residential properties grow faster than rents.[15] To reduce the risk of outlier bias, in the following analysis, we only consider observations whose rent-price ratio does not belong to the highest or lowest 1%, thus, the rent-price ratio varies between 2.226% and 9.619% with a mean of 4.655% (Table 4).

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

[15] 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 3 Distribution of the rent-price ratio. [Color figure can be viewed at wileyonlinelibrary.com]

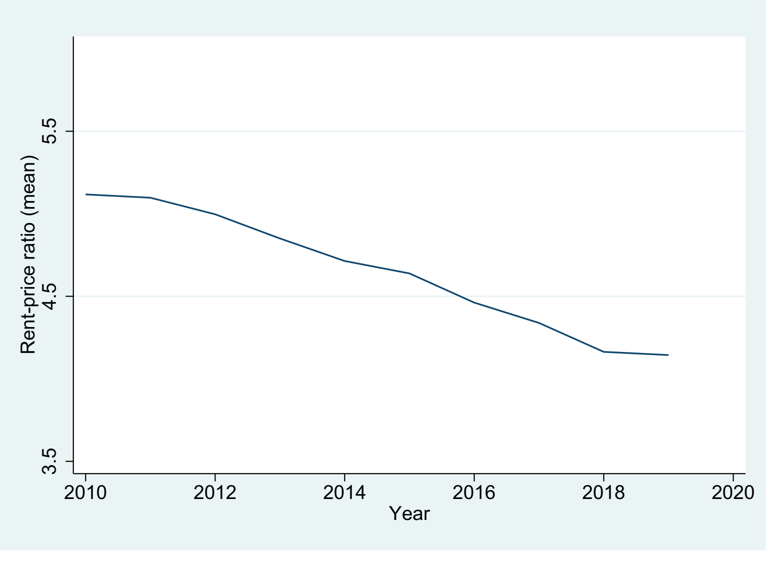

FIGURE 4 Evolution of the mean of the rent-price ratio (in %). [Color figure can be viewed at wileyonlinelibrary.com]

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 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 & Pignatti Morano di Custoza, 2015; Halket et al., 2020; Huang et al., 2018; Hwang et al.,

TABLE 4 Summary statistics of the rent-price ratio.

Summary statistics: Rent-price ratio	Obs.	Mean	Min	p25	Median	p75	Max
Rent-price ratio	5,662,358	4.655	2.226	3.692	4.514	5.447	9.619
Summary statistics: Rent-price ratio by living space							
Living space (sqm)	**Obs.**	**Mean**	**Min**	**p25**	**Median**	**p75**	**Max**
$x < 56.16$	1,415,779	5.171	2.226	4.107	5.055	6.085	9.619
$56.16 \leq x < 72$	1,377,815	4.623	2.226	3.713	4.532	5.408	9.618
$72 \leq x < 91$	1,449,848	4.479	2.226	3.618	4.372	5.212	9.618
$x \geq 91$	1,418,916	4.350	2.226	3.475	4.192	5.050	9.618
Summary statistics: Rent-price ratio by number of rooms							
Number of rooms	**Obs.**	**Mean**	**Min**	**p25**	**Median**	**p75**	**Max**
1	1,109,113	5.041	2.226	3.976	4.888	5.923	9.619
2	1,763,651	4.734	2.226	3.763	4.61	5.561	9.619
3	1,910,958	4.505	2.226	3.623	4.393	5.252	9.618
4 or more	878,636	4.332	2.226	3.458	4.188	5.038	9.618
Summary statistics: Rent-price ratio by year of construction							
Year of construction	**Obs.**	**Mean**	**Min**	**p25**	**Median**	**p75**	**Max**
$x < 1957$	1,401,681	4.807	2.226	3.845	4.693	5.616	9.619
$1957 \leq x < 1975$	1,355,815	4.733	2.226	3.823	4.632	5.495	9.619
$1975 \leq x < 1997$	1,448,975	4.774	2.226	3.815	4.654	5.580	9.618
$x \geq 1997$	1,455,887	4.316	2.226	3.408	4.091	5.007	9.619
Summary statistics: Rent-price ratio by district type							
Year of construction	**Obs.**	**Mean**	**Min**	**p25**	**Median**	**p75**	**Max**
City	2,928,906	4.517	2.226	3.535	4.347	5.332	9.619
Urban district	1,957,428	4.790	2.226	3.939	4.686	5.510	9.618
Rural district (urbanized)	423,089	4.746	2.226	3.683	4.537	5.591	9.619
Rural district (sparsely inhabited)	337,576	4.898	2.226	3.752	4.688	5.85	9.619

Note: This table shows descriptive statistics of the rent-price ratio, which is calculated for each rental object by the yearly net rent divided by the predicted sale price, which is derived from a hedonic model. 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 urban districts, the rents are smaller in proportion to the sale prices; thus, their rent-price ratio on average is smaller. The considered dataset covers the period from 2010 to 2019.

2006; Ito & Hirono, 1993; Smith & Smith, 2006). In cities, the rent-price ratio is smaller which is consistent with the results of Hilber and 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 analyses (see Sections 5.2 and 5.3).

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 m into a treatment group, where rent control is introduced in 2015 or later by the corresponding federal state,

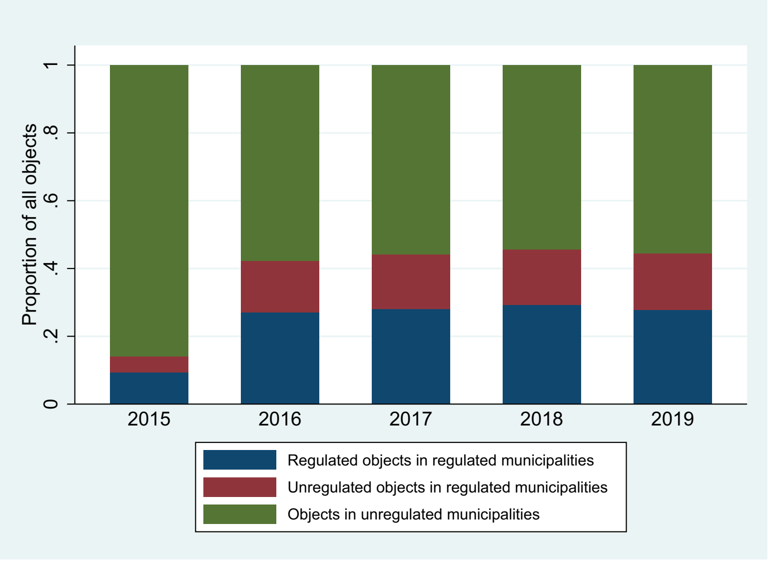

FIGURE 5 Proportion of regulated and unregulated objects. [Color figure can be viewed at wileyonlinelibrary.com]

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 m and across time on a quarterly basis q. 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 i 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 i because it was built after 2014 or its condition is categorized as *first occupancy*, *first occupancy after reconstruction*, or *like new*.

