Airbnb or Not Airbnb? That is the Question: How Airbnb Bans Disrupt Rental Markets

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Abstract

This study focuses on legislative bans imposed on short-term rentals and evaluates their effects on long-term rentals in Irvine, CA. We find that a legislative ban on short-term rentals reduces contract rental prices in the long-term rental market by 2.7% while the number of long-term rental units increases. The results are primarily driven by the supply side relative to the demand side for long-term rentals. The decline in rents is more pronounced: 1) for long-term rental units that have similar property characteristics as those listed through Airbnb, and 2) for those located in geographic areas with greater Airbnb exposure before the ban was enacted.

Keywords: Airbnb; Rental Listings; Rental Contracts; Rental Prices; Shared Economy; Short-term Rentals; Short-term Rental Policies

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1. Introduction

In recent decades, short-term housing rental platforms (such as Airbnb) became one of the fastest growing businesses. Their success is based on providing a convenient service for travelers, especially larger travel groups, to find a private place to stay. Despite the many benefits that short-term rentals (STRs) provide, they also are harshly criticized by the hotel industry, local residents, and policy makers. In that regard, STRs are often accused of contributing to an affordability crisis in real estate markets. One reason is that STRs cause homeowners to convert long-term rentals to short-term rentals, resulting in a shortage in the long-term rental market and a higher growth of rents. Consequently, cities worldwide have begun regulating STR platforms by either setting restrictions on their activities or completely banning all STRs. The effects of STR regulations on the real estate market can be ambiguous (as will be explained later). As a result, STR regulations have raised different viewpoints and opinions so more insight is desired on this politically charged topic.

Our study aims to provide further empirical insight into the effects of STR regulations on the long-term rental market, that is, the availability of rental units and rental prices. We focus on Airbnb since the company is the leader in the STR platform market with a presence in over 100,000 cities across 220 countries, generating more than $150 billion in annual revenues.[1]

The evaluation of Airbnb activity on the long-term rental market is beset with several difficulties. Most importantly, Airbnb activity is an endogenous decision made by landlords, and this decision is dependent on rental prices and other unobserved (to the econometrician) variables that affect rental prices. To address this endogeneity problem, previous studies usually use an instrumental variable approach. Appropriate instrumental variables, however, are difficult to find, so our study takes a different route. We identify the Airbnb activity effect by taking advantage of an exogenous ordinance policy that was adopted by municipalities to prohibit Airbnb activities. It is important to note that there exist different types of Airbnb

[1]See https://news.airbnb.com/about-us/ in March, 2022. Other prominent STR platforms are Vrbo and HomeAway. From now onward, we use STR and Airbnb interchangeably.

ordinances and most municipalities do not strictly enforce these ordinances so they are often ignored by landlords. For this reason, we focus on a very particular Airbnb ordinance that was enacted in Irvine (CA). Irvine is one of a very few cities that strictly enforce STR regulation, and it entirely prohibits Airbnb activities in residential zoning areas.[2] As will be explained in Section 2.1, Irvine assigned extra resources to enforce these regulations and the city cooperates with a leading PropTech company for monitoring and detecting violations. The strict enforcement of the Airbnb ban in Irvine serves as an appropriate identification tool that is novel in the literature and enables us to causally identify the effect of Airbnb activity on long-term rental prices.[3]

A further challenge with measuring the effect of Airbnb on rental prices is data availability. Previous studies had to rely on the *posted asking* long-term rental prices. Our study uses information on the *actual contracted* long-term rental prices.[4] Information on actual contracted rental prices is rare in the extant literature. It is important to recognize that the asking rent is quite different to the contract rent. The actual contracted long-term rental prices reflect equilibrium prices. In contrast, the posted asking long-term rental prices are higher than the actual contracted long-term rental prices. They relate to any realizations on the supply curve for long-term rentals that are located on and above the equilibrium long-term rents. Therefore, the posted numbers exceed the actual numbers and do not properly capture changes in rental prices due to STR ordinances.[5] This data limitation can cause serious inaccuracy implications on the measurement of the effects of STR ordinances and would likely result in underestimated effects on long-term rental prices. In fact, Haurin et al. (2013) and Thanos and White (2014) mention that the asking price is more rigid downwards and less sensitive

[2]Note that the Airbnb ban is applicable to properties in the residential zoning districts while Airbnb listings were still allowed in the commercial zoning districts. We refer to this as "residential" Airbnb ban.

