HOUSING LAB WORKING PAPER SERIES

2024 | 2

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OSLOMET

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Nasjonalt senter for boligmarkedsforskning

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Abstract

We investigate the price effect of enforcing regulation on the share of small and large apartments being built in the inner city of Oslo. An apartment size regulation set a minimum of 35 square meters per apartment in 2008. The regulation was intended to ensure that the stock of new units would consist of both small and large apartments to secure a mixed demographic structure. Newly built apartments below the minimum size plummeted after the regulation was implemented in both the regulated inner city area and the rest of Oslo. We use transaction data for apartments to investigate the effect of the regulation on apartment prices within a difference-in-difference framework. We find that the price of apartments below the minimum size of 35 square meters increased by 3.3 percent compared to the control size segment of 40-50 square meters after the implementation of the apartment size regulation. We also examine the price effect on large apartments. Despite an increase in the number of large newly built apartments in the regulated inner city, we find that the prices of these apartments increased compared to the districts in Oslo that was not regulated. We suggest that this price increase can partially be explained by higher demand for large apartments from families with children, in line with the intention of the regulation.

Keywords: Housing supply and markets, Government policy
JEL-codes: R31; R38

*We thank Cloé Garnache, André K. Anundsen, Dag Einar Sommervoll, Andreas Benedictow, and Erlend Eide Bø for their useful comments. This paper has been presented at Workshop for housing and urban research at Oslo Met and at the Ragnar Frisch Centre for Economic Research.

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1 Introduction

High and increasing house prices in metropolitan areas, along with the role of restrictions on housing supply, have been extensively debated in recent years, see e.g., Glaeser and Gyourko (2018). Restrictions in and regulations of housing supply in metropolitan areas can have large welfare implications by reducing labour mobility and hindering potential agglomeration effects (Ciccone, 2002; Hsieh & Moretti, 2019; Saks, 2008). In addition, cities may increasingly cater to the wealthy and established as housing becomes more unaffordable (Baum-Snow & Hartley, 2020; Su, 2022). Government regulations on housing development, such as zoning, building heights limits and land use restrictions, vary across cities and between local housing markets within the same neighbourhoods. These regulations impact local house prices and demographics by shaping the mix of housing units available. Collectively, these regulations influence the overall housing supply within a city.

In this paper, we study effects of a 2008 policy change in the Norwegian housing market on square meter prices of apartments. The policy set restrictions on the shares of various size segments that would be allowed to be constructed in a building project in specified districts in Oslo, the capital of Norway. The regulation sought to improve housing quality, as well as the construction of a wider variety of apartments to accommodate diverse demographic and social groups. Specifically, it aimed to ensure the development of larger apartments suitable for families with children (Oslo Kommune, 2007). A lower limit on apartments allowed to be built was set to 40 square meters in 2008 and relaxed to 35 square meters after 2013. There were also minimum and maximum share restrictions on other size segments. A minimum of 50 percent of the apartments had to be above 80 square meters. This share was relaxed to a minimum of 40 percent in 2013. Using transaction data on residential apartments and a difference-in-difference approach, we explore whether the lower bound on apartment size led to increased prices of these apartments. We also investigate whether the increase in the supply of apartments above 80 square meters had an impact on square meter prices in this size segment in the inner city. Furthermore, we merge the data with tax registers providing

information at the household level to examine whether there was an increase in families with children buying apartments in the inner city as was indented by the norm.

The data on newly built apartments show that the construction of apartments below the minimum size of 35 square meters dropped markedly after the implementation of the apartment size regulation in both in the regulated inner city area and the rest of Oslo. For apartments above 80 square meters, it seems that the regulation only affected new apartments in the inner city, where there was a substantial increase in their construction.

We find that the square meter price of apartments below the lower size limit of 35 square meters increased significantly after the apartment size regulation was implemented in 2008. Using a static difference-in-difference framework, we find an effect amounting to a 3.3 percent price increase for apartments below 35 square meters. The effect is estimated using apartments between 40 and 50 square meters as the control group. In these estimations, all districts in Oslo are included in the treatment group since newly built apartments below the lower limits decreased markedly after the regulation was introduced in the entire city, not only the regulated districts. When we investigate the effects on the regulated area, the inner city, and other districts in Oslo, separately, we find highly similar sizes of the effects. We continue with a dynamic difference-in-difference analysis to investigate the timing of effects. The effect of the apartment size regulation is statistically significant from 2016 to 2021. Since the building processes can take up to several years from the time when the general permission is given until the construction is finished, and new apartments comprise a small fraction of the stock of apartments, it seems reasonable that the price effect of the introduction of the regulation comes with a time lag.

We perform several sensitivity checks to test the robustness of our results and whether we can interpret them as causal effects of the apartment size regulation. Our control group consists of small apartments between 40 and 50 square meters. Although our control group also consists of small apartments, one hypothesis could be that the increase in prices of apartments below 35 square meters relative to the slightly larger apartments in the control group is caused by a general trend of rising prices in all size segments, not by the apartment

size regulation (Landvoigt et al., 2015). Higher prices in the larger size segments might force more households to buy smaller apartments, which could lead to increased demand and relatively higher price growth for the smallest size segment. To test this hypothesis, we estimate the model with placebo size groups in the small apartment segment, with apartments below 25 square meters relative to apartments between 26 and 35 square meters, and apartments between 40 and 44 square meters relative to apartments between 45 and 50 square meters. There is no statistically significant difference between the price growth in the placebo treatment and the control groups. We also test and find no effects with the placebo size segment measuring 60-69 square meters relative to 70-79 square meters. Furthermore, we test for effects in placebo cities and find no positive, statistically significant effects on apartments below 35 square meters compared to 40-50 square meters in these cities.

We also explore the impact of the apartment size regulation on the square meter prices of apartments above 80 square meters, again using a difference-in-difference framework. Newly built apartments in this size segment increased in the inner city as a response to the regulation. The regulation did, however, not seem to alter the trend in new apartments above 80 square meters in the outer city. In this part of the analysis the control group therefore consists of apartments above 80 square meters in the outer city. We find that the prices of large apartments in the inner city increased by 4.4 percent after the implementation of the apartment size regulation, relative to large apartments in the outer city. One interpretation of the positive price effect on large apartments is that demand for large apartments has increased more than supply and that prices would have risen even more without the increase in supply caused by the apartment size regulation.

Lastly, we investigate if the increase in prices of large apartments in the inner city is caused by an increase in demand from families with children, in line with the intention of the regulation. Aggregate data on household types by district show an increase in the number of families living in the inner city. Transaction data merged with household data also show an increase in the number of families with children buying large apartments in the inner city. These findings suggest that the regulation may have successfully encouraged more families

with children to move to the inner city, potentially driving up demand and contributing to the rise in prices of larger apartments. However, it is important to interpret these results cautiously, as there has been a general increase in households of all types within the inner city, and the proportion of families remains relatively low compared to the outer city. As such, the rise in large apartment prices could stem from broader demand trends, rather than being exclusively driven by families with children.

Our article contributes to two strands of literature documenting the costs of regulations on housing development. First, our findings add to the literature investigating price effects of stringent regulations. The strong link between strict housing development regulations and rising house prices is well established (Gyourko & Krimmel, 2021; Jackson, 2018; Quigley & Raphael, 2005; Zabel & Dalton, 2011), see Gyourko and Molloy (2015) and Molloy (2020) for a review. The wedge between actual house prices and counterfactual prices if the regulations were more lenient is referred to as a regulatory or zoning tax (Glaeser & Gyourko, 2003, 2018). This zoning tax can be substantial. Gyourko and Krimmel (2021) estimate the zoning tax as the gap between the value of land with the extensive and intensive margins and find that this gap amounts to USD 400,000 for a quarter acre in San Francisco. Gyourko et al. (2021) construct a regulatory index and document the degree and heterogeneity of regulatory restrictiveness across metropolitan areas in the US. Gyourko and Krimmel (2021) find that the index is strongly correlated with their measures of zoning taxes. Although a number of studies find a positive correlation between stringent regulations and house prices, establishing a causal relationship is more complicated, as these regulations often depend on various community-specific characteristics (Davidoff, 2015; Saiz, 2010). As Molloy (2020) points out, there is also great variation in regulations both across and within cities, and these regulations frequently overlap, complicating efforts to isolate the impact of any single policy. We overcome this problem by using other apartments within the same city as control group in the difference-in-difference framework. We contribute to this literature by identifying a causal relation between the construction halt for apartments below 35 square meters and their relative price increase. The second strand of literature to which we contribute comprises the

changes in buyer composition and demography in cities over time (Baum-Snow & Hartley, 2020; Couture et al., 2020; Su, 2022). While the existing research primarily focuses on the increase in high-income and highly educated households in central cities, we focus on families with children and show that there was an increase in the number of families living in the inner city after the implementation of the apartment size regulation.

The rest of this paper is structured as follows. In Section 2 we describe the institutional setting and the implemented apartment size regulation. In Section 3, we present the empirical framework, and in Section 4, we describe the data. We discuss the results regarding the square meter prices of the small apartments and the large apartments in Sections 5 and 6, respectively. In Section 7, we draw our conclusions.

2 Institutional setting

2.1 Residential real estate sales process

Residential real estate is normally sold through ascending-bid auctions in Norway, where an open house showing takes place before the auction. Both the showing and the auction are led by a realtor. The realtor is hired by the seller but obligated by law to protect the interests of both the seller and the buyer. The bids are usually placed on digital platforms, and all bids are legally binding. The realtor informs the participants of developments in the auctions. The auction is completed, whether the seller accepts a bid or rejects all bids.

2.2 Apartment size regulation - Leilighetsnormen

In January 2008, the local government in Oslo implemented a size regulation on the construction of residential apartments, called Leilighetsnormen, in the inner city of Oslo.[1] Prior to this, there existed a regulation on the number of rooms in apartments, while the apartment size regulation set limits for the share of different size segments in a the construction project. The regulation aimed to promote high housing quality, as well as the construction of

[1]The regulation was announced in September 2007 and implemented in January 2008.

a larger variety of apartments in which a range of demographic and social groups could live. Particularly, the regulation was supposed to secure building of large apartments suitable for families with children (Oslo Kommune, 2007). The apartment size regulation was originally applicable to five districts in the inner city and set upper limits on the percent of small apartments that could be built. In the first column of Table 1, we summarize the regulation implemented in 2008, in which the minimum size of apartments allowed to be built was set at 40 square meters. In addition, a maximum share of 20 percent of apartments between 40 and 50 square meters was allowed in each building project, while the shares of apartments between 50 and 80 square meters and above this range were set at a minimum of 30 and 50 percent, respectively.

Table 1 Overview the apartment size regulation - Leilighetsnormen.

	January 2008	September 2013
Inner city:	Nydalen, Gamle Oslo, Sagene, Grünerløkka, St. Hanshaugen	Gamle Oslo, Sagene, Grünerløkka, St. Hanshaugen
Minimum size	40 square meters	35 square meters
Square meter segment 1	40-50: Maximum 20 percent	35-50: Maximum 35 percent
Square meter segment 2	50-80: Minimum 30 percent	80+ : Minimum 40 percent
Square meter segment 3	80+ : Minimum 50 percent	

Notes: This table shows an overview of the districts and areas that were covered by size regulation. Oslo is divided into 15 districts. Here we name the regulated districts the inner city and the other districts the outer city.