Overall, 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 5 shows the proportion of regulated and unregulated objects in regulated municipalities of all objects listed for each year since the rent control was introduced. For example, in 2018, about 45% of all offered apartments were located in regulated municipalities, as 29.24% of all advertised apartments were subject to the regulation of rent control and 16.35% were offered in a regulated municipality but excluded from the rent control due to its year of construction and object condition.[16]

[16] For additional visualizations of the regional and temporal distribution of rent control in Germany please consider Breidenbach, Eilers, et al. (2022).

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.[17] Our baseline regression is specified as follows:

$$rent\_price\_ratio_i = \alpha + \gamma\, municip\_reg_m + \delta_1\, municip\_reg\_applied_{mq} \times object\_reg_i + \delta_2\, municip\_reg\_applied_{mq} \times object\_unreg_i + \beta\, X_{imdqy} + A_d + B_y + \varepsilon_i. \quad (3)$$

The dependent variable is the rent-price ratio of object i, that is, the yearly net rent divided by the object's potential sale price. The coefficient γ accounts for general differences between the treated and the untreated municipalities m, 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 rent control on the rent-price ratio of regulated objects. The effect of the treatment on untreated, that is, unregulated, objects in municipalities where 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 average yield per municipality m and quarter q, if the object is located in an urban or metropolitan area in Western or Eastern Germany, the population density and the completion of living space in municipality m in year y, as well as the population growth, the primary income per capita, the number of students, the unemployment rate, and the proportion of social assistance recipients in district d in year y. Furthermore, we add cross-sectional fixed effects at the district-level (A_d) and year fixed effects (B_y). 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.

With this setup, we intend to achieve consistent estimators even though the introduction of the regulation is contingent on previous price dynamics in the local rental housing market. Similar to the approach in the macro analysis in Section 4, we control for several object-specific, socioeconomic, and time-invariant regional characteristics, as well as year fixed effects to create the best possible control group and to meet the requirements for conditional parallel trends as best as possible. To get an indication of the existence of parallel trends, we plot the rent-price ratios of "eligible for treatment dwellings" from never-treated control municipalities and from regulated treatment municipalities. Specifically, we plot for treatment and control municipalities the average rent-price ratios of dwellings which fulfill the conditions of the regulation (year of construction before 2014 and object condition not categorized as *first occupancy*, *first occupancy after*

[17] Please note that the novel estimator proposed by Callaway and Sant'Anna (2021) we use in Section 4 to estimate the staggered difference-in-differences framework with the aggregated panel dataset cannot be applied here. The reason is that with the repeated cross-sectional micro data, we analyze multilevel treatment due to the design of the German rent control, as we observe treated and (excluded) untreated objects in treatment municipalities. However, as we include a rich set of control variables and examine several subsamples, we are confident that our results are valid.

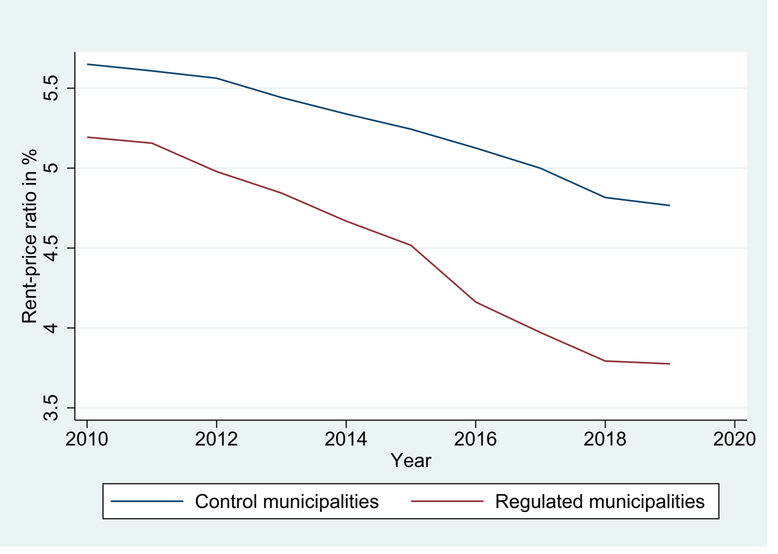

FIGURE 6 Rent-price ratio of (potentially) regulated objects in treatment and control municipalities. [Color figure can be viewed at wileyonlinelibrary.com]

reconstruction, or *like new*), and thus, would be subject to rent control if they were located in a treatment municipality (Figure 6). This graph clearly illustrates parallel trends before the beginning of the treatment and a drop in the ratio of treated objects in treated regions after that.[18] This graph is our point of departure for the validation of the model, it presents the unconditional trends in the sense that the different region-specific and socioeconomic covariates that we include in our regression to incorporate the pretreatment differences between treated and control municipalities are not accounted for. In the regression models we account for these covariates and thus further improve the quality of the control group.[19]

To further address concerns that the ex ante price dynamics in treated municipalities differ substantially from untreated municipalities, we additionally analyze the within-municipality variation in treated municipalities. Therefore, we only include observations from municipalities from the treatment group and thus estimate Equation (3) without the coefficients γ and δ_2. In this analysis, the exempted newer objects (newbuilds and reconstructed) are used as control group. Moreover, to have a deeper look at potential drivers of the within-municipality variation, we examine if the results are driven by exempted newbuilds or exempted renovated objects. For this purpose, we estimate the model using only the subsample of regulated municipalities and (i) excluding renovated objects that are excluded from rent control because their object condition

[18] The average rent-price ratios of treatment group apartments are lower because sale prices are higher in relation to rents in municipalities from the control group where housing markets are less tight. House prices have risen much more rapidly over the last two decades than rents, especially in urban areas where housing markets are tight. In Section 5.2.3, we elaborate on the change in sale prices and the change in rents separately to shed light on what drives the development of the rent-price ratio.