[3]A further advantage to focusing on Irvine is that it is one of the most well-known "master-planned" cities in the U.S., which implies fairly homogeneous neighborhoods. This uniformity across the town reduces concerns about omitted variable bias stemming from unobserved neighborhood-level and property-level characteristics.

[4]We use posted rent, listed rent and asking rent interchangeably, as we do actual rent, realized rent, and contract rent.

[5]In our data, posted asking long-term rental prices are about 7% higher than the actual contracted long-term rental prices.

to market supply and demand, and as such, using asking rents instead of contract rents may weaken regulation effects.[6] The use of realized information opposed to posted information enables us to evaluate the ultimate effect on prices in the rental markets.

Finally, our study uses detailed rental information at the property-level in Irvine. The property-level information on rentals allows us to evaluate heterogeneous effects of STR ordinances and therefore enables us to identify which types of housing units have been affected to larger or smaller extents, and further identify which group of landlords suffer more due to STR regulations.

Our difference-in-difference estimation results show that the number of Airbnb listings declined by 23.1% after the STR ordinance in Irvine compared with control cities.[7] This result confirms that the residential Airbnb ban was effective and had a drastic impact on Airbnb activities. We further find the STR ordinance leads to the decline in contractual rental price by 2.7%, on average, which amounts to $101 relative to the mean value. Given that there are 58,998 renter-occupied units in Irvine as of 2019, that sums up to a reduction of $72M in annual total rental spending.[8] The finding that the Airbnb ban eventually increases both the equilibrium number of long-term rentals completed in the market and the number of long-term rental supply provides evidence that the Airbnb ban has a stronger impact on the rental supply side (reallocation of properties from the short-term to the long-term rental market) compared with the rental demand side (that results from employment losses caused by exits of STR platforms). Furthermore, the rental price reduction is especially pronounced for properties that share similar characteristics compared with Airbnb listings. Specifically, rentals of larger size, higher quality, and with more bedrooms experience larger declines in rental prices. Since those kinds of rentals are more likely to be owned by wealthy landlords, the regulation of Airbnb activities acts like a "rental tax" on wealthy landlords and may help

[6]Supported by this argument, we find the STR ordinance only has a significant effect on the contract rent and a minor effect on the asking rent.

[7]Note that the remaining Airbnb listings that are still active in the market place relate to listings in the commercial zone districts that are not the target of the (residential) Airbnb ban in Irvine.

[8]https://www.populationu.com/cities/irvine-ca-population.

reduce wealth inequality. Lastly, rental properties located in areas with a higher share of pre-existing Airbnb listings are affected more severely and experience stronger price reductions.

Our study contributes to several strands of literature. First, it contributes to the impact of STRs in housing markets. A large number of studies show that Airbnb entry has an impact on home sale prices.[9] Only few studies concentrate on the effect of Airbnb on the property-level rental prices. For example, Horn and Merante (2017) find that the presence of Airbnb raises asking rental prices in Boston. Duso et al. (2021) and Gauß et al. (2022) study Airbnb regulations in Berlin, Germany, though Gauß et al. (2022) also include Munich and Hamburg. Their results are mixed, while Duso et al. (2021) find that Airbnb regulation decreases rental prices, Gauß et al. (2022) document there is no such effect. Our study differs from previous studies in that previous studies use listed (inferior) asking rents while our study uses actual (contract) rental prices, which allows us to evaluate the effect of the Airbnb ban on equilibrium prices. This distinction is crucial since asking rental prices are more rigid downward relative to the contract rents, see Haurin et al. (2013) and Thanos and White (2014). We find the regulation on Airbnb activities only has a non-trivial effect on the contract rent, rather than the asking rent. Our study, therefore, contributes to existing literature that finds mixed results.