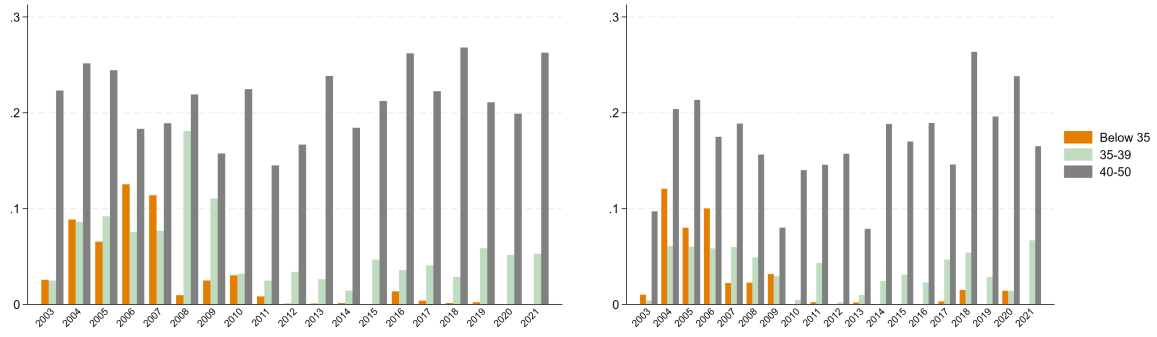
The apartment size regulation in 2008 was criticized for not matching the demand for residential apartments in the inner city (Oslo Kommune, 2013). The inner city has a large percentage of single households and a high and increasing demand for small apartments. Six years after the original regulation was implemented, it was changed in September 2013 to better match the demand for apartments (see Table 1, second column). This liberalization of the regulation included decreasing the minimum size allowed to be built from 40 to 35 square meters and increasing the share of apartments allowed to be built between 35 and 50 square meters from 20 to 35 per cent. In addition, the local government argued that the apartment size regulation should be practiced in a flexible way, in which exceptions were allowed, for

example, due to technical reasons or complications related to the existing housing stock.

2.3 Newly built apartments

The apartment size regulation applies to the construction of new apartments. Due to the slow nature of building processes, it takes time for the impact of this regulation to become visible on the housing stock and consequently on house prices. The building process can involve regulating the lots for residential housing,[2] applying for and receiving a building permit from the local government, preselling a certain required share of the apartments to receive external financing, and, finally, the building process itself. The total process can take several years.[3]

Figure 1 New apartments: Size shares small apartments (2003-2021).



(a) Inner city **(b)** Outer city

Notes: The figure shows the apartments size shares of newly built apartments at the time of sale in Oslo between 2003 and 2021. The inner city is defined as the four districts covered by the regulation (Gamle Oslo, Grünerløkka, St. Hanshaugen, and Sagene), while the outer city is defined as the remaining 11 districts in Oslo.

Figure 1 and Figure 2 display the size shares for new apartments at the time of sale, between 2003 and 2021[4]. In Figure 1 the shares of new apartments below 35 square meters and between 35 and 39 square meters (represented by orange and light green bars) in the

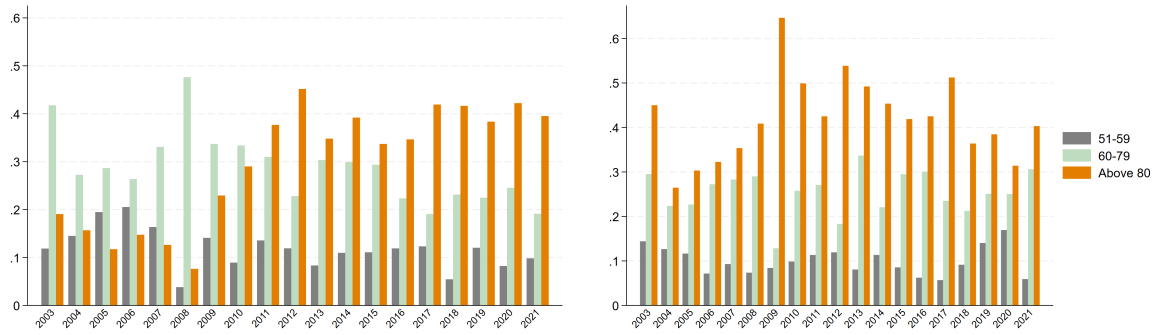
[2]However, several large construction firms have regulated lots available in their portfolios.

[3]Samfunnsøkonomisk Analyse collect data on new development projects at the time of sale and provide a data base over all new apartments in projects of 15 units or more. According to the cited source, it normally takes two to three years from the presale to the completion of apartment buildings in Oslo.

[4]The number of new apartments by the respective size groups are shown in Figure A.1 and Figure A.2 in Appendix A.

inner city ranges from 5 percent in 2003 to between 17 and 20 percent annually in the years leading up to the apartment size regulation introduced in 2008. As a consequence of the regulation, the number of new apartments these size categories plummeted in the inner city, and interestingly also dropped markedly in the outer city. It seems that the municipality has enforced the apartment size regulation outside the regulated districts (Kristiansen, 2023).[5] The average share of apartments that were built in the inner city between 40 and 50 square meters was 21.8 and 21.2 in the pre- and post period of the policy change respectively. Thus, the policy change does not appear to have affected the share of apartments built in this size segment.

Figure 2 New apartments: Size shares large apartments. (2003-2021).



(a) Inner city **(b)** Outer city

Notes: The figure shows the apartments size shares of newly built apartments at the time of sale in Oslo between 2003 and 2021. The inner city is defined as the four districts covered by the regulation (Gamle Oslo, Grünerløkka, St. Hanshaugen, and Sagene), while the outer city is defined as the remaining 11 districts in Oslo.

Figure 2 illustrates share of new apartments (at time of sale) by size segments above 50 square meters. The size regulation required that, starting in 2008, 50 percent of the apartments built in the inner city had to exceed 80 square meters. This requirement was

[5]In the article, the City Development Commissioner at the time states that the Planning and Building Agency considers 35 square meters to be a minimum requirement for ensuring good living quality. However, she also notes that "developers, can for example, factor in the proportion of high-quality shared space along with the private area per unit. If there are high quality projects or other compelling reasons, it is possible to build units below 35 square meters." We have reached out to the Planning and Building Agency and asked how they have enforced the minimum requirement of 35 square meters outside the regulated area, but have not received a response. Based on the former City Development Commissioner's statement, we interpret that an additional threshold exists for developers seeking approval to build units below 35 square meters also in the unregulated districts.

relaxed to 40 percent in 2013. As shown in Figure 2, this regulation had a strong impact on the number of new apartments above 80 square meters (orange bars) in the regulated inner city area. Unlike the regulation on the smallest apartments, this policy did not appear to affect the size distribution of newly built large apartments in the outer city.

Samfunnsøkonomisk Analyse (2022) investigated how the apartment size regulation affected the housing stocks in the districts in the inner city that were covered by the regulation compared to the other districts in Oslo. In line with the above-mentioned results, the share of the housing stock below 35 square meters declined, while the share of apartments between 40 and 50 square meters increased. This trend started slowly after the original regulation and accelerated after the update of the regulation in 2013.

3 Empirical framework

We examine two possible effects of the apartment size regulation: the impact on the prices of the smallest apartments and the impact on the prices of the largest apartments. First, we examine the effect of the apartment size regulation on prices per square meters on apartments below 35 square meters. The regulation set a construction halt on this size segment throughout the implementation period. The empirical framework is a difference-in-differences approach in which we compare the development in prices in the treated group (apartments below 35 square meters) to a control group before and after the regulations were implemented. As the construction of apartments below 35 square meters was halted in the outer city as well, we cannot use the outer city as our control group. Therefore, we use apartments between 40 and 50 square meters as the control group. We start with a simple difference-in-differences setup where we compare pretreatment to posttreatment as represented in Equation 1.

$$p_i = \alpha_i + \omega P_i^{2008} I_i^{35} + \mathbf{b'X_i} + Y_i^y + Q_i^q + D_i^d + Y_i^y D_i^d + \eta u_d + \rho u_m I_i^{35} + \varepsilon_i \tag{1}$$

The dependent variable p_i denotes the log price per square meter for transaction i. P_i^{2008} is a dummy variable equal to 1 posttreatment. I_i^{35} is a dummy variable equal to 1 if the

transaction occurs in the treatment group, that is, below 35 square meters. $P_i^{2008} I_i^{35}$ represents an interaction between the posttreatment and the treatment groups; thus, ω is the coefficient identifying the effect of the treatment. We also include a vector, $\mathbf{X_i}$, consisting of apartment characteristics: apartment size, apartment size squared, and apartment age deciles.[6] The model is run with yearly, Y_t, quarterly, Q_τ and district, D_d, fixed effects, as well as district times yearly fixed effects. We also add the quarterly unemployment rate at the municipality level, u_m, and an interaction term between unemployment and the treated size segment to control for the local business cycle and its potential different effects on the treated size segment versus the control size segment.

We also expand on the analysis and use a dynamic framework to capture the timing and duration of the effects since building processes are slow and the effects naturally come with a time lag. The model is presented in Equation 2.

$$p_i = \alpha_i + \sum_{y=2003, y\neq 2007}^{y=2021} \beta_y I_i^{35} + \mathbf{b}'\mathbf{X_i} + Y_i^y + Q_i^q + D_i^d + Y_i^y D_i^d + \eta u_d + \rho u_d I_i^{35} + \epsilon_i \quad (2)$$

The dynamic difference-in-differences includes the same control variables and fixed effects as in the static estimation in Equation 1. In the dynamic setup the β_y values show the effect of the interaction between treatment and years. The year prior to the implementation of the regulation, $y = 2007$, is left out. For the results to indicate an effect of the regulation, we should see statistically significant coefficients for the β_y values after the implementation of the regulation, while they should be insignificant in the years prior to the implementation. In all estimations, based on Equations 1 and 2, standard errors are clustered by a three-digit postal code. As the minimum size restriction of 40/35 square meters seems to have been implemented in both the regulated inner city and the non-regulated outer city, we treat the entire city of Oslo as regulated by this size restriction in the static and dynamic setups. We also present the results of the effects in the inner and outer city areas separately.

[6]The age deciles are calculated across all size segments combined, as the regulation may influence the age distribution within each segment.

Second, we investigate whether the increase in the supply of apartments above 80 square meters had an effect on the prices in this size segment. We apply a difference-in-difference framework as above. Apartments above 80 square meters in the regulated areas are set as the treated group. Since the trend in the construction of apartments above 80 square meters in the outer city was unaltered by the regulation, we use apartments above 80 square meters in the unregulated areas as the control group.[7] The model is presented in Equation 3:

$$p_i = \alpha_i + \psi P_i^{2008} I_i^{inner} + \mathbf{b'X_i} + Y_i^y + Q_i^q + D_i^d + Y_i^y D_i^d + \vartheta_i \tag{3}$$

I^{inner} is a dummy variable equal to 1 if the district was covered by the regulation. The remaining variables are the same as those in Equation 1. Thus, we are interested in ψ, which captures the effect on the price per square meter in the inner city area after the implementation of the regulation.

4 Data and summary statistics

4.1 Transaction data and price trends

The dataset used for analyzing price effects stemming from the size regulation is obtained from Eiendomsverdi. The dataset contains information about residential real estate transactions for second-hand apartments in Oslo over the period 2003-2021 including the sales date, asking and selling prices, apartment size, and other apartment and location characteristics. Table 2 displays summary statistics for both the inner city and the outer city of Oslo.[8]

We can see that selling prices for apartments vary between a little less than NOK 700,000 and NOK 16.19 million in the inner city, while the apartment sizes vary between 18 and 176

[7]There may still be spillover effects of the regulation on the outer city, as these markets are closely interconnected. For instance, demand could shift from the outer city to the inner city. If the regulation leads to increased demand for large apartments in the inner city, it could result in reduced demand in the outer city. In such a scenario, we might overestimate the positive impact of the regulation on inner-city apartment prices.