[19] Due to the nonexistence of exempted newbuilds (year of construction after 2014 with a categorized object condition of *first occupancy*, *first occupancy after reconstruction*, or *like new*) before treatment, we cannot graphically illustrate the trends of these dwellings from the treatment and the control group. In the regressions, we ensure the validity of our results by also including various object-specific characteristics as covariates to absorb dynamics that inhibit the comparability of treatment and control groups.

is categorized as *first occupancy after reconstruction* and *like new*; or (ii) excluding all newbuilds that were completed in 2014 or later and are therefore not regulated. 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 rent control on the rent-price ratio, we estimate several specifications based on Equation (3). The main results are presented 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 prices of comparable objects in these areas do not adapt to the regulation in a similar proportion. The estimated coefficient δ_1 suggests that their rent-price ratio lies 0.133 percentage points lower than the rent-price ratio of comparable objects in unregulated areas. The yield of regulated objects decreases due to the introduction of 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 0.252 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. From a landlord's perspective, these results demonstrate the reduced incentive to let regulated affordable apartments to tenants.

The analyses within the regulated municipalities confirm the results (Table 5, Columns 2, 3, and 4). Compared to unregulated newbuilds or renovated apartments, the rent-price ratios of rent-controlled objects are significantly smaller after the introduction of the regulation. When looking at the driver of this effect, the coefficients of the difference of rent-price ratios between regulated and unregulated apartments is larger if newbuilds are excluded from the control group (Column 3).

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 (nonregulated) 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 in the previous section (Section 4): the goal of the German rent control to foster the provision of affordable living space seems to be undermined by the increasing incentives for new construction and renovations, which increase the proportion of high-value properties and could force renters in tense housing markets with a high demand overhang to move into more expensive apartments. An additional analysis indeed shows that the number of building completions in regulated municipalities increases in the 3 years after the implementation of the rent control (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. Moreover, we cannot observe further housing-related expenditures that might be affected by increased investments, for example, investments in energy-saving renovations that could lead to decreasing energy cost burdens of households in the future.

TABLE 5 The effect of the rent control on the rent-price ratio.

Variables	(1) Rent-price ratio	(2) Rent-price ratio	(3) Rent-price ratio	(4) Rent-price ratio
Treatment municipality	0.0260***			
	(0.0093)			
Regulated objects in regulated mun	−0.1330***	−0.2788***	−0.1944***	−0.1471***
($municip\_reg\_applied_{mq} \times object\_reg_i$)	(0.0192)	(0.0424)	(0.0378)	(0.0228)
Unregulated objects in regulated mun	0.2522***			
($municip\_reg\_applied_{mq} \times object\_unreg_i$)	(0.0288)			
Object-specific variables:				
Base yield	0.9551***	0.9754***	0.9809***	0.9768***
	(0.0217)	(0.0282)	(0.0269)	(0.0162)
Year of construction	−0.0003	−0.0008***	−0.0014***	−0.0012***
	(0.0002)	(0.0001)	(0.0002)	(0.0002)
Living space	0.0001	0.0015*	0.0017*	−0.0012
	(0.0009)	(0.0008)	(0.0009)	(0.0009)
Number of rooms	−0.2310***	−0.2333***	−0.2424***	−0.2210***
	(0.0053)	(0.0073)	(0.0063)	(0.0052)
Basement (dummy)	−0.0066***	−0.0082***	−0.0084***	−0.0059***
	(0.0013)	(0.0015)	(0.0016)	(0.0015)
Balcony (dummy)	−0.1203***	−0.1327***	−0.1337***	−0.1107***
	(0.0104)	(0.0169)	(0.0142)	(0.0097)
Object condition	0.1536***	0.1491***	0.1549***	0.1024***
(1 = new; 10 = demolition)	(0.0046)	(0.0080)	(0.0070)	(0.0052)
Region-specific variables:				
Urban area (dummy)	0.0097	0.0148	0.0169	−0.0052
(Regional centers)	(0.0141)	(0.0370)	(0.0398)	(0.0139)
City/metropolitan area (dummy)	−0.0278	−0.0665***	−0.0660***	−0.0324
	(0.0180)	(0.0230)	(0.0237)	(0.0199)
West/East Germany (dummy)	0.0657**	−0.0873	−0.1180**	−0.4779***
(1 = West, 0 = East)	(0.0305)	(0.0584)	(0.0547)	(0.1544)
Socioeconomic variables:				
Population density	0.0014	0.0001	0.0058	0.0088
	(0.0089)	(0.0117)	(0.0121)	(0.0094)
Population growth	0.3231***	0.1679	0.1256	0.1858**
	(0.0746)	(0.1734)	(0.1692)	(0.0788)
Primary income per capita	−0.0063**	−0.0055	−0.0088***	−0.0082***
	(0.0025)	(0.0035)	(0.0033)	(0.0026)
Students	0.4240	0.5223	0.6020	1.2369**
	(0.3168)	(0.5629)	(0.5244)	(0.4975)

(Continues)

TABLE 5 (Continued)

Variables	(1) Rent-price ratio	(2) Rent-price ratio	(3) Rent-price ratio	(4) Rent-price ratio
Unemployment rate	3.0265**	3.7454*	4.8997**	2.2513
	(1.4089)	(2.0504)	(1.9070)	(1.7935)
Construction completions	0.0682*	0.1633**	0.0489	0.1118
	(0.0365)	(0.0633)	(0.0593)	(0.0682)
Social assistance recipients	−0.0017***	−0.0012	−0.0022**	−0.0020**
	(0.0006)	(0.0012)	(0.0011)	(0.0009)
Constant	0.4678	1.3856***	2.4277***	3.1244***
	(0.3272)	(0.3565)	(0.3428)	(0.4064)
Observations	4,619,727	2,406,160	2,247,501	3,739,728
R^2	0.6192	0.5875	0.5786	0.6228
Year FE	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes
Sample	Full	Regulated municipalities	Regulated municipalities w/o newbuilds	Regulated municipalities w/o renovated

Note: This table presents the results of the OLS regression modeling the determinants of housing yield described in Equation (3) using micro data. The dependent variable is the rent-price ratio, that is, 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 $municip\_reg\_applied_{mq}$, 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.

In the estimation of Column 1, regulated and unregulated municipalities are considered. In Columns 2, 3, and 4, we conduct within-municipality analyses; that is, we only include regulated municipalities in our estimation. In Column 3, objects that are categorized as *first occupancy* are excluded from the sample. In Column 4, objects that are categorized as *first occupancy after reconstruction* and *like new* are excluded.

The control variables can be categorized as object-specific, region-specific, and socioeconomic variables. The object-specific control variables include the base yield, that is, the quarterly mean of the rent-price ratio in the object's 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. Fixed effects for years and districts 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.