Several studies use an instrumental variable approach to overcome endogeneity issues related to Airbnb activity. They find that Airbnb activities increase rents (see, for example, Garcia-López et al. (2020), Barron, Kung, and Proserpio (2021), and Franco and Santos (2021), and Li, Kim, and Srinivasan (2022)). Our study applies a different approach for identification and builds on an exogenous STR ordinance, which accounts for potential endogeneity and allows for identifying causal effects. In this regard, we capitalize on an Airbnb ban that was strictly enforced by the municipality in Irvine (CA) due to extra resources and monitoring enforcement applications. Note, previous studies (for example, Duso et al. (2021)

[9]See, for example, Sheppard and Udell (2016), van Holm (2020), Barron, Kung, and Proserpio (2021), Koster, Van Ommeren and Volkhausen (2021), Valentin (2021), Franco and Santos (2021), Chen, Wei, and Xie (2022), and Garcia, Miller and Morehouse (2022).

and Gauß et al. (2022)) that consider the effect of STR ordinances on rental markets focus on municipalities that do not strictly enforce these laws. For example, Gauß et al. (2022) document that there is substantial non-compliance with regulations, and Cox and Haar (2020) indicate that 80% of Airbnb listings in Berlin do not have a registration number even it is required by law.[10]

This study is organized as follows. Section 2 introduces the institutional background of STR ordinances and discusses their potential effects on the rental market. Section 3 introduces the data sources and data descriptives. Section 4 reports the empirical models and results. We conclude in Section 5.

2. STR Ordinances: Institutional Background and Discussion of Effects

2.1. STR Ordinances: Institutional Background

STR ordinances can be distinguished between restrictions and complete bans. Most major cities in Europe, including Amsterdam, Berlin, London and Paris as well as some cities in the U.S. (including San Francisco, Philadelphia and Nashville) restrict the use of STR platforms using either night-caps (the maximum number of nights each residential property is allowed to be rented out for STR use) or units-caps (the maximum number of residential units allowed to be rented out for STR use). Some cities, such as New Orleans (partial), Santa Monica, Fort Lee, and Barcelona, fall into this second category as these cities banned STR completely to ease the pressure of tourism and to encourage affordable housing. Irvine is also classified into the second category.

The enforcement of STR regulations is expensive and time-consuming, and municipalities

[10]The registration number became a requirement in Berlin after August 2018.

have limited resources and time to spend on door knocking properties for STR detection (see Leshinsky and Schatz (2018)). As such, Airbnb hosts often ignore city rules due to lack of enforcement. This is confirmed by cities such as New York, in which 85% of active listings are illegal (see Cox and Haar (2020)). Another example is New Orleans. The study by van Holm (2020) finds the reduction in STR was only temporary following regulation and that growth in STRs resumed quickly after a one-time decline. City officials acknowledge that New Orleans simply does not have the resources to enforce Airbnb rules.[11] The number of documented violations of Airbnb rules have also been widely covered by social media.[12]

Unlike other cities, Irvine began assigning resources to enforce regulations after observing gross violations of Airbnb restrictions. The most innovative feature of the regulation is that Irvine is working with Host Compliance, a leading PropTech company specializing in monitoring and enforcement solutions, to help identify short-term rentals operating illegally in local neighborhoods.

The Irvine City Council has passed three Irvine Zoning Ordinances to address the negative effect of STR and to completely ban STR.[13] The City Council adopted its first STR ordinance, Chapter 3-25 titled "Short term rentals", in the Irvine Zoning Code to regulate the growth of STR within the city in April 2018. Chapter 3-25 contains six sub-chapters, of which the third sub-chapter, Chapter 3-25-3, states that short-term rentals and the advertisement of short-term rentals are prohibited in any residential zoning district.

Although Irvine completely banned STR, the city initially failed to enforce the rules in the following months, and the lucrative nature of the home-rental business continued, resulting

[11] https://www.nytimes.com/2016/03/06/business/airbnb-pits-neighbor-against-neighbor-in-tourist-friendly-new-orleans.html

[12] https://mv-voice.com/news/2020/01/03/airbnb-hosts-ignore-city-rules;
https://www.azcentral.com/story/news/local/scottsdale/2019/04/09/scottsdale-enforcing-its-occupancy-rules-airbnb-short-term-rentals/3334790002/;
https://www.salon.com/2017/06/30/how-the-berlin-government-could-rein-in-airbnb-and-protect-local-housing$_p artner/$

[13] Detailed information on STR regulations in Irvine can be found in the City municipal code at https://library.municode.com/ca/irvine/codes/zoning?nodeId=ZOOR$_D IV3GEDESTLAUSRE_C H3 - 25SHTERE$.

in a significant number of properties in the city being advertised and operated as short-term rentals. Appendix Figure 1 depicts the number of active Airbnb listings in Irvine by each month from July 2017 to March 2022, revealing no persistent decrease in the number of STR after April 2018.