[8]The data are trimmed by removing units with missing construction year and the oldest buildings (comprising 1 percent) are removed. We trim on the 0.1^{st} and 99.5^{th} percentile on living room area on all observations, and 0.5^{th} and 99.5^{th} percentile per year for price per square meter and price.

Table 2 Summary statistics (transaction data), Oslo (2003– 2021).

Area	Variable	Min.	pct10	pct50	Average	pct90	Max.
Inner city	Sales prices (NOK 1000)	693.4	1,750.0	3,206.2	3,477.7	5,568.2	16,189.0
	Interior square meter (sqm)	18	35	56	59	85	176
	Square meter price (NOK 1000)	14.5	34.3	58.1	61.0	91.2	156.7
	Number of observations			41,512			
	Share with *size* <= 35 sqm			0.11			
Outer city	Sales prices (NOK 1000)	670.0	1,692.0	3,050.0	3,522.0	6,024.0	17,202.0
	Interior square meter (sqm)	18	40	67	70	104	177
	Square meter price (NOK 1000)	12.7	27.3	47.5	51.4	82.0	156.3
	Number of observations			50,778			
	Share with *size* <= 35 sqm			0.06			

Notes: pct10 refers to the 10 percent of observations with the lowest value, while pct90 refers to the 10 percent of observations with the highest value. pct50 is the median.

square meters. The median selling price is NOK 3.21 million, while the median square meter price is NOK 58,100. There are 41,512 transactions, and the share of apartments below 35 square meters is 11 percent. In the outer city, there are 50,778 transactions and the share of apartments of below 35 square meters is 6 percent. The median selling and square meter prices are slightly lower than in the inner city, at NOK 3.05 million and NOK 47,500, respectively, while the minimum and maximum values for prices and sizes are quite similar.

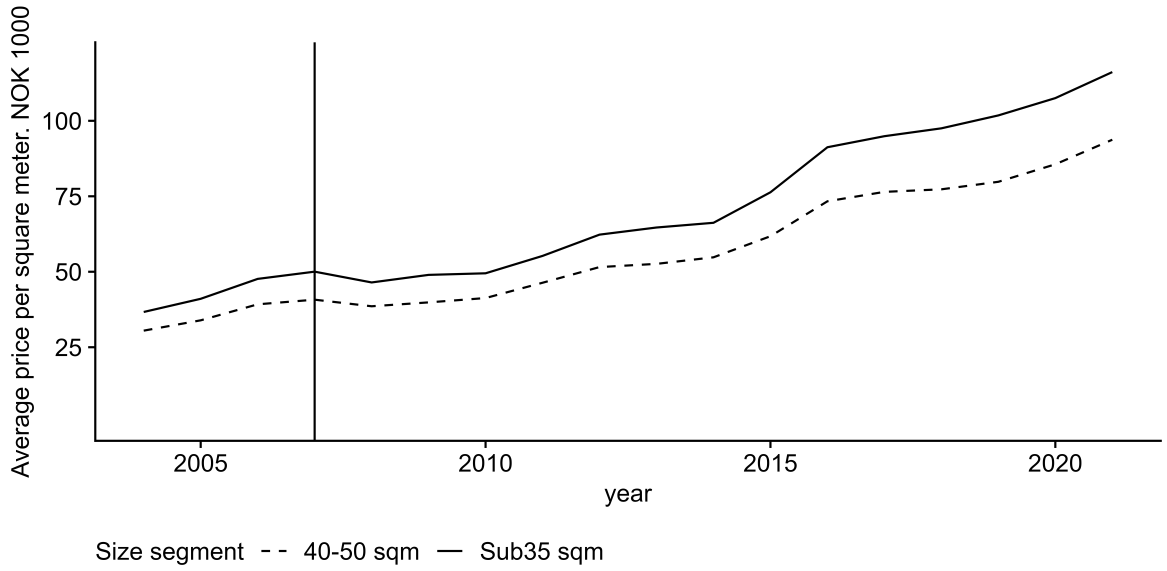
Figure 3 displays the annual average square meter price for apartments below 35 square meters (solid black line) and apartments between 40 and 50 square meters (dashed line) (NOK 1000) between 2004 and 2021 in Oslo. We see that the prices in the smallest size segment are higher than the slightly larger apartments. Furthermore, the prices have increased more for the smallest size segment (below 35 square meters) than for the slightly larger apartments (40-50 square meters) over this time period.

In Figure 4, we show average square meter prices for the inner city and the outer city separately. We can see that square meter prices are both higher and increasing more rapidly for the smallest size segment, in both the inner city and the outer city, in line with the trend for Oslo in total.[9]

Figure 5 illustrates the average prices for apartments between 80 and 100 square meters

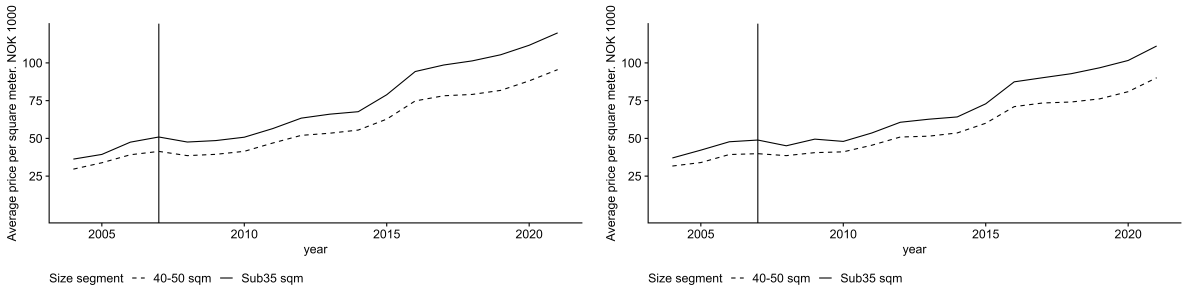
[9]Relative price trends between the treated and control size segments are included in Figure A.3 and Figure A.4 in Appendix A.

Figure 3 Average square meter prices of small apartments in Oslo (2004-2021).



Notes: This figure shows average annual square meter prices for apartments in Oslo (NOK 1000) from 2004 to 2021 for the treatment (< 35 square meters) and control (40-50 square meters) size segments.

Figure 4 Average square meter prices of small apartments in inner city and outer city (2004-2021).

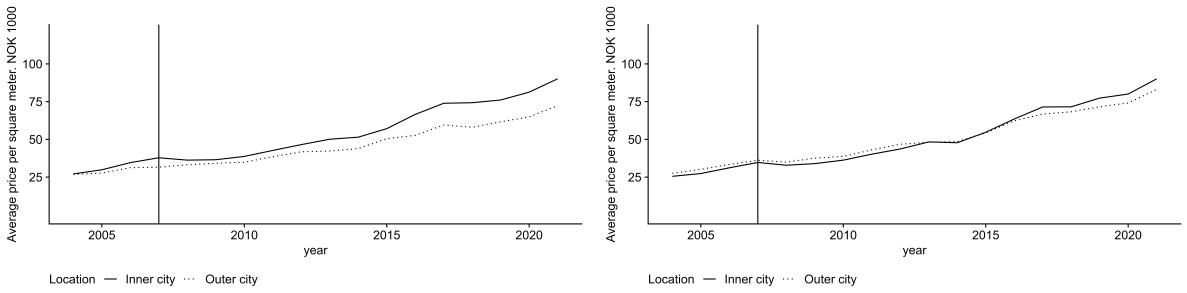


(a) Inner city. NOK 1000

(b) Outer city NOK 1000

Notes: This figure shows average annual square meter prices for apartments in Oslo (NOK 1000) from 2004 to 2021 for the treatment (< 35 square meters) and control (40-50 square meters) size segments. The inner city is defined as the four districts covered by the regulation (Gamle Oslo, Grünerløkka, St. Hanshaugen, and Sagene), while the outer city is defined as the remaining 11 districts in Oslo.

Figure 5 Average square meter prices of large apartments in Oslo (2004-2021).



(a) Apartments 80-100 square meters **(b)** Apartments above 100 square meters

Notes: This figure shows average annual square meter prices for large apartments in Oslo (NOK 1000) from 2004 to 2021. The inner city is defined as the four districts covered by the regulation (Gamle Oslo, Grünerløkka, St. Hanshaugen, and Sagene), while the outer city is defined as the remaining 11 districts in Oslo.

in panel a) and above 100 square meters in panel b), in the inner city and the outer city of Oslo. It is evident that square meter prices for apartments between 80 and 100 square meters have been growing at a faster pace in the inner city compared to the outer city, including in the period before the implementation of the apartment size regulation. For apartments above 100 square meters, the price trends look parallel in the preperiod, and the price per square meter has increased slightly more in the inner city compared to the outer city by the end of the period.

4.2 Household balance sheet data

The transaction data are linked to a dataset from the Norwegian tax registry, which includes annual observations on households' balance sheets for the period 2004-2019. The data consist of balance sheet information, including income, debt, and wealth, as well as education, profession, age, gender, and household type. In particular, the dataset shows the number of people, including the number of children, in the household. This allows us to analyze effects on different types of households buying apartments.[10]

Summary statistics for apartment buyers in Oslo from 2004 to 2019 are provided in Table

[10]We trim on the 0.1^{st} and 99.5^{th} percentiles on living room area on all observations and 0.5^{th} and 99.5^{th} percentiles per year for price per square meter and price.

3. We can see that there are 33,251 observations in the inner city (regulated) area and 40,972 observations in the outer city area.[11] The buyers in the inner city are younger, have higher education on average and have a slightly lower household income than their counterparts in the outer city. The shares of single buyers (one-person household) are 35.4 and 31.0 percent in the inner city and outer city respectively, while the shares of families (one or more adults living with children) buying apartments are 16.5 percent in the inner city and 27.2 percent in the outer city. Couples (two adults) buy a shares of 29 percent and 27.2 percent in the inner city and outer city respectively, while multiperson households (three or more adults) buy shares of 19.2 percent and 14.7 percent. Although we use the term *couples*, we do not know the actual status of these households; we only know how many people bought the apartments. In the *couple* category, there might be a single person buying an apartment together with a parent.[12]

Table 3 Summary statistics, apartment buyers in Oslo (2004-2019).

	Inner city		*Outer city*	
	Median	Mean	Median	Mean
Square meter price (NOK 1000)	54.3	57.4	45.6	48.9
Household income (NOK 1000)	640.1	807.9	640.8	842.4
Age (Year)	30	34	34	39
High education (Percent)		73.6		58.6
Single (Percent)		35.4		31.0
Family (Percent)		16.5		27.2
Couple (Percent)		29.0		27.2
Multiperson (Percent)		19.2		14.7
Observations	33,251		40,972	

Notes: This table shows summary statistics for apartment buyers in Oslo from 2004 to 2019. The inner city is defined as the four districts covered by the regulation (Gamle Oslo, Grünerløkka, St. Hanshaugen, and Sagene), while the outer city is defined as the remaining 11 districts in Oslo.

[11] This dataset contains slightly fewer observations than the transaction dataset, primarily due to the household dataset covering a time period that is three years shorter.

[12] We have checked whether co-buying with parents affects our results by excluding households where the age difference between individuals buying an apartment together is more than 20 years. According to our data, the share of households co-buying with parents is just 2 percent and does not affect the main patterns presented here. See Figure B.1 and Figure B.2 in Appendix B. We also show the development in other household characteristics, such as income, age, and education, in Figure B.3.