We review the results in several robustness analyses. Specifically, we show that the direction and significance of the results are robust to including the year of construction and the object condition as categorical variables (Table A2). Furthermore, we show that the estimates are robust to an extension of the observation period from 2010–2019 to 2008–2019 (Table A3, A4, Column 2). We also ensure that the results are not driven by a specific subsample, for example, in the largest cities or housing markets with high construction activity.

TABLE 6 The effect of the rent control on the rental and sale prices.

Variables	(1) Rent price per sqm (log)	(2) Rent price per sqm (log)	(3) Sale price per sqm (log)	(4) Sale price per sqm (log)
Treatment municipality	0.0632***		0.0850***	
	(0.0140)		(0.0245)	
Regulated objects in regulated mun	**0.0236***	**−0.0064**	**0.0987***	**0.0735***
($municip\_reg\_applied_{mq} \times object\_reg_i$)	(0.0055)	(0.0066)	(0.0099)	(0.0206)
Unregulated objects in regulated mun	**0.0426***		**−0.0093**	
($municip\_reg\_applied_{mq} \times object\_unreg_i$)	(0.0126)		(0.0082)	
Year of construction (log)	−0.4313	−1.0019***	0.5455	−0.5379*
	(0.2871)	(0.1922)	(0.7097)	(0.3098)
Living space (log)	−0.0013	0.0209	0.2474***	0.2512***
	(0.0311)	(0.0362)	(0.0269)	(0.0289)
Number of rooms (log)	−0.0650***	−0.0703***	−0.1438***	−0.1403***
	(0.0138)	(0.0171)	(0.0144)	(0.0151)
Basement (dummy)	−0.0018***	−0.0017***	0.0009	0.0016
	(0.0004)	(0.0005)	(0.0014)	(0.0014)
Balcony (dummy)	0.0200***	0.0169***	0.0329***	0.0262***
	(0.0035)	(0.0052)	(0.0039)	(0.0037)
Urban area (dummy)	0.0442*	0.1112***	0.0454	0.1922**
(Regional centers)	(0.0246)	(0.0229)	(0.0465)	(0.0908)
City/metropolitan area (dummy)	−0.0090	−0.1104***	−0.0113	−0.1282***
	(0.0325)	(0.0089)	(0.0442)	(0.0344)
West/East Germany (dummy)	0.0991	0.2437***	0.0982*	0.1968***
(1 = West, 0 = East)	(0.0645)	(0.0508)	(0.0557)	(0.0381)
Population density (log)	0.0441***	0.0213***	0.0495***	0.0040
	(0.0068)	(0.0079)	(0.0114)	(0.0137)
Population growth (log)	0.0014	0.0037	−0.0069***	−0.0036
	(0.0022)	(0.0049)	(0.0025)	(0.0054)
Primary income per capita (log)	0.2254***	0.1638*	0.6727***	0.5359***
	(0.0845)	(0.0882)	(0.1092)	(0.0998)
Students (log)	−0.0092	−0.0071	−0.0123	0.0007
	(0.0107)	(0.0152)	(0.0159)	(0.0129)
Unemployment rate (log)	−0.2109*	−0.3313**	−0.2579***	−0.3812***
	(0.1154)	(0.1417)	(0.0826)	(0.0744)
Construction completions (log)	0.0157***	0.0113**	0.0272***	0.0164**
	(0.0029)	(0.0055)	(0.0043)	(0.0079)
Social assistance recipients (log)	−0.0234	−0.0577	0.1073*	0.1747*
	(0.0527)	(0.0805)	(0.0625)	(0.0902)
Constant	0.9231	6.6185***	−11.8200**	−2.7222
	(3.0588)	(2.4338)	(5.1400)	(2.7286)

(Continues)

TABLE 6 (Continued)

Variables	(1) Rent price per sqm (log)	(2) Rent price per sqm (log)	(3) Sale price per sqm (log)	(4) Sale price per sqm (log)
Observations	3,064,152	2,017,686	1,716,317	1,210,342
R^2	0.6618	0.5514	0.6895	0.6125
Year FE	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes
Sample	Full	Regulated municipalities	Full	Regulated municipalities

Note: This table presents the results of the OLS regression modeling the determinants of rental and sale prices described in Equation (4) using micro data. The dependent variable in Columns 1 and 2 is the log of the rent price per square meter and in Columns 3 and 4; it is the log of the sale price per square meter. The variable "Treatment municipality" is a dummy variable which divides the sample into a treatment and a control group depending on the application of the rent control. The second and third reported estimators belong to the interaction terms of the dummy variable $municip\_reg\_applied_{mq}$, 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. They display the effects of the introduction of rent control on the rent-price ratio depending on the individual objects' regulation status.
In the estimation of Columns 1 and 3, regulated and unregulated municipalities are considered. In Columns 2 and 4, we conduct within-municipality analyses; that is, we only include regulated municipalities in our estimation. Thus, we cannot estimate coefficients for "Treatment municipality" and for "Unregulated objects in regulated mun" as the unregulated objects are the control group.
The control variables can be categorized as object-specific, region-specific, and socioeconomic variables. The object-specific control variables include the log of the object's year of construction, the log of the living space, the log of the number of rooms, dummy variables considering if the object has a basement and a balcony or terrace, and for the different object condition categories (unreported).
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. Fixed effects for years and districts 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.

5.2.3 | Respective effects on rental and sale prices

In sum, our micro-level results so far are consistent with the district-level results reported in Section 4 and suggest a supply-driven within-market shift toward 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. To examine if the effect on the rent-price ratio is driven by the rental or sale prices, we separately estimate the effects on rents and sale prices with the simple model:

$$p_i = \alpha + \gamma\, municip\_reg_m + \delta_1\, municip\_reg\_applied_{mq} \times object\_reg_i + \delta_2\, municip\_reg\_applied_{mq} \times object\_unreg_i + \beta X_{imdy} + A_d + B_y + \varepsilon_i, \quad (4)$$

where p_i is either the log of the rental or sale price of object i, γ accounts for general differences between the treated and the untreated municipalities m as $municip\_reg_m$ is the treatment group indicator. The coefficient δ_1 (δ_2) displays the effect of the introduction of the rent control on the price variable of (un)regulated objects (in regulated municipalities). X contains several object-

TABLE 7 Spillover effects of rent controls in regulated areas to regulated and excluded objects.