Due to growing concerns about negative externalities, and in response to increasing residential complaints regarding STR, the City Council held a public hearing to develop a proactive enforcement strategy for STR regulations in March 2019.[14] After the public hearing, the Irvine City Council began to direct a more proactive enforcement strategy, identifying and enforcing restrictions on short-term rental listings within the city. For example, in April 2019, the City Council directed staff to take a proactive approach to STR enforcement. The most innovative feature of regulation enforcement is that the city hired Host Compliance, a PropTech company to identify STR listings in May 2019. Shortly after, in August 2019, the city passed the second ordinance to amend the zoning code by re-emphasizing the prohibition of STR. As shown in Appendix Figure 1, since the passage of the second ordinance in August 2019, there has been a persist and significant drop in the number of active STR listings. By January 2021, listings declined by almost 50 percent.

In January 2021, Irvine took further steps to regulate the STR and it added Chapter 3-25-7 titled "Hosting platforms shall not complete booking transactions". The city placed the responsibility on the online platforms such as Airbnb, HomeAway and Vrbo to not complete any STR bookings and required these platforms to verify that a listing within the city of Irvine is not for a STR. We observe a further drop in STR listings after the third ordinance was adopted after January 2021, see Figure 1. Considering the enforcement timing of ordinances, we choose the implementation date of the second ordinance, August 2019, as the event date throughout the paper for the empirical study.

[Insert Appendix Figure 1]

[14] https://irvinewatchdog.org/2019/03/11/public-hearing-on-boarding-houses-short-term-rentals/

2.2. STR Ordinances: Discussion of Effects

The effect of STR bans on the long-term rental market is determined by several forces: First, STR regulations may force landlords to switch from supplying the STR market to supplying the market for long-term rentals. This increases the supply of long-term rentals and leads to an increase in the number of rental units and a reduction in rental price, see Appendix Figure 2(A).

Second, STR regulations may help eliminate disamenities associated with STRs such as a higher turnover of unfamiliar people in their neighborhood increased noise levels, reduction in safety perception, crowding, littering, and so forth. (see Filippas and Horton (2022)). As such, we may expect that the ban implies higher willingness to pay and an outward demand shift for rental units. This would increase the number of rental units and rental prices, see Appendix Figure 2(B).

Third, STR regulations can affect the local job market. For example, Xu and Xu (2021) and Hidalgo, Riccaboni, and Velazquez (2022) document that the entry of STR platforms create job opportunities, spur business growth and increase the local employment rate especially in complementary local business areas such as bars, and restaurants. Therefore, an STR ordinance may cause some workers to lose their jobs and move out of the city, which reduces demand and prices in the long-term rental market, see Appendix Figure 2(C).

In sum, we conjecture that strictly enforced STR regulations can ambiguously affect equilibrium rental price and units rented; it is therefore ultimately an empirical question. Since we are in possession of the actual number of rental units and the actual (contractual) rental prices, we are able to measure the net effect of STR regulations on equilibrium outcomes in the rental market.

[Insert Appendix Figure 2]

3. Data Sources and Data Descriptives

3.1. Data Sources

To estimate and evaluate the effectiveness of STR ordinances on housing rental markets, our study relies on three datasets: the residential rental listing dataset, the Airbnb listing dataset, and a U.S. census dataset.

Rental Listing Data

We obtain property-level residential rental listing data from the Multiple Listing Service (MLS) provided by CoreLogic. The database is based on property information that is entered by local agents into their board's MLS system. The rental listing information includes list date and asking rent (listing price), and, if the listing is closed, closing date and contract rent (closing prices), and home attributes including the property type (i.e., single-family houses, townhouses, condominiums), house size, number of bedrooms, number of bathrooms, number of garages, property age based on the close date and year built, and geographic location.