5 Empirical results: Effect of apartment size regulation of small apartments

In this section, we explore whether prices of apartments below 35 square meters were affected by the implementation of the apartment size regulation in 2008. As shown in Section 2.3, there was a drop in the number of newly built apartments below 35 square meters in the whole city. Therefore, we classify apartments below 35 square meters *in the whole city* as the treatment group and we use apartments between 40 and 50 square meters in the whole city as the control group.

5.1 Price effect on the smallest apartments

Table 4 displays the estimated results on prices of apartments below 35 square meters after the implementation of the regulation. The estimations are done in the difference-in-difference setup displayed in Equation 1. The treatment group comprises apartments below 35 square meters and interacted with postperiod from 2008.[13] Apartments between 40 and 50 square meters comprise the control group. We have conducted a Wald test for parallel pretrends between the treatment and the control groups across size segments. The Wald test results are presented in Table A.4 in Appendix A, and we cannot reject the null hypothesis of parallel pretrends.

The price effect on apartments below 35 square meters is captured by the coefficient on the interaction $P_{2008} * I^{35}$ in the first row of Table 4. The first column presents the results before including any control variables or fixed effects in the specification. The effect of the regulation is then measured to be 1.4 percent but not statistically significant. When we add apartment-specific control variables to the specification, the effect drops to below 1 percent

[13] From 2008 to 2013, the minimum size for apartments was 40 square meters. We have tested whether the period of restrictions on building apartments between 35 and 39 square meters had an effect on these apartments. The estimation results are presented in Table A.3 in Appendix A. The interaction of 35-39 square meters with the time between 2008 and 2013 is statistically insignificant. Hence, we continue with the specification of below 35 square meters throughout the period.

Table 4 Estimation results price effect on apartments below 35 square meters in Oslo.

Dependent Variable:	log(sqmprice)				
Model:	(1)	(2)	(3)	(4)	(5)
Variables					
$P^{2008} * I^{35}$	0.014	0.009	0.033***	0.033***	0.040***
	(0.013)	(0.010)	(0.006)	(0.006)	(0.006)
I^{35}	0.197***	-0.019	-0.019*	-0.027***	-0.033***
	(0.017)	(0.019)	(0.010)	(0.010)	(0.010)
square meter		-0.029***	-0.020***	-0.020***	-0.020***
		(0.003)	(0.003)	(0.003)	(0.002)
square meter^2		0.0002***	0.0001***	0.0001***	0.0001***
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
unemp				-0.001	-0.002*
				(0.001)	(0.001)
I^{35}*unemp				0.002**	0.003***
				(0.001)	(0.001)
Fixed effects					
year	Yes	Yes	Yes	Yes	Yes
age deciles		Yes	Yes	Yes	Yes
quarter		Yes	Yes	Yes	Yes
district			Yes	Yes	Yes
district-year					Yes
Fit statistics					
Observations	20,587	20,587	20,587	20,587	20,587
R^2	0.811	0.867	0.928	0.928	0.931
Within R^2	0.268	0.482	0.517	0.517	0.526

Notes: The table reports the effect of the cap on building apartments below 35 square meters based on a difference-in-difference model (see Equation 1). The treatment group is apartments below 35 square meters, and the control group consists of apartments between 40 and 50 square meters. The time period is 2003-2021. Robust standard errors in parentheses are clustered by a three-digit postal code. Significance levels: * p<.1, ** p<.05, *** p<.01.

Table 5 Estimation results of price effect on apartments below 35 square meters in the inner city and outer city of Oslo.

Dependent Variable:	log(sqmprice)		
	(Oslo)	(Inner city)	(Outer city)
Variables			
$P^{2008} * I^{35}$	0.033***	0.032***	0.036***
	(0.006)	(0.007)	(0.010)
I^{35}	-0.027***	-0.030***	-0.023
	(0.010)	(0.011)	(0.017)
square meter	-0.020***	-0.026***	-0.008**
	(0.003)	(0.003)	(0.004)
square meter^2	0.0001***	0.0002***	0.000
	(0.000)	(0.000)	(0.000)
unemp	-0.001	-0.001	-0.003
	(0.001)	(0.001)	(0.002)
I^{35}*unemp	0.002**	0.0004	0.006***
	(0.001)	(0.001)	(0.002)
Fixed effects			
district	Yes	Yes	Yes
quarter	Yes	Yes	Yes
year	Yes	Yes	Yes
age deciles	Yes	Yes	Yes
Fit statistics			
Observations	20,587	12,283	8,304
R^2	0.928	0.929	0.928
Within R^2	0.517	0.571	0.450

Notes: The table reports the effect of the cap on building apartments below 35 square meters based on a difference-in-difference model (see Equation 1). The treatment group is apartments below 35 square meters, and the control group consists of apartments between 40 and 50 square meters. The time period is 2003-2021. The inner city is defined as the four districts covered by the regulation (Gamle Oslo, Grünerløkka, St. Hanshaugen, and Sagene), while the outer city is defined as the remaining 11 districts in Oslo. Robust standard errors in parentheses are clustered by a three-digit postal code. Significance levels: * p<.1, ** p<.05, *** p<.01.

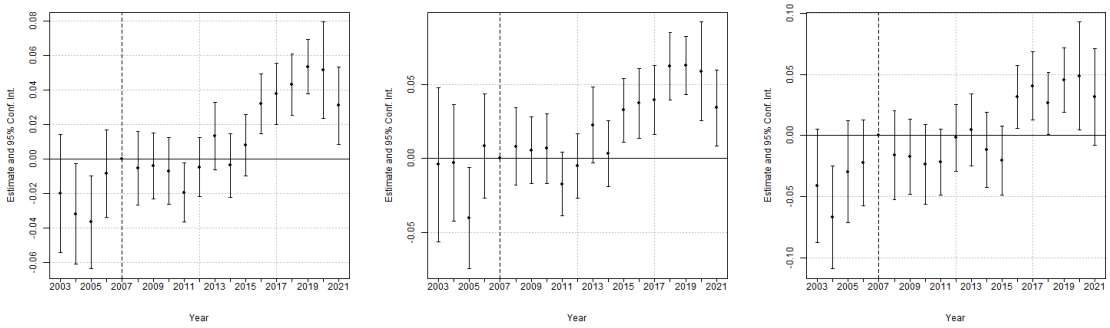
and is still not statistically significant (column 2). When district fixed effects are included (column 3), the effect of the regulation is estimated to be 3.3 percent for the whole of Oslo and is statistically significant at the 1 percent level. This indicates that the price per square meter for the apartments below 35 square meters increased 3.3 percent more than apartments between 40 and 50 square meters on average after the size regulation was implemented in 2008. This estimate remains unchanged when we add the unemployment rate (column 4), both as a separate term and interacted with the treatment variable, to control for how the local business cycle potentially affects the apartments in the treatment group differently than the apartments in the control group. We also add year-by-district fixed effects in column 5 to control for time-varying district-level heterogeneity, resulting in a slight increase in the estimated effect to 4 percent, which remains statistically significant at the 1 percent level.

We also divide the city into the inner city (the districts covered by the regulation) and the outer city (the districts not covered by the regulation) and run the models on the two areas separately. We choose the specification with control variables and district fixed effects (column 4 in Table 4) as our main specification.[14] The results are presented in Table 5. The effects of the regulation are measured to be 3.2 and 3.6 percent in the inner city and the outer city, respectively, and both coefficients are statistically significant at the 1 percent level. The inner city and the outer city also pass the parallel pretrend test when we test the areas separately (see Table A.4 in Appendix A).

The results obtained from the dynamic difference-in-difference model for the same specification, as shown in Table 5, are displayed in Figure 6. The results for Oslo as a whole are presented in panel (a), and those for the inner city and the outer city are presented in panels (b) and (c), respectively. The inner city and the outer city each has one interaction between treated and annual dummies that are statistically significant in the preperiod. It looks as though the relative prices of apartments below 35 square meters increased in 2006 and 2007 prior to the implementation of the regulation. These coefficients might be affected by the run-up to the great financial crisis in 2007-2009. We attempt to control for the business

[14]Detailed results with all specifications from Table 4 for the inner city and the outer city separately are shown in Table A.1 and Table A.2 in Appendix A.

Figure 6 Dynamic difference-in-difference price effect on apartments below 35 square meters.



(a) Oslo **(b)** Inner city **(c)** Outer city

Notes: The figure shows the estimated results of the interaction treated size and annual dummies from Equation 2 for the period 2003-2021. The treatment group comprises apartments below 35 square meters, and the control group consists of apartments between 40 and 50 square meters. The inner city is defined as the four districts covered by the regulation (Gamle Oslo, Grünerløkka, St. Hanshaugen, and Sagene), while the outer city is defined as the remaining 11 districts in Oslo. Standard errors are clustered by three-digit postal code.

cycle by including the local unemployment rate in our estimation, but we might not be able to control for all effects of the financial crisis. However, it is reassuring that the Wald tests for parallel trends in the preperiod do not reject parallel pretrends.[15]

For Oslo as a whole and the outer city, the interaction with treated apartments below 35 square meters and annual dummies are statistically significant from 2016 in the posttreatment period. For the inner city, the interactions are statistically significant from 2015. Since the building processes can take up to several years from the time when the general permission is given to the time when the construction is finished and it takes time before new apartments have an effect on the composition of size segments, it seems reasonable that the price effects of the regulation are visible some time after implementation.

5.2 Sensitivity checks

We conduct several sensitivity checks to test the robustness of our results and whether we can interpret them as causal effects of the apartment size regulation. We test the difference-

[15]The results are presented in Table A.4 in Appendix A. We cannot reject parallel trends in the preperiod at the 5 percent level in Oslo as a whole. The same applies for the inner city and the outer city separately.

in-difference model with placebo size groups and placebo cities.

One hypothesis could be that the increase in prices of small apartments could be caused by a general trend of increasing prices in all size segments, not by the apartment norm. One argument against this hypothesis is that our control group also consists of small apartments, with sizes between 40 and 50 square meters. Nevertheless, higher prices in the larger size segments might force more households to buy smaller apartments, which could lead to increased demand and relatively higher price growth for the smallest size segment.

Furthermore, we perform the analysis with small-sized placebo groups. Because the regulation placed restrictions on different size segments, we need to choose placebo size groups carefully. We test if the prices of apartments below 26 square meters rose more than those of apartments between 26 and 35 square meters. We perform a similar test for apartments between 40 and 44 square meters relative to apartments between 45 and 50 square meters. There are no statistically significant differences between the price increases in these placebo groups. We also test and find no effects in the placebo size segment measuring 60-69 square meters relative to 70-79 square meters. Detailed results are shown in Table A.5 and Figure A.5

We also perform estimations with placebo cities, Bergen and Trondheim, the second and the third largest cities after Oslo. In addition, we do estimations for Bærum and Lillestrøm, cities close to Oslo. Treatment and control groups are set equal to the treatment and control groups in our main specification, where the treatment group comprises apartments below 35 square meters, and the control group consists of apartments between 40 and 50 square meters. There are no significant effects in any of the placebo cities, except in Bergen, where there are measured negative price effects after 2007 on apartments below 35 square meters. However, Bergen does not pass the test for parallel pretrends. (See Table A.7 and Table A.8 for the results of this estimation and of the Wald test, respectively. Dynamic difference-in-difference for placebo cities are displayed in Figure A.6.)