Variables	(1) Rent-price ratio
Direct treatment effect	−0.6154***
$object\_reg_i$	(0.0118)
Spillover effects to treated units	**0.4010*** **
$object\_reg_1 \times \overline{object\_reg_{my}}$	(0.0174)
Spillover effects to control units	**0.1370*** **
$(1 - object\_reg_1) \times \overline{object\_reg_{my}}$	(0.0052)
Object-specific variables:	
Year of construction	−0.0038***
	(0.0000)
Living space	0.0058***
	(0.0000)
Number of rooms	−0.3487***
	(0.0012)
Basement (dummy)	−0.0056***
	(0.0004)
Balcony (dummy)	−0.1473***
	(0.0015)
Object condition	0.1485***
(1 = new; 10 = demolition)	(0.0003)
Region-specific variables:	
Urban area (dummy)	0.4525***
(Regional centers)	(0.0083)
City/metropolitan area (dummy)	−0.5006***
	(0.0095)
West/East Germany (dummy)	−0.0739***
(1 = West, 0 = East)	(0.0154)
Socioeconomic variables:	
Population density	0.1041***
	(0.0026)
Population growth	−0.0007
	(0.0749)
Primary income per capita	−0.0262***
	(0.0007)
Students	−3.4645***
	(0.1163)
Unemployment rate	1.9816***
	(0.3575)
Construction completions	0.6494***
	(0.0107)

(Continues)

TABLE 7 (Continued)

Variables	(1) Rent-price ratio
Constant	13.3005***
	(0.0443)
Observations	2,406,210
R^2	0.4266
Year FE	Yes
District FE	Yes

Note: This table presents the results of the spillover analysis based on Equation (5) using micro data. The dependent variable is the rent-price ratio, that is, the yearly net rent divided by the objects' predicted sale price. The dummy variable $object\_reg_i$ displays the direct treatment effect. The variable $\overline{object\_reg_{mq}}$ is the group-level average treatment intensity, that is, 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 $(1 - object\_reg_i)$ in the regulated area with the group-level average treatment intensity $\overline{object\_reg_{mq}}$.
The control variables can be categorized as object-specific, region-specific, and socioeconomic variables. The object-specific control variables include the base yield, that is, 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.

specific and region-specific control variables[20] and we include district and year fixed effects in A_d and B_y. We also estimate the effect that occurs within the regulated municipalities (Table 6, Columns 2 and 4).

The results reveal that the rent price per square meter of regulated objects is 2.36% higher in regulated municipalities than the rent price per square meter of comparable objects in unregulated municipalities (Table 6, Column 1). This shows that the difference between the rents in regulated and unregulated municipalities increased after the introduction of the regulation. However, as the sale prices for regulated objects are 9.87% higher after the introduction of rent control in these municipalities (Table 6, Column 3), the rent-price ratio of regulated objects is smaller after the application of the regulation. The analysis from the previous section shows that the rent-price ratio of unregulated, new objects in regulated municipalities increased after the introduction of rent control. Since rents are 4.26% higher (Table 6, Column 1) and sale prices are not affected significantly (Table 6, Column 3), this coefficient can be explained by the higher rental prices for unregulated newbuilds and renovated objects in tense housing markets.

If we conduct the analysis only in treatment municipalities where rent control is introduced during the observation period, we can confirm that compared to unregulated objects, the rent-price ratio of regulated objects is smaller (Table 5) because of increases in sale prices for these objects (Table 6, Column 4). If the regulation was successful, we would expect a significant

[20] Included control variables are the logs of the year of construction, living space, and number of rooms, dummy variables for a basement, balcony, or terrace, the location in an urban area, city, and Western Germany, the logs of the socioeconomic factors population growth, primary income per capita, number of students, unemployment rate, and social assistance recipients in each district d and year y, and construction completions in each municipality m and year y.

negative coefficient of regulated objects in the analysis of the rent price (Table 6, Column 2) because the rents for regulated objects are compared to rents for unregulated objects, as we only observe treatment municipalities in this subsample analysis. However, the estimation shows that rent control does not significantly affect the difference between rent prices per square meter of regulated and unregulated objects (Table 6, Column 2).

These results further explain the inefficiency of the German rent control in improving affordability. Moreover, they highlight the potential relevance of the spillover effects of the rent control regulation from regulated to nonregulated objects that we will explicitly account for in the estimation in the next section.

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 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 municipalities where 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:

$$rent\_price\_ratio_i = \alpha + \beta_1\, object\_reg_i + \beta_2\, object\_reg_i \times \overline{object\_reg_{mq}} + \beta_3(1 - object\_reg_i) \times \overline{object\_reg_{mq}} + \gamma' X_{imdy} + A_d + B_y + \varepsilon_i. \quad (5)$$

The dependent variable is the rent-price ratio of object i. 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 ($\overline{object\_reg_{mq}}$), which is given by the proportion of regulated apartments in a municipality m for each quarter q. 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. Additionally, we control for several covariates in X that affect the rent-price ratio of each object i in municipality m in district d and year y and we include district and year fixed effects in A_d and B_y.

5.3.2 | Results

The results of the spillover analysis (Table 7) confirm that there is a direct treatment effect of the introduction of rent controls, as the estimate for β_1 suggests that the rent-price ratio of regulated

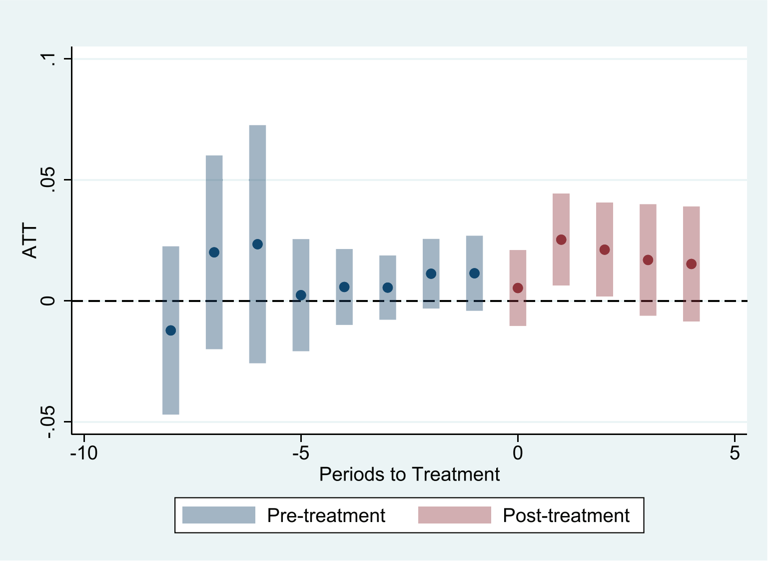

FIGURE 7 Coefficients of dynamic analysis of proportion of offered new dwellings. [Color figure can be viewed at wileyonlinelibrary.com]

objects is significantly lower than the one of not treated dwellings. The analysis points toward spillover effects to treated units, thus, the proportion of regulated units in a municipality where the regulation applies affects the yield of regulated objects. Specifically, the results show that the yield of treated objects in municipalities with a higher share of treated objects decreases less after the introduction of rent control compared to municipalities with a smaller share of regulated objects.