The rental listing data in our paper has several advantages over previous studies. First, we use property-level rental listings rather than rental information at the aggregated ZIP code level, which allows us to conduct the analysis on rents at a more granular (i.e., property) level.[15] Second, rather than using asking rents (as is frequently used in other studies), we use contract rents in the analysis, which enables us to use an appropriate reflection of the equilibrium-level market rental rate. Third, we observe both the number of rental listings (a variety of observations along the supply and above the equilibrium rental price) and the number of equilibrium rental contracts (an outcome measure of rental quantity demanded in the market that is constituted by the equilibrium outcome of supply and demand of rental units). Observing the number of rental contracts allows us evaluate the effect of STR regulation on

[15] Chen, Wei, and Xie (2022) and Koster, Van Ommeren, and Volkhausen (2021) use rental price index at the ZIP code level from Zillow.

equilibrium outcomes.

We consider rentals in Irvine as the treated sample and its neighboring cities as a control sample see, Appendix Figure 3.[16] We limit the sample period from August 1, 2018, through March 31, 2021 (that is, one year before the policy was enacted and up to the most recent date that we observed in our dataset). Furthermore, we remove rental listings with missing rents or rents smaller than $1,000 to exclude rentals that are likely to have erroneous inputs. Also, physical characteristics such as house size are winsorized at the 1% and 99% levels to reduce the influence of outliers. Lastly, we establish measurements at the rental market-level by aggregating the number of rental listings and rental contracts for every month at the ZIP code level.

[Insert Appendix Figure 3]

Airbnb Listing Data

The Airbnb listing data are obtained from AirDNA, a data analytics company. AirDNA scrapes every Airbnb listing from Airbnb.com. We observe for each day the listings' active booking status, prices, number of reservations, as well as monthly performance information in terms of booked days and generated revenue. The dataset also contains property-level characteristics, like number of bedrooms or bathrooms, property type (house, apartment, condominium, etc.), listing type (entire home, private room, and shared room) and location.

Following Bekkerman et al. (2022), we derive a measure of overall Airbnb supply based on the Airbnb activities at the ZIP code-level in Irvine and its neighboring cities, and count the number of active Airbnb listings by month.[17]

Figure 1 shows changes in the number of active Airbnb listings over time.[18] Before the

[16] These include Tustin, Santa Ana, Costa Mesa, Laguna Woods, Laguna Hills as well as Newport Beach. Since Lake Forest prohibits STR, we do not include Lake Forest to ensure the cities in our control group have never been treated.

[17] For confidentiality purposes, Airbnb.com does not provide the exact address of the listings but shifts the latitude and longitude by up to a few hundred meters. Consequently, ZIP codes are the lowest level of geography provided by AirDNA upon which we can rely.

[18] We normalize the number of active Airbnb listings at August 2019 to 100 for ease of comparison.

implementation of the STR ordinance took place in August 2019, we observe a parallel trend between the number of Airbnb listings in Irvine and the control cities. However, the trend diverges after the regulation. The number of active listings in Irvine experienced a one-time greater drop compared to the listings from control cities and it never bounces back, though there is a common declining trend. Note, the reason that the Airbnb listings do not drop to zero is explained by the fact that the regulation only applies to listings in residential zoning districts.

[Insert Figure 1]

Census Data

To control for neighborhood conditions, we leverage the demographic characteristics (including total population, population density, median age, ratio of Caucasians, education level and employment rate), economics characteristics (including median household income, per capita income (PCI), and poverty rate), and housing characteristics (including total housing units, occupied ratio, median housing price) at the ZIP code-level from American Community Survey (ACS) complied by the U.S. Census. The sample period is 2018, 2019, and 2020.

3.2. Data Descriptives

Our final sample contains 11,608 closed rental listings in Irvine (CA) and its neighboring cities. Table 1 presents the summary statistics of key variables used in our study. The median contract rent in our sample is $3,400. On average, a typical property has 1,833 square feet, 3 bedrooms, 3 bathrooms, 2 garages, and is 27 years old.

Table 1 also shows neighborhood characteristics that we categorize into three groups: 1) Regarding demographic characteristics, on average, the population is 5,549 per square mile, 58.9% are college educated (bachelor's degree or higher), and 95.66% of the population is employed. 2) For economic characteristics, the median household income is $106,617, and 10.81% of the population is under the poverty line. 3) In terms of housing characteristics,

92.13% of the 14,953 housing units are occupied, of which half are owner-occupied. And the median housing price is $924,790. We also report the number of rental listings from MLS and Airbnb listings from AirDNA aggregated at the ZIP code-level by month. On average, there are 24 rental listings posted on the MLS each month at each ZIP code, of which 14 listings are closed. Regarding Airbnb activities, 136 Airbnb listings are on the market, of which 101 are booked. Airbnb brings, on average, $438,102 in revenue, and 1,471 reservation days each month for each ZIP code.