6 Empirical results: Effect of apartment size regulation of large apartments

6.1 Price effect on the largest apartments

We explore whether the introduction of the minimum share of 50 percent of newly built large apartments in 2008, and the modification to 40 percent in 2013, had a price effect on these apartments. As can be seen in Figure 2, this led to a substantial increase in new apartments in this size segment in the regulated area, while the number of large apartments in the outer city was more stable between the preregulation and the postregulation periods. For a given demand, an increase in supply would lead to lower prices. However, a higher share of large apartments may lead to more stable living situations, enhancing residents' connection to the community and fostering a better quality of life. Additionally, for families with children, there may be certain thresholds where an increase in the number of families living in a neighborhood may augment the demand for other families. These two effects may lead to increased demand, which will pull in the direction of relatively higher prices of these apartments. As described in Section 3, we apply a difference-in-difference framework where apartments above 80 square meters in the inner city comprise the treatment group, and the control group consists of apartments in the equivalent size segment in the outer city. The estimation results are presented in Table 6 where the column header denotes the size segments based on which the model is estimated. For the whole size segment, 80+ and 80-99 square meters, we can reject parallel trends in the pretreatment period. For apartments above 100 square meters, we cannot reject parallel trends in the pretreatment period; therefore, we focus on this size segment. We find that apartments above 100 square meters increased 4.4 percent more in price on average in the inner city compared to the outer city after the implementation of the apartment size regulation. For these large apartments, it seems that the effect of the increase in demand surpassed the impact of increased supply.

To explore whether the increased demand stems from family buyers, we investigate

Table 6 Estimation results of price effect on apartments above 80 square meters.

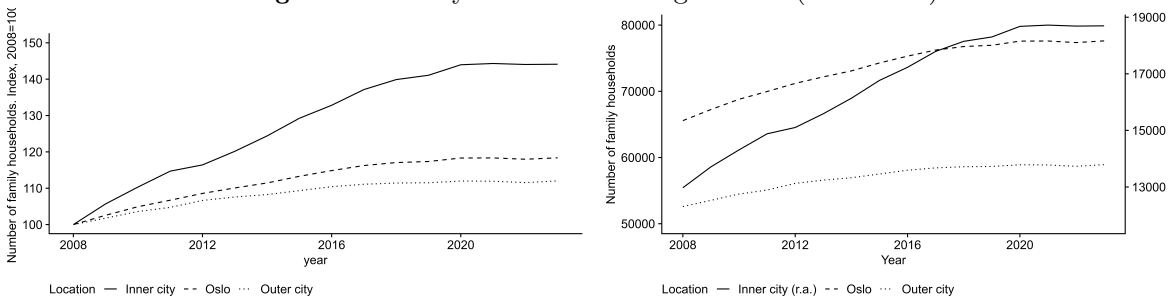
Dependent Variable:	log(sqmprice)		
Size segment:	(80+)	(80-99)	(100+)
Variables			
$P^{2008} * I^{inner}$	0.031***	0.027**	0.044***
	(0.011)	(0.012)	(0.016)
square meter	0.0009	0.002	0.003
	(0.001)	(0.013)	(0.002)
square meter^2	-0.00001**	-0.00002	-0.00002**
	0.000005	0.00008	0.000008
Fixed effects			
year	Yes	Yes	Yes
quarter	Yes	Yes	Yes
district	Yes	Yes	Yes
Fit statistics			
Observations	21,143	13,089	8,054
R^2	0.878	0.891	0.861
Within R^2	0.201	0.197	0.197

Notes: The table reports the effect of increased construction of apartments above 79 square meters, based on a difference in difference framework, see Equation 3. The treatment group comprises apartments in the inner city, regulated by the norm in the size group denoted by the column title and the control group is apartments in the outer city in the same size segment. The inner city is defined as the four districts covered by the regulation (Gamle Oslo, Grünerløkka, St. Hanshaugen, and Sagene), while the outer city is defined as the remaining 11 districts in Oslo. The time period is 2003-2021. Robust standard errors in parenthesis are clustered by a three-digit postal code. Significance levels: * p<.1, ** p<.05, *** p<.01.

whether the number of families *living* in the inner district and number of the *buyers* of the large apartments have increased.

6.2 Families *living* and *buying* apartments in Oslo

Figure 7 Family households living in Oslo (2008-2023).



(a) Index: 2008 = 100 **(b)** Number of households

Notes: This figure shows an index for family households (households with children who are not adults) living in Oslo and in the inner and outer city. In 2023 the number of family households in Oslo was 77,617 with 18,696 living in the inner city and 58,921 living in the outer city. The total number of households in Oslo was 365,777 with 125,439 living in the inner city and 240,338 living in the outer city. The index base year is 2008. The inner city is defined as the four districts covered by the norm (Gamle Oslo, Grünerløkka, St. Hanshaugen and Sagene), while the outer city is defined as the remaining 11 districts in Oslo.

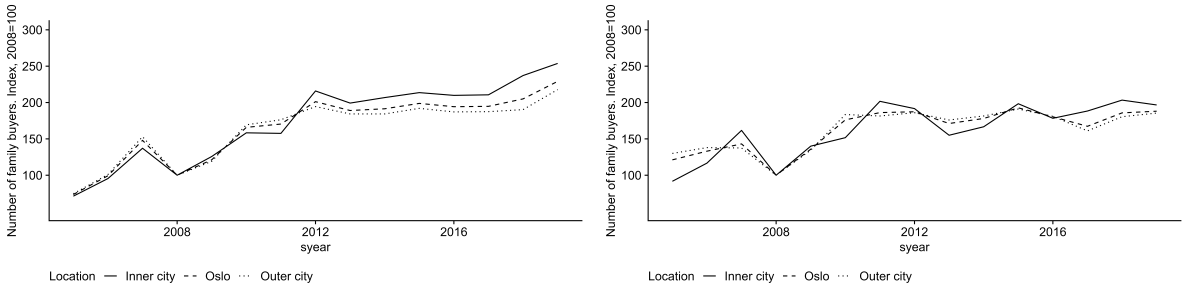
To study whether the goal of an increased number of families *living* in the inner city has been achieved, we start with aggregate data on household types per district in Oslo from 2008 to 2023.[16] The left panel of Figure 7 displays an index of the development in the number of family households in Oslo between 2008 and 2021. As we can observe, there is a notable increase in family households living in the inner city in the studied period. In the right panel of Figure 7, we also show the total number of households in the inner city (right axis), outer city and Oslo (left axis), to emphasise that although growth in the number of families in the inner city has been high over the last years, the level of family households is still low, compared to that of the outer city.

The increase in the number of families in the inner city can partially support the hypothesis that the apartment size regulation has had a positive effect on the share of families

[16]This data is downloaded from the municipality of Oslo's web page: https://www.oslo.kommune.no/statistikk/husholdninger/

living in the area. However, we lack access to the data on household types per district prior to the implementation of the regulation and therefore cannot observe the trend path in the preperiod.

Figure 8 Families buying apartments in Oslo, the inner city, and the outer city (2004– 2019). Index: 2008 = 100.



(a) Apartments between 80 and 100 square meters **(b)** Apartments above 100 square meters

Notes: This figure shows an the number of families with children (households with children who are minors) buying apartments in Oslo from 2004 to 2019. The left panel shows an index with 2008 as base year, while the right panel shows the total number of households. The inner city is defined as the four districts covered by the regulation (Gamle Oslo, Grünerløkka, St. Hanshaugen, and Sagene), while the outer city is defined as the remaining 11 districts in Oslo.

Figure 8 displays an index of the number of family *buyers* of the larger apartment sizes in the period 2004-2019 in Oslo, the inner, and the outer city. As we can see, the number of family buyers has more than doubled for the apartments between 80 and 99 square meters both in the inner and outer city. The increase is slightly larger in the inner city. The number of family buyers of apartments above 100 square meters has also increased substantially in the time period. It shows the number of families buying apartments in the inner city was increasing also before the apartment size regulation came into effect.[17]

In summary, there has been an increase in the number of families living in the inner city of Oslo over the period with the apartment size regulation. There has also been an increase in the number of families buying large apartments in the inner city, both before the regulation was implemented and after. These findings provide support to the hypothesis of

[17]The *share* of families buying the apartments in the larger size segment is presented in Figure B.4 in Appendix B. The share of family buyers is unchanged for apartments between 80 and 99 square meters and slightly increases for apartments above 100 square meters.

increased demand from families with children contributing to the price increase of largest apartments in the inner city. We should, however, be careful concluding that the increase in family households is a causal effect of the apartment size regulation, since the total number of households in the inner city has been increasing over this period, not only family households.

7 Conclusion

In this paper, we use transaction- and household-level data and a difference-in-difference framework to empirically investigate the effect of a Norwegian regulation (limiting the construction of small apartments and promoting that of large apartments) on the prices of apartments in the inner city of Oslo, the capital of Norway.

The regulation, introduced in 2008, mandated a minimum apartment size of 40 square meters, with at least 50 percent of newly built apartments required to exceed 80 square meters. In 2013, these restrictions were relaxed to 35 square meters and 40 percent, respectively. The aim of the regulation was to ensure the construction of larger apartments that could accommodate families with children, among other demographic groups.

We demonstrate a significant decline in newly built apartments below the minimum size requirement following the implementation of the regulation, both in the inner city covered by the regulation and the outer city not covered by the regulation. Furthermore, we find that prices of apartments below the minimum requirement has increased significantly by 3.3 percent after the regulation was implemented compared to apartments between 40 and 50 square meters (the control group).

We continue to show that despite an increase in the number of newly built apartments over 80 square meters, their prices rose in the inner city after the regulation was introduced. We show that the number of families living in the inner city increased after the regulation was implemented, as did the number of families buying apartments. This suggests that the positive price effect could be caused by an increase in demand for large apartments from families with children, in line with the intention of the regulation. However, it is important to interpret these results cautiously, as there has been a general increase in households of all

types within the inner city, and the proportion of families remains relatively low compared to the outer city.

With this paper, we contribute to the growing literature investigating the price effects of government regulation of housing supply. The availability of data and the Norwegian policy change in 2008 allow a causal investigation of a particular regulation. Future research on supply-side policy reforms in other countries could provide more information about the external validity of our results.

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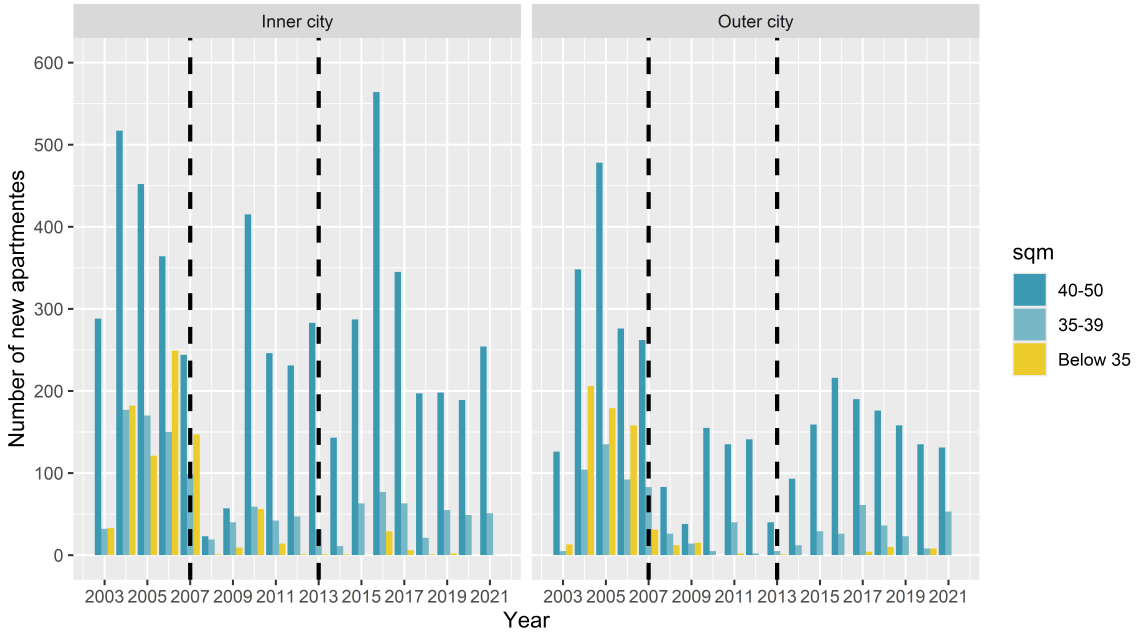
Appendix A: Additional charts and sensitivity price effects

Figure A.1. Number of new apartments by size (2003-2021).