Moreover, the positive, significant coefficient of β_3 confirms our conclusion from the previous analysis that the introduction of 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 consistent with our district-level findings of the limited effectiveness of the rent control as they indicate that the incentives to invest in unregulated rental housing are increasing after the introduction of the policy and this is particularly the case in municipalities where rent control was ex ante having a high coverage.

Moreover, in an analysis of the share of listed rental apartments in regulated municipalities that are new or renovated, we observe a significant increase of 2.5 and 2.1 percentage points one and two years after the introduction of rent control (Figure 7).

Our results go along with recently published 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.

6 | CONCLUSION

In this article, 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 onward. In our empirical analyses, we exploit the temporal, regional, and object-specific variation caused by the implementation of rent control by the federal states in tight rental markets at different points in time. We study the effectiveness of 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 1.22 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 lies 0.252 percentage points higher after the implementation of the regulation and the yield on controlled inventory objects decreases by 0.133 percentage points after the introduction of the law. The separate examination of the effect of rent control on rental and sale prices shows that this effect on regulated objects is driven by the larger increase in sale prices, while the higher yield of unregulated dwellings in regulated municipalities occurs due to a significant increase in rents. Moreover, the findings of the spillover analysis add to these results 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. We show 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 3 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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ORCID

Vera Baye https://orcid.org/0000-0002-5392-5790

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APPENDIX

TABLE A1 Number of building completions after introduction of rent control.

Variables	(1) Lag of implementation = 1	(2) Lag of implementation = 2	(3) Lag of implementation = 3
y = number of building completions	($L = 1$)	($L = 2$)	($L = 3$)
$municip\_reg_m$	22.3212**	27.7601***	31.8351***
(Treatment municipality)	(9.1955)	(7.8060)	(6.5848)
$municip\_reg_m \times period\_reg_{t-L}$	57.6797**	55.9226*	63.7477*
(implementation of rent control)	(27.4879)	(30.2519)	(35.9447)
Inhabitants	0.0031***	0.0031***	0.0031***
	(0.0003)	(0.0003)	(0.0003)
Urban area (dummy)	15.8539	15.4476	15.1274
(regional centers)	(12.3264)	(12.2953)	(12.2514)
City/metropolitan area	−199.5527***	−198.9124***	−198.5782***
(dummy)	(60.9356)	(61.1287)	(61.2912)
Western/Eastern GER	7.1835**	7.2029**	7.1657**
(1 = West, 0 = East)	(2.8580)	(2.8597)	(2.8476)
Constant	−16.1400***	−16.6407***	−16.9681***
	(2.9808)	(3.1131)	(3.2374)
Observations	45,905	45,905	45,905
Number of municipalities	7201	7201	7201
Year FE	Yes	Yes	Yes
Municipality-type FE	Yes	Yes	Yes

Note: This table presents the results of the OLS regression modeling the determinants of the number of building completions described by the equation $building\ completions_{my} = municip\_reg_m + municip\_reg_m \times period\_reg_{y-L} + X_{my} + B_y + \varepsilon$. Building completions show the number of building completions per municipality m in year y. 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 $period\_reg_{y-L}$ 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 1, 2, and 3 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 A2 Robustness test with categorical variables.

Variables	**(1)** **Categorical variables for object condition**	**(2)** **Categorical variables for object condition and year of construction**
y = rent-price ratio		
Treatment municipality	0.0297***	0.0382***
	(0.0097)	(0.0101)
Regulated objects in regulated mun	−0.1910***	−0.1870***
$(municip\_reg\_applied_{mq} \times object\_reg_i)$	(0.0186)	(0.0190)
Unregulated objects in regulated mun	0.3545***	0.3280***
$(municip\_reg\_applied_{mq} \times object\_unreg_i)$	(0.0262)	(0.0274)
Object-specific variables:		
Base yield	0.9525***	0.9355***
	(0.0220)	(0.0216)
Year of construction	−0.0001	
	(0.0003)	
Living space	0.0004	−0.0008
	(0.0009)	(0.0010)
Number of rooms	−0.2395***	−0.2203***
	(0.0052)	(0.0057)
Basement (dummy)	−0.0060***	−0.0063***
	(0.0013)	(0.0013)
Balcony (dummy)	−0.1212***	−0.1159***
	(0.0102)	(0.0105)
Region-specific variables:		
Urban area (dummy)	0.0049	0.0044
(Regional centers)	(0.0149)	(0.0143)
City/metropolitan area (dummy)	−0.0258	−0.0336*
	(0.0170)	(0.0201)
West/East Germany (dummy)	0.0339	−1.0584***
(1 = West, 0 = East)	(0.0298)	(0.0498)
Socioeconomic variables:		
Population density	−0.0000	0.0163*
	(0.0091)	(0.0088)
Population growth	0.3439***	0.2823***
	(0.0784)	(0.0809)
Primary income per capita	−0.0076***	−0.0119***
	(0.0026)	(0.0035)
Students	0.4909	0.4376
	(0.3353)	(0.3646)

(Continues)

TABLE A2 (Continued)

Variables	(1) Categorical variables for object condition	(2) Categorical variables for object condition and year of construction
Unemployment rate	2.7590**	2.2974*
	(1.3092)	(1.2633)
Construction completions	0.0699*	0.0665
	(0.0421)	(0.0434)
Social assistance recipients	−0.0016**	−0.0015**
	(0.0007)	(0.0006)
Constant	0.2661	1.4412***
	(0.5183)	(0.1291)
Observations	4,619,727	4,619,724
R^2	0.6352	0.6492
Object condition	Categorical	Categorical
Year of construction		Categorical
Year FE	Yes	Yes
District FE	Yes	Yes

Note: This table presents the results of the OLS regression modeling the determinants of housing yield described in Equation (3) using micro data. The dependent variable is the rent-price ratio, that is, 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 $municip\_reg\_applied_{mq}$, 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, that is, 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 A3 Robustness analysis with different subsamples.