[Insert Table 1]

4. Empirical Models and Results

4.1. Impact of STR Ordinance

STR Ordinance on Airbnb Activities

The STR regulation in Irvine represents a quasi-experiment that shifts rental usage in the neighborhood, and we can thus use the policy-induced changes to Airbnb as an exogenous shock to study the impact of STR on rental markets. However, as documented in the literature, many cities fail to enforce STR ordinances, and if this also applies to Irvine, we may not be able to use an STR ordinance as an exogenous shock to study the Airbnb effect. Therefore, we begin our empirical analysis with validating the effectiveness of STR regulations and determine if Airbnb activities are indeed restricted following the implementation of the STR ordinance in Irvine. We consider the following difference-in-difference regression (DID):

$$Airbnb\ Activities_{z,t} = \alpha + \beta \times Treated_z * Post_t + \gamma_z + \mu_t + \epsilon_{z,t}. \quad (1)$$

As shown in equation (1), the observation unit is the ZIP code (z)-time (t) level. Our main measurement of Airbnb activities is the natural logarithm of the number of active Airbnb

listings at ZIP code z and time t since it directly measures the supply side of Airbnb. We also replace this main variable with the total the number of booked listings, total revenue generated from Airbnb operations as well as total the number of reversed days for robustness checks. The dummy variable $Treated_z$ equals 1 for a ZIP code in Irvine, and 0 otherwise. The dummy variable $Post_t$ equals 1 if the lease is signed after August 2019, and 0 otherwise. The coefficient on the interaction term, β, measures the average impact of the STR ordinance on Airbnb activities in Irvine relative to the control group. We also control for ZIP code (γ_z) and year-month fixed effects (μ_t) to eliminate location-specific and time-specific confounding factors. Standard errors are clustered at the ZIP code level.

To provide visual evidence of differences in Airbnb activities between treated and control cities over time, and to confirm that the Airbnb activities are similar prior to the event date in both groups, we add different leads/lags and estimate the time-disaggregated treatment effects for each month of data both pre- and post-implementation:

$$Airbnb\ Activities_{z,t} = \alpha + \beta_t \sum (Treated_z \times Post_t) + \gamma_z + \mu_t + \epsilon_{z,t}, \tag{2}$$

where our base month is August 2019, $t = -1$ indicates one month prior to the STR regulation date, $t = 1$ indicates one month after the treatment occurs, and so forth. The coefficients on the interaction terms, β_t, capture differences between the treated and control groups from one year before the event date to two and half years after. This allows us to not only check our assumption of a parallel trend between the two groups before the event, but also to track the dynamic path of the effect of the STR regulation on Airbnb activities over time.

Before getting to the main results, we want to validate the parallel trend assumption. We plot changes in the number of active Airbnb listings over time for the treatment and control groups in Figure 2 Panel A, after controlling for ZIP code fixed effects and year-month fixed effects. The number of active Airbnb listings is shown in natural logarithm form and

normalized at the event time. We observe that the number of active listings in the treatment group and control ZIP codes evolved in a similar pattern, and there are no differential trends in the pre-treatment period between groups. This provides strong evidence in support of the parallel trend assumption. The two groups diverged after the event, and the treated group exhibits a significantly decreasing trend. The fact that the trend only diverges after the regulation has been enacted provides evidence that the STR ordinance may cause such change.

To formalize this observation, Column (1) of Table 2 reports the estimation result of how the STR ordinance affects the number of active Airbnb listings. We find the coefficient of the interaction term, -0.231, to be highly statistically significant. The regression result indicates that the number of active listings in Irvine decreases by 23.1% compared to the control group after the STR ordinance. This means the STR ordinance has a non-trivial effect on the supply of Airbnb.

Figure 2 Panel B plots the estimated coefficient β_t with the corresponding confidence intervals from equation (2). The non-significant coefficients prior to the event again validate our parallel trend assumption. The significant and negative impact of the STR ordinance on Airbnb supply only appears after Irvine enforced its regulations.