Source: Samfunnsøkonomisk Analyse. **Notes:** The figure shows the number of newly built apartments at the time of sale in Oslo between 2003 and 2021. The inner city is defined as the four districts covered by the regulation (Gamle Oslo, Grünerløkka, St. Hanshaugen, and Sagene), while the outer city is defined as the remaining 11 districts in Oslo.

Table A.1. Estimation results: price effect on apartments below 35 square meters (inner city).

Dependent Variable:	log(sqmprice)				
	(1)	(2)	(3)	(4)	(5)
Variables					
$P^{2008} * I^{35}$	0.030***	0.032***	0.032***	0.032***	0.034***
	(0.011)	(0.007)	(0.007)	(0.007)	(0.007)
I^{35}	0.192***	-0.032***	-0.028***	-0.030***	-0.032***
	(0.011)	(0.011)	(0.010)	(0.011)	(0.012)
square meter		-0.029***	-0.026***	-0.026***	-0.026***
		(0.002)	(0.003)	(0.003)	(0.003)
square meter^2		0.0002***	0.0002***	0.0002***	0.0002***
		(0.000)	(0.000)	(0.000)	(0.000)
unemp				-0.001	-0.002
				(0.001)	(0.001)
I^{35}*unemp				0.0004	0.0008
				(0.001)	(0.001)
Fixed effects					
year	Yes	Yes	Yes	Yes	Yes
age deciles		Yes	Yes	Yes	Yes
quarter		Yes	Yes	Yes	Yes
district			Yes	Yes	Yes
district-year					Yes
Fit statistics					
Observations	12,283	12,283	12,283	12,283	12,283
R^2	0.887	0.916	0.929	0.929	0.930
Within R^2	0.403	0.554	0.571	0.571	0.575

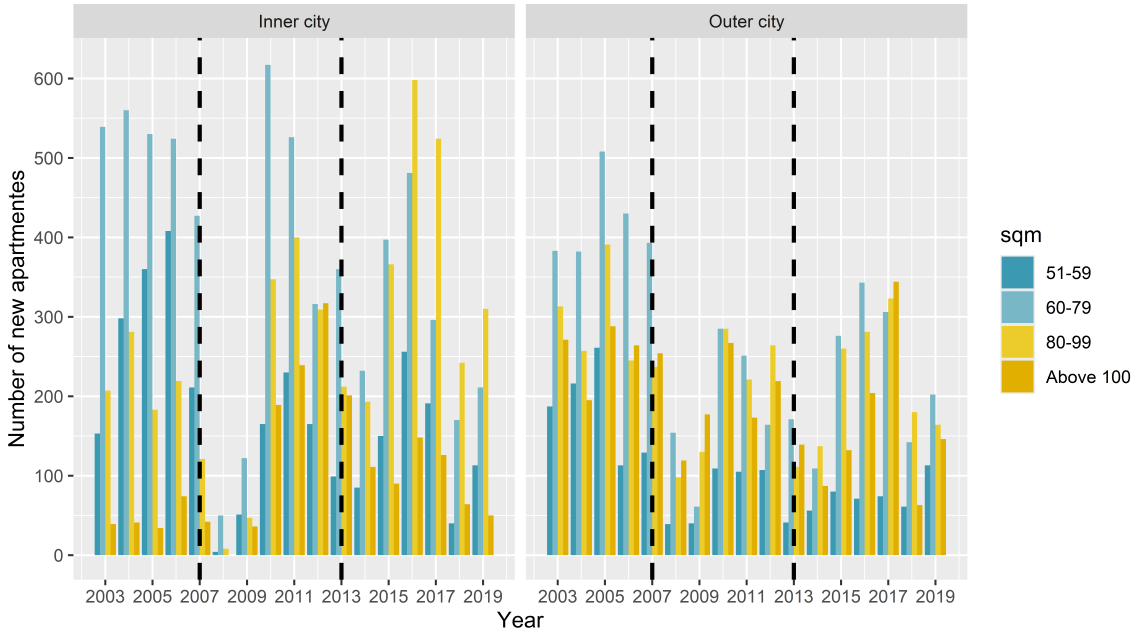
Notes: The table reports the effect of the cap on building apartments below 35 square meters based on a difference-in-difference model (see Equation 1). The treatment group comprises apartments below 35 square meters and the control group is apartments of 40-50 square meters. The time period is 2003-2021. Robust standard errors in parentheses are clustered by a three-digit postal code. Significance levels: * p < .1, ** p < .05, *** p < .01.

Table A.2. Estimation results: price effect on apartments below 35 square meters (outer city).

Dependent Variable:	log(sqmprice)				
	(1)	(2)	(3)	(4)	(5)
Variables					
$P^{2008} * I^{35}$	0.005	0.003	0.035***	0.036***	0.043***
	(0.023)	(0.016)	(0.010)	(0.010)	(0.009)
I^{35}	0.200***	-0.009	-0.002	-0.023	-0.032*
	(0.033)	(0.036)	(0.016)	(0.017)	(0.017)
square meter		-0.020***	-0.008**	-0.008**	-0.009***
		(0.006)	(0.004)	(0.004)	(0.003)
square meter^2		0.000	0.000	0.000	0.000
		(0.000)	(0.000)	(0.000)	(0.000)
unemp				-0.003	-0.003
				(0.002)	(0.002)
I^{35}*unemp				0.006***	0.006***
				(0.002)	(0.002)
Fixed effects					
year	Yes	Yes	Yes	Yes	Yes
age deciles		Yes	Yes	Yes	Yes
quarter		Yes	Yes	Yes	Yes
bid			Yes	Yes	Yes
bid-year					Yes
Fit statistics					
Observations	8,304	8,304	8,304	8,304	8,304
R^2	0.722	0.830	0.928	0.928	0.933
Within R^2	0.190	0.504	0.449	0.450	0.457

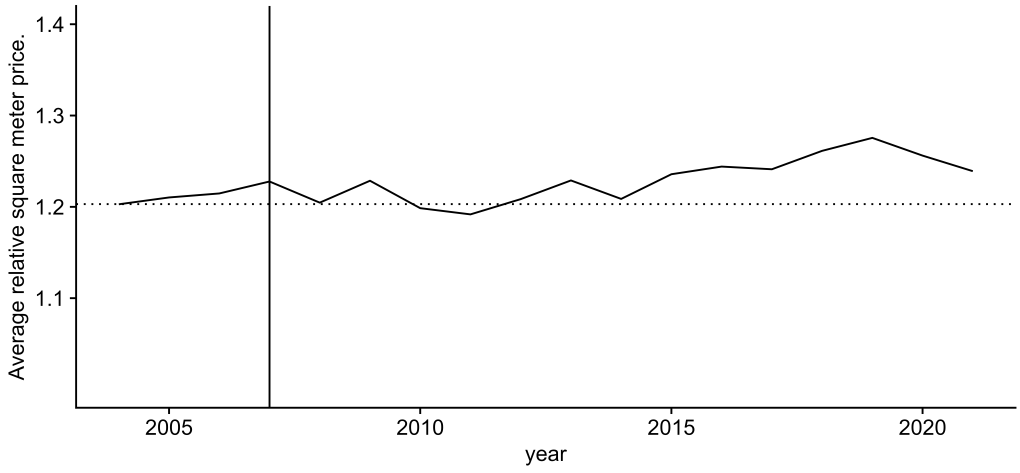
Notes: The table reports the effect of the cap on building apartments below 35 square meters based on a difference-in-difference model (see Equation 1). The treatment group comprises apartments below 35 square meters, and the control group consists of apartments between 40 and 50. The time period is 2003-2021. Robust standard errors in parentheses are clustered by a three-digit postal code. Significance levels: * p < .1, ** p < .05, *** p < .01.

Figure A.2. Number of new apartments by size (2003-2021).



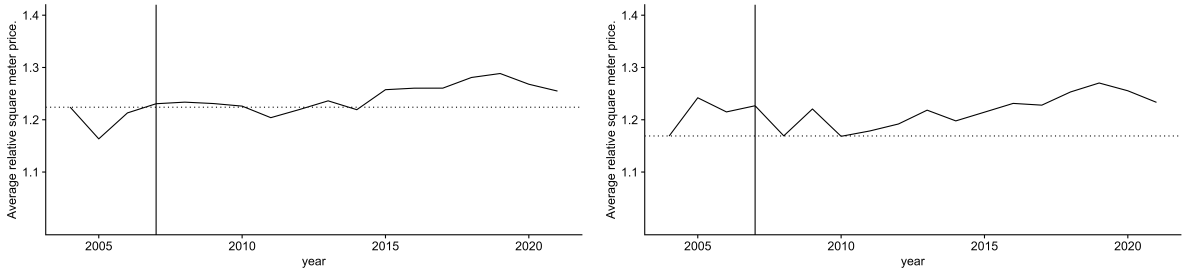
Source: Samfunnsøkonomisk Analyse. **Notes:** The figure shows the number of newly built apartments in Oslo between 2003 and 2021. The inner city is defined as the four districts covered by the regulation (Gamle Oslo, Grünerløkka, St. Hanshaugen, and Sagene), while the outer city is defined as the remaining 11 districts in Oslo.

Figure A.3. Relative square meter prices in Oslo (2004-2021)



Notes: This figure shows relative square meter prices between the treatment (< 35 square meters) and the control (40-50 square meters) size segments for apartments in Oslo from 2004 to 2021. The dotted line shows the starting point for the relative square meter price.

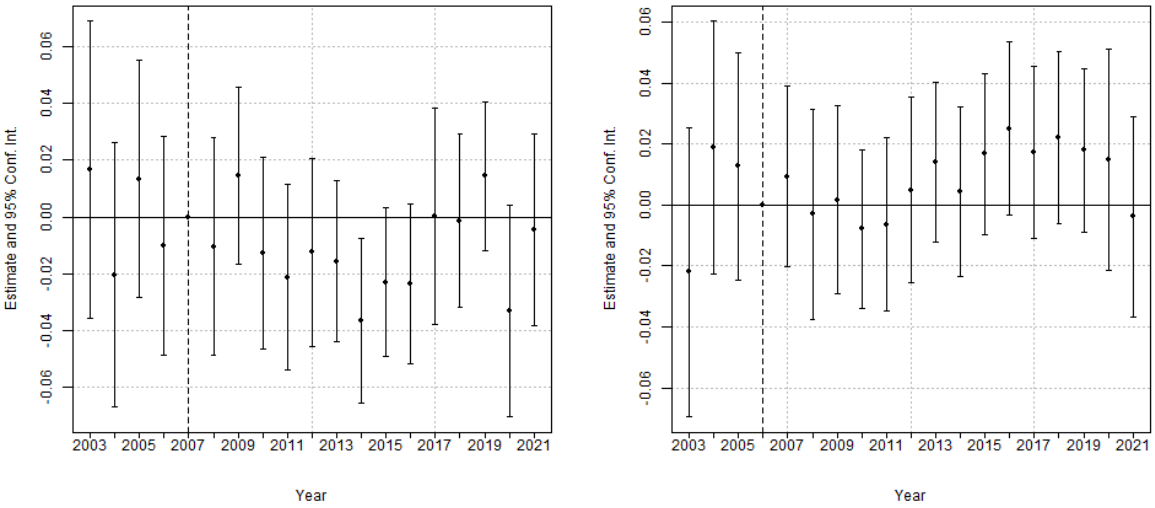
Figure A.4. Relative square meter prices in inner city and outer city (2004-2021).