Variables	(1) Baseline	(2) Baseline	(3) Top 7 cities	(4) Little construction completions	(5) Many construction completions
y = rent-price ratio					
Treatment municipality	0.0260***	0.0260***		0.0346**	0.0364***
	(0.0093)	(0.0094)		(0.0141)	(0.0106)
Regulated objects in regulated mun	−0.1330***	−0.1365***	−0.0893***	−0.1096***	−0.1871***
$(municip\_reg\_applied_{mq} \times object\_reg_i)$	(0.0192)	(0.0188)	(0.0227)	(0.0185)	(0.0243)
Unregulated objects in regulated mun	0.2522***	0.2620***	0.2275***	0.2224***	0.2709***
$(municip\_reg\_applied_{mq} \times object\_unreg_i)$	(0.0288)	(0.0299)	(0.0469)	(0.0299)	(0.0427)
Object-specific variables:					
Base yield	0.9551***	0.9547***	0.9919***	0.9664***	0.8980***
	(0.0217)	(0.0226)	(0.0238)	(0.0246)	(0.0097)
Year of construction	−0.0003	−0.0003	−0.0009***	−0.0002	−0.0005**
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Living space	0.0001	0.0002	0.0031***	0.0006	−0.0016*
	(0.0009)	(0.0009)	(0.0005)	(0.0011)	(0.0009)
Number of rooms	−0.2310***	−0.2320***	−0.2172***	−0.2359***	−0.2004***
	(0.0053)	(0.0057)	(0.0130)	(0.0050)	(0.0089)
Basement (dummy)	−0.0066***	−0.0043***	−0.0105**	−0.0065***	−0.0050**
	(0.0013)	(0.0012)	(0.0030)	(0.0015)	(0.0021)
Balcony (dummy)	−0.1203***	−0.1159***	−0.1100***	−0.1039***	−0.1507***
	(0.0104)	(0.0104)	(0.0179)	(0.0102)	(0.0070)
Object condition	0.1536***	0.1572***	0.1393***	0.1474***	0.1544***
(1 = new; 10 = demolition)	(0.0046)	(0.0049)	(0.0130)	(0.0055)	(0.0034)

(Continues)

TABLE A3 (Continued)

Variables	(1) Baseline	(2) Baseline	(3) Top 7 cities	(4) Little construction completions	(5) Many construction completions
Region-specific variables:					
Urban area (dummy)	0.0097	0.0091		0.0164	0.0031
(Regional centers)	(0.0141)	(0.0139)		(0.0150)	(0.0167)
City/metropolitan area (dummy)	−0.0278	−0.0289*		−0.0228	−0.0331
	(0.0180)	(0.0172)		(0.0166)	(0.0322)
West/East Germany (dummy)	0.0657**	−0.6544***	−0.0081	0.0958***	1.9781***
(1 = West, 0 = East)	(0.0305)	(0.0399)	(0.3333)	(0.0103)	(0.0716)
Socioeconomic variables:					
Population density	0.0014	−0.0013	−0.4700**	−0.0096	0.0353***
	(0.0089)	(0.0090)	(0.1392)	(0.0099)	(0.0120)
Population growth	0.3231***	0.3134***	−0.4874*	0.1940***	0.4364***
	(0.0746)	(0.0816)	(0.2443)	(0.0611)	(0.1336)
Primary income per capita	−0.0063**	−0.0078***	−0.0412***	−0.0076**	−0.0036
	(0.0025)	(0.0019)	(0.0102)	(0.0031)	(0.0027)
Students	0.4240	0.3999	0.7087	0.7587**	−0.2503
	(0.3168)	(0.2858)	(0.7883)	(0.3555)	(0.5304)
Unemployment rate	3.0265**	2.3026**	−10.8256**	2.0086	6.8074***
	(1.4089)	(1.0735)	(3.2604)	(1.5577)	(1.0968)
Construction completions	0.0682*	0.2007***	−0.0958*	0.1005**	0.1010
	(0.0365)	(0.0355)	(0.0398)	(0.0418)	(0.0823)
Social assistance recipients	−0.0017***		0.0017*	−0.0010**	−0.0038***
	(0.0006)		(0.0008)	(0.0005)	(0.0008)

(Continues)

TABLE A3 (Continued)

Variables	(1) Baseline	(2) Baseline	(3) Top 7 cities	(4) Little construction completions	(5) Many construction completions
Constant	0.4678	1.1814***	3.7102***	0.2707	−0.8682**
	(0.3272)	(0.3233)	(0.8117)	(0.3574)	(0.3663)
Observations	4,619,727	5,111,963	1,140,284	3,244,786	1,767,476
R^2	0.6192	0.6155	0.5431	0.6209	0.6464
Year FE	Yes	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes	Yes

Note: This table presents the results of the OLS regression modeling the determinants of housing yields described in Equation (3) using micro data. The dependent variable is the rent-price ratio. Column 1 shows the baseline specification as described in Section 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, and Munich). Because of the reduction of the sample, all municipalities are subject to 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 A4 Robustness analysis with subsamples divided by building permits.

Variables	(1) Little building permits	(2) Many building permits	(3) Little building permits	(4) Many building permits	(5) Little building permits	(6) Many building permits
y = rent-price ratio			Lag = 1 year	Lag = 1 year	Lag = 2 years	Lag = 2 years
Treatment municipality	0.0274**	0.0341***	0.0277**	0.0340***	0.0282**	0.0336***
	(0.0109)	(0.0122)	(0.0110)	(0.0121)	(0.0110)	(0.0121)
Regulated objects in regulated mun	−0.0897***	−0.1705***	−0.0886***	−0.1717***	−0.0878***	−0.1731***
$(municip\_reg\_applied_{mq} \times object\_reg_i)$	(0.0235)	(0.0246)	(0.0235)	(0.0244)	(0.0237)	(0.0244)
Unregulated objects in regulated mun	0.1948***	0.2764***	0.1945***	0.2774***	0.1939***	0.2773***
$(municip\_reg\_applied_{mq} \times object\_unreg_i)$	(0.0395)	(0.0344)	(0.0396)	(0.0347)	(0.0397)	(0.0350)
Object-specific variables:						
Base yield	0.9574***	0.9222***	0.9576***	0.9225***	0.9574***	0.9225***
	(0.0214)	(0.0226)	(0.0214)	(0.0226)	(0.0214)	(0.0225)
Year of construction	−0.0002	−0.0006***	−0.0002	−0.0006***	−0.0002	−0.0006***
	(0.0003)	(0.0002)	(0.0003)	(0.0002)	(0.0003)	(0.0002)
Living space	0.0002	−0.0007	0.0002	−0.0007	0.0002	−0.0007
	(0.0011)	(0.0008)	(0.0011)	(0.0008)	(0.0011)	(0.0008)
Number of rooms	−0.2409***	−0.1989***	−0.2410***	−0.1990***	−0.2410***	−0.1989***
	(0.0096)	(0.0070)	(0.0096)	(0.0070)	(0.0096)	(0.0069)
Basement (dummy)	−0.0063***	−0.0059***	−0.0063***	−0.0058***	−0.0062***	−0.0057***
	(0.0016)	(0.0018)	(0.0016)	(0.0018)	(0.0016)	(0.0018)
Balcony (dummy)	−0.1078***	−0.1358***	−0.1080***	−0.1357***	−0.1080***	−0.1358***
	(0.0109)	(0.0111)	(0.0109)	(0.0111)	(0.0109)	(0.0111)
Object condition	0.1514***	0.1483***	0.1515***	0.1487***	0.1516***	0.1489***
(1 = new; 10 = demolition)	(0.0031)	(0.0066)	(0.0031)	(0.0066)	(0.0031)	(0.0066)