Although a reduction in the number of active listings suggests fewer units are offered by hosts, this decline in supply may result from stale listings, where properties are listed on Airbnb but for which the hosts have no intention of renting for a certain period. Therefore, we also estimate the policy impact on three other measures of Airbnb activities that reflect the market equilibrium. Table 2, Columns (2) to (4), shows that the number of booked listings, total generated revenue as well as total reservation days experience a 35%-37% drop in treated ZIP codes compared with control groups following the policy shocks, which indicates that the STR ordinance also effectively decreases Airbnb activities. These estimates once again confirm the effectiveness of the policy on Airbnb listings.

[Insert Figure 2 & Table 2]

In sum, we find that the STR ordinance has a first-order effect on the STR market, and our results confirm that the policy meaningfully and dramatically reduced Airbnb activity.

STR Ordinance on Rental Prices

We combine quasi-experimental methods with hedonic property models and estimate the following DID equation to quantify the effect of STR regulations on rental prices:[19]

$$ln(Contract\ Rent_{i,z,t}) = \alpha + \beta \times Treated_z * Post_t + \gamma_z + \mu_t + X_i + \epsilon_{i,z,t}. \quad (3)$$

In equation (3), the observation unit is the rental (i)-ZIP code (z)-time (t) level. Our main outcome variable of interest is the natural logarithm of contract rent for rental i at ZIP code z during time t. X_i is a series of housing characteristic controls commonly used in hedonic models, including house size, number of bedrooms, bathrooms and garages, property age, and property age squared. We continue using the same set of fixed effects (ZIP code fixed effects and year-month fixed effects) as in equation (1). Again, we estimate standard errors that are robust to clustering at the ZIP code level.

To provide visual evidence of differences in contract rent between treated and control cities over time, we design the following dynamic regression similar to equation (2):

$$ln(Contract\ Rent_{i,z,t}) = \alpha + \beta_t \sum (Treated_z \times Post_t) + \gamma_z + \mu_t + X_i + \epsilon_{i,z,t}. \quad (4)$$

We now discuss the effects of STR ordinances on rental prices. Again before showing the main results, we visually show the satisfaction of the parallel trend assumption and plot changes in the natural logarithm of rents over time in two groups in Figure 3 Panel A, after controlling for ZIP code fixed effects and year-month fixed effects. We find there is no systematic differences in the changes of rent in treated and control groups prior to treatments,

[19]Note for the sake of notational simplicity, we apply a slight abuse of notation since parameters in equation 3 take on different values than the correspond parameters in equation 1.

which confirms the key identifying assumption that the rent in the two groups develop in a parallel way. The trend in rent diverges after the STR ordinance in August 2019, and rent growth in the treated ZIP codes is significantly lower than in the control groups.

After the validation of the parallel trend assumption, Table 3 presents the regression results from equation (3) using different housing characteristics as controls. In Column (1), we do not include any housing characteristics, and the result shows that the policy shock generated an average decline of 2.4% in contract rent in treated ZIP codes compared with control groups.

To address potential concerns that this result may be driven by housing characteristics, we gradually add different housing characteristics as controls to check how they affect our regression results, and we find the magnitude as well as significance of the coefficients are quite stable when adding different housing attributes, as Columns (2) and (3) of Table 3 show. Column (4) confirms the result with all housing characteristics including housing size, number of beds/baths/garages, property age, and property age squared as controls. STR ordinance leads to a 2.7% significant decrease in contract rents, on average, after its enforcement in Irvine, compared with control cities.[20] Relative to the mean, our estimate suggests that contract rents decline by \$101 (\$3,749*2.7%) after the regulations on Airbnb became effective. Given that there are 58,998 renter-occupied units in Irvine as of 2019 according to the census data that sums to a reduction of \$72M in total annual rental spending.

To provide visual evidence of the impact of the STR ordinance over different time periods, we plot the coefficients of time-disaggregated β_t from equation (4) with the corresponding confidence intervals in Figure 3 Panel B. As with the Airbnb market dynamic effects, we see little to no evidence of significantly different pre-trends in two groups leading up to the policy enactments, which again validates the parallel trend assumption required for difference-in-difference to achieve an unbiased estimation. We see a decrease in rent among