(a) Inner city (NOK 1000) **(b)** Outer city (NOK 1000)

Notes: This figure shows relative square meter prices between the treatment (< 35 square meters) and the control (40–50 square meters) size segments for apartments in Oslo from 2004 to 2021. The dotted line shows the starting point for the relative square meter price. The inner city is defined as the four districts covered by the norm (Gamle Oslo, Grünerløkka, St. Hanshaugen, and Sagene), while the outer city is defined as the remaining 11 districts in Oslo.

Figure A.5. Dynamic difference-in-difference price effect on placebo sizes, small apartments in Oslo



(a) Treatment group: below 26 square meters. **(b)** Treatment group: 40-44 square meters.

Notes: The figure shows the estimated results of the for the interaction-treated size and annual dummies from Equation 2 for the period 2003-2021. The treatment group is denoted in the caption. In panel (a), the treatment group is set at below 26 square meters, and the control group is set at 26–34. Of the 7365 observations, 1501 of these are 25 square meters and below. In panel (b), the treatment group comprises apartments between 40 and 44 square meters, and the control group consists of apartments between 45 and 50 square meters. Standard errors are clustered by a three-digit postal code.

Table A.3. Estimation results: price effect on small apartments, including interaction-treated apartments between 35 and 39 square meters (Oslo).

Dependent Variable:	log(sqmprice) Oslo
Variables	
$P^{2008} * I^{35}$	0.030***
	(0.006)
I^{35}	-0.026***
	(0.010)
$P^{2008-2013} * I^{35-39}$	-0.004
	(0.004)
I^{35-39}	0.001
	(0.005)
square meter	-0.020***
	(0.002)
square meter^2	0.0001***
	(0.000)
unemp	-0.0004
	(0.001)
I^{35}*unemp	0.002**
	(0.001)
Fixed effects	
age deciles	Yes
district	Yes
quarter	Yes
year	Yes
Fit statistics	
Observations	25,223
R^2	0.927
Within R^2	0.479

Notes: The table reports the price effect of the cap on building apartments below 35 square meters from 2008 and the additional cap on building 35–39-square-meter apartments between 2008 and 2012, based on a difference-in-difference model (see Equation 1). The treatment group comprises apartments below 35 square meters from 2008 to 2021 and 35–39-square-meter apartments between 2008 and 2012. The control group consists of 40–50-square-meter apartments. The time period is 2003-2021. Robust standard errors in parentheses are clustered by a three-digit postal code. Significance levels: * p < .1, ** p < .05, *** p < .01.

Table A.4. Results of Wald parallel-trends test.

Model: Apt. below 35 sqm		H0: Linear trends are parallel pre<2008
Model: Oslo	F(1,1)=	14.56
	Prob >	0.16
Model: Inner city	F(1,1)=	5.17
	Prob >	0.26
Model: Outer city	F(1,1)=	63.84
	Prob >	0.08
Model: Apt. above 79 sqm.		H0: Linear trends are parallel pre<2008
Model: 79 sqm+	F(1,1)=	1719
	Prob >	0.015
Model: 80 - 99 sqm	F(1,1)=	563
	Prob >	0.03
Model: 100 + sqm	F(1,1)=	22.3
	Prob >	0.13

Notes: The table reports the statistics of a Wald test of parallel trends prior to treatment. H0 states that linear trends prior to treatment are parallel. The tests are run with the command estat ptrends after didregress in Stata. The test statistics for the models estimating the effect on apartments under 35 square meters correspond to column 4 in Table 4 and Table 5, while the test statistics for apartments above 79 square meters correspond to Table 6.

Table A.5. Estimation results: placebo sizes.

Dependent Variable:	log(square meter price)		
	(1) T: sqm < 25	(2) T: sqm=40-44	(3) T: sqm= 60-69
Variables			
I^{25}	0.022*		
	(0.013)		
$P^{2008} * I^{25}$	-0.013		
	(0.010)		
I^{40-44}		-0.014	
		(0.010)	
$P^{2008} * I^{40-44}$		0.004	
		(0.007)	
I^{60-69}			0.027***
			(0.009)
$P^{2008} * I^{60-69}$			-0.002
			(0.006)
square meter	-0.011	-0.021	-0.023**
	(0.009)	(0.018)	(0.011)
square meter ^{2}	0.000	0.0001	0.0002**
	(0.0002)	(0.0002)	(0.000)
unemp	-0.0008	-0.0003	-0.006***
	(0.002)	(0.002)	(0.002)
I^{size} *unemp	0.001	-0.0004	-0.0009
	(0.002)	(0.001)	(0.001)
Fixed effects			
age deciles	Yes	Yes	Yes
district	Yes	Yes	Yes
quarter	Yes	Yes	Yes
year	Yes	Yes	Yes
Fit statistics			
Observations	7,365	13,222	30,249
R^2	0.939	0.920	0.884
Within R^2	0.307	0.230	0.193

Notes: The table reports results from Equation 1 for placebo size groups. In the first model, the treatment group is set to below 26 square meters, and the control group is set at 26–34 square meters. Of 7365 observations, 1501 are 25 square meters and below. In model (2), the treatment group comprises 40–44-square-meter apartments, and the control group consists of 45–50-square-meter apartments. In model (3), the treatment group consists of 60–69-square-meter apartments, and the control group comprises 70–79-square-meter apartments. Robust standard errors in parentheses are clustered by a three-digit postal code. Significance levels: * p < .1, ** p < .05, *** p < .01.

Table A.6. Results of Wald parallel-trends test, placebo sizes.

Model: T = below 26 square meters	F(1,1) =	45.2
	Prob >	0.09
Model: T = 40-44 square meters	F(1,1) =	15.4
	Prob >	0.16
Model: T = 60-69 square meters	F(1,1) =	53.2
	Prob >	0.09

Notes: The table reports the statistics of a Wald test of parallel trends prior to treatment. H0 states that linear trends prior to treatment are parallel. The tests are run with the command estat ptrends after didregress in Stata.

Table A.7. Estimation results: placebo cities. Price effect on apartments below 35 square meters

Dependent Variable:	log(sqmprice)			
	(Bergen)	(Trondheim)	(Bærum)	(Lillestrøm)
Variables				
$P^{2008} * I^{35}$	-0.027**	-0.014	0.035	0.004
	(0.010)	(0.015)	(0.025)	(0.044)
I^{35}	-0.004	0.017	-0.028	0.063
	(0.021)	(0.022)	(0.070)	(0.041)
square meter	-0.012***	-0.012	-0.024	-0.0002
	(0.004)	(0.008)	(0.016)	(0.003)
square meter^2	0.000	0.000	0.0002	0.000
	(0.000)	(0.000)	(0.0002)	(0.000)
unemp	-0.011***	0.002	0.002	
	(0.004)	(0.006)	(0.005)	
I^{35}*unemp	0.006*	-0.002	0.019	
	(0.003)	(0.004)	(0.009)	
Fixed effects				
age deciles	Yes	Yes	Yes	Yes
district	Yes	Yes	Yes	Yes
quarter	Yes	Yes	Yes	Yes
year	Yes	Yes	Yes	Yes
Fit statistics				
Observations	4,730	4,410	1,070	998
R^2	0.837	0.845	0.952	0.928
Within R^2	0.424	0.455	0.378	0.434

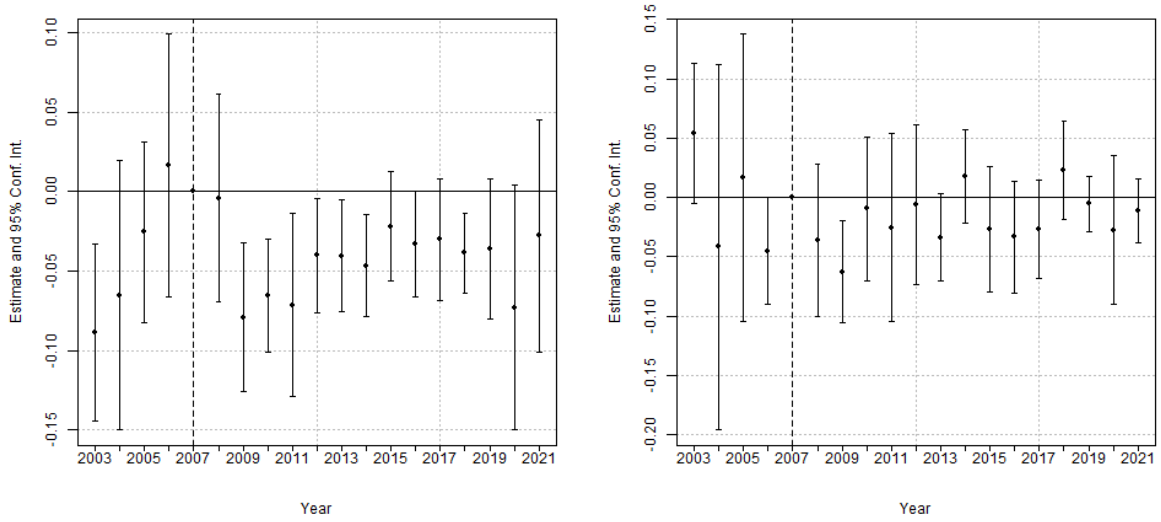
Notes: The table reports results from estimations using Equation 1 in placebo cities Bergen, Trondheim, Bærum, and Lillestrøm. Treatment group = 35 square meters, control group = 40–50 square meters. For Bergen, H0 of parallel trends prior to treatment can be rejected at the 5 percent level. Unemployment rates are not available for Lillestrøm since the municipality was established in 2020. The time period is 2003-2021. Robust standard errors in parentheses are clustered by a three-digit postal code. Significance levels: * p < .1, ** p < .05, *** p < .01.

Table A.8. Results of Wald parallel-trends test: placebo cities.

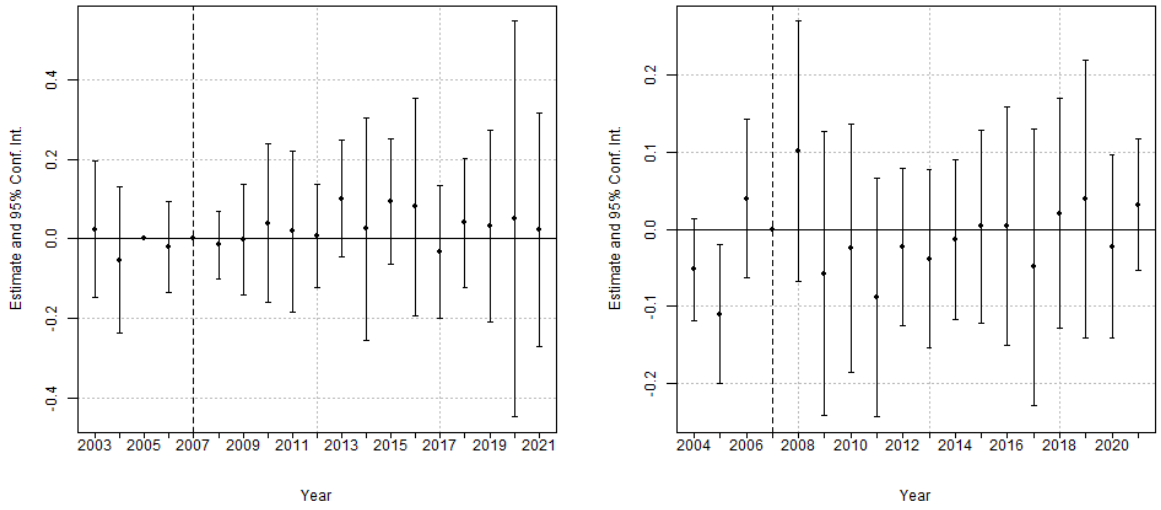
Mod. placebo Bergen	F(1,1)=	11120.9
	Prob >	0.00
Mod placebo Trondheim	F(1,1)=	62.0
	Prob >	0.08
Mod placebo Bærum	F(1,1)=	198.4
	Prob >	0.05
Mod placebo Lillestrøm	F(1,1)=	135423.5
	Prob >	0.00

Notes: The table reports the statistics of a Wald test of parallel trends prior to treatment. H0 states that linear trends prior to treatment are parallel. The tests are run with the command estat ptrends after didregress in Stata.

Figure A.6. Dynamic difference-in-difference price effect on placebo cities.



(a) Bergen **(b)** Trondheim

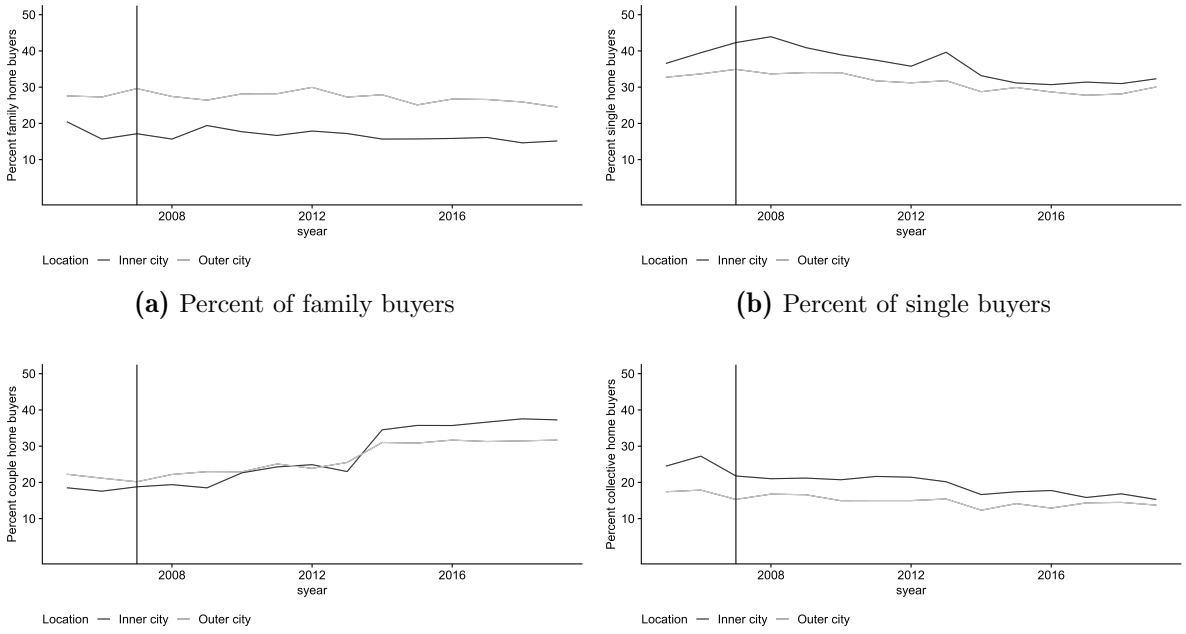


(c) Bærum **(d)** Lillestrøm

Notes: The figure shows the estimated results for the interaction-treated size and annual dummies from Equation 2 for the period 2003-2021 for placebo cities Bergen, Trondheim, Bærum, and Lillestrøm. The placebo city is denoted in the caption. Standard errors are clustered by a three-digit postal code.

Appendix B: Additional charts apartment buyers

Figure B.1. Apartment buyers in Oslo (2004-2019). Type of household.



(a) Percent of family buyers

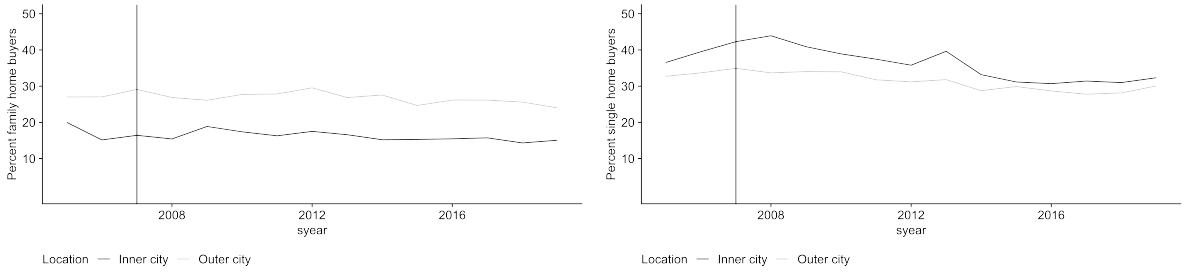
(b) Percent of single buyers

(c) Percent of couple buyers

(d) Percent of multiperson buyers

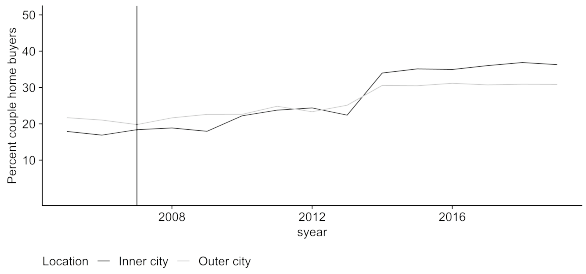
Notes: The figure shows the annual percentages of apartments bought by families, single households, multiperson households, and couples without children in Oslo from 2004 to 2019. The inner city is defined as the four districts covered by the regulation (Gamle Oslo, Grünerløkka, St. Hanshaugen, and Sagene), while the outer city is defined as the remaining 11 districts in Oslo.

Figure B.2. Apartment buyers in Oslo (2004-2019) excluding households co-buying with parents.

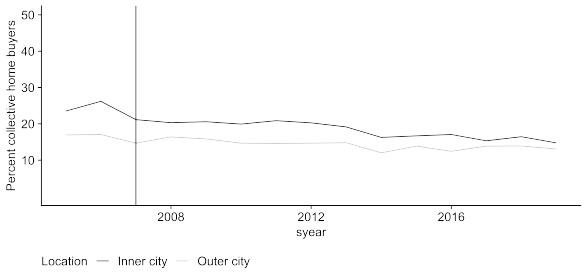


(a) Percent of family buyers

(b) Percent of single buyers



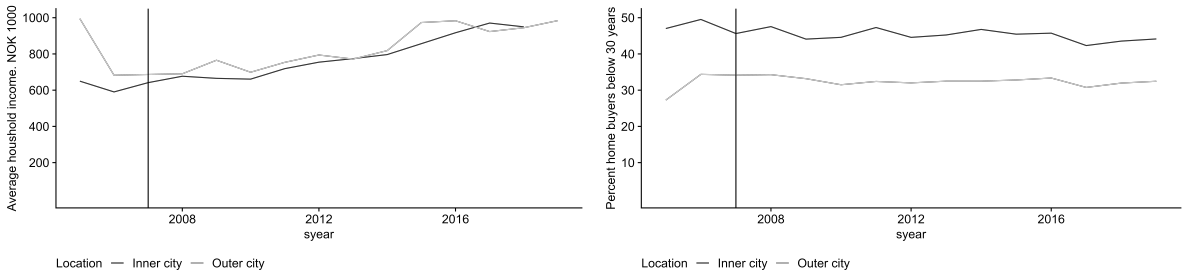
(c) Percent of couple buyers



(d) Percent of multiperson buyers

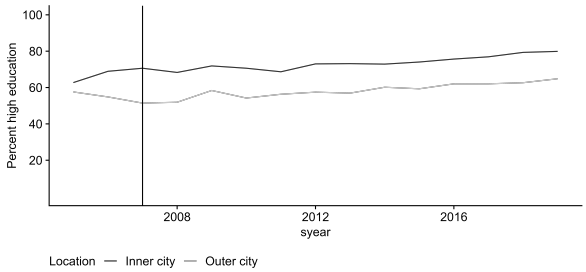
Notes: The figure shows the annual percentages of apartments that are bought by families, single households, multiperson households, and couples without children in Oslo from 2004 to 2019. Households in which the age difference between the buyers is more than 20 years are assumed to be households buying together with a parent and are excluded from the dataset. The inner city is defined as the four districts covered by the regulation (Gamle Oslo, Grünerløkka, St. Hanshaugen, and Sagene), while the outer city is defined as the remaining 11 districts in Oslo.

Figure B.3. Apartment buyers in Oslo (2004-2019), income, education and age.

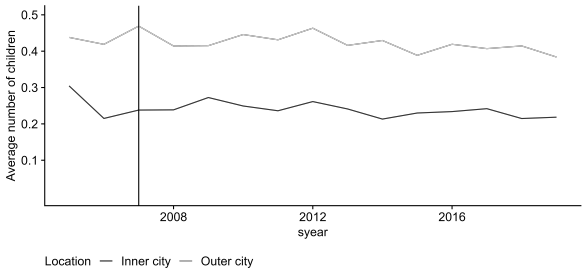


(a) Household income. NOK 1000.

(b) Percent of households below 30 years



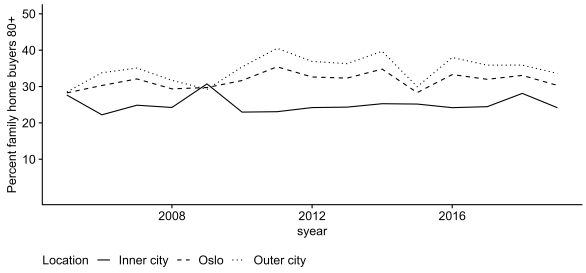
(c) Percent of households with high education



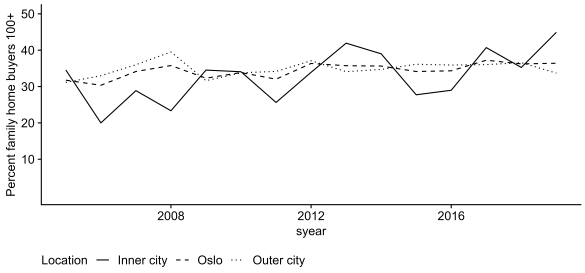
(d) Average number of children

Notes: The inner city is defined as the four districts covered by the norm (Gamle Oslo, Grünerløkka, St. Hanshaugen, and Sagene), while the outer city is defined as the remaining 11 districts in Oslo.

Figure B.4. Percent of transactions bought by families (2004-2019).



(a) Apartments between 80 and 100 square meters



(b) Apartments over 100 square meters

Notes: This figure shows the shares of transactions made by families with children (households with children who were minors) in Oslo from 2004 to 2019. The inner city is defined as the four districts covered by the regulation (Gamle Oslo, Grünerløkka, St. Hanshaugen, and Sagene), while the outer city is defined as the remaining 11 districts in Oslo.

Acknowledgements:
Housing Lab is partly funded by the Norwegian Ministry of Finance and the Norwegian Ministry of Modernisation and Municipalities. Housing Lab also receives financial support from OBOS, Krogsveen and Sparebank1-Gruppen. We are greatful for the financial support. All views expressed in our papers are the sole responsibility of Housing Lab, and do not necessarily represent the views of our sponsors.

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ISSN: 2703-786X (Online)

OSLOMET

HOUSING LAB
Nasjonalt senter for boligmarkedsforskning