(Continues)

TABLE A4 (Continued)

Variables	(1) Little building permits	(2) Many building permits	(3) Little building permits	(4) Many building permits	(5) Little building permits	(6) Many building permits
Region-specific variables:						
Urban area (dummy)	0.0238	−0.0060	0.0252	−0.0073	0.0247	−0.0068
(Regional centers)	(0.0160)	(0.0133)	(0.0159)	(0.0133)	(0.0160)	(0.0132)
City/metropolitan area (dummy)	−0.0256	−0.0315	−0.0266	−0.0311	−0.0268	−0.0320
	(0.0179)	(0.0273)	(0.0180)	(0.0264)	(0.0181)	(0.0264)
West/East Germany (dummy)	−0.0229	0.1362***	−5.4607***	2.1477***	0.4122***	−0.0488
(1 = West, 0 = East)	(0.0150)	(0.0329)	(0.3978)	(0.0676)	(0.0699)	(0.0421)
Socioeconomic variables:						
Population density	−0.0019	0.0310**	−0.0021	0.0316**	−0.0019	0.0316**
	(0.0085)	(0.0126)	(0.0084)	(0.0126)	(0.0084)	(0.0127)
Population growth	0.2555***	0.3645***	0.2438***	0.3666***	0.2345***	0.3640***
	(0.0704)	(0.1122)	(0.0684)	(0.1138)	(0.0669)	(0.1101)
Primary income per capita	−0.0065**	−0.0058**	−0.0065**	−0.0059**	−0.0065**	−0.0060**
	(0.0031)	(0.0027)	(0.0031)	(0.0027)	(0.0031)	(0.0026)
Students	0.7227**	−0.2937	0.7196**	−0.2802	0.7255**	−0.2848
	(0.3258)	(0.5549)	(0.3253)	(0.5532)	(0.3239)	(0.5482)
Unemployment rate	2.6516	5.4674***	2.6814	5.4439***	2.6481	5.6040***
	(1.6867)	(1.1005)	(1.6872)	(1.0817)	(1.6814)	(1.0707)
Construction completions	−0.0469	0.0550	−0.0421	0.0586	−0.0371	0.0652
	(0.0795)	(0.0651)	(0.0801)	(0.0645)	(0.0788)	(0.0645)
Social assistance recipients	−0.0027***	−0.0006	−0.0027***	−0.0006	−0.0028***	−0.0007
	(0.0007)	(0.0006)	(0.0007)	(0.0006)	(0.0007)	(0.0006)

(Continues)

TABLE A4 (Continued)

Variables	(1) Little building permits	(2) Many building permits	(3) Little building permits	(4) Many building permits	(5) Little building permits	(6) Many building permits
Constant	0.3281	0.9773***	5.7616***	−1.0371***	−0.1063	1.1421***
	(0.4163)	(0.3150)	(0.4908)	(0.3030)	(0.3929)	(0.3229)
Observations	3,005,476	2,006,786	3,005,988	2,007,398	3,007,339	2,008,881
R^2	0.5990	0.6513	0.5985	0.6516	0.5983	0.6522
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: This table presents the results of the OLS regression modeling the determinants of housing yields described in Equation (3) 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 (Columns 1 and 2), 1-year lag (Columns 3 and 4), and a 2-year lag (Columns 5 and 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.

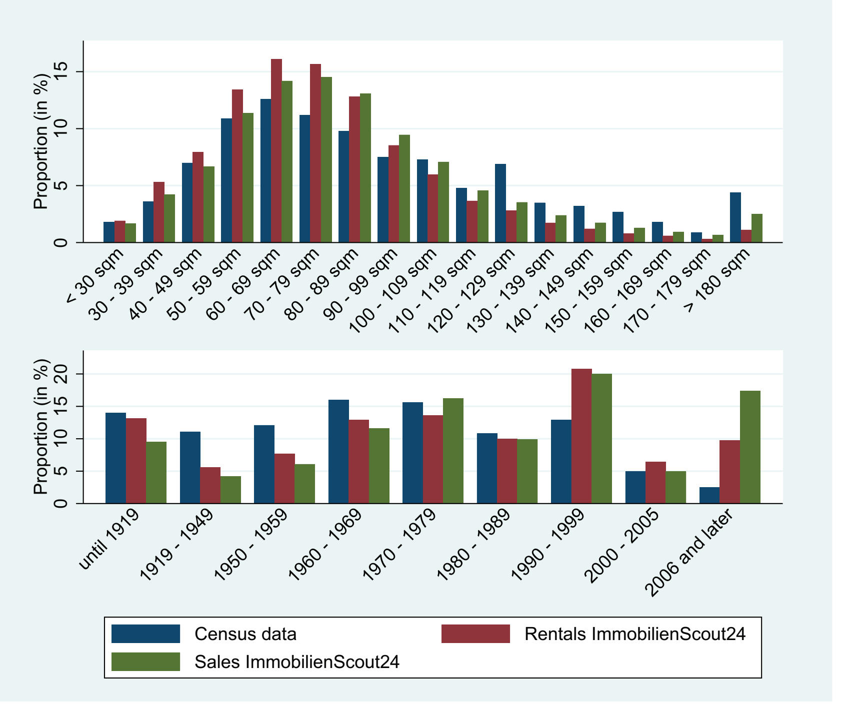

FIGURE A1 Distribution of apartments over size and year of construction. [Color figure can be viewed at wileyonlinelibrary.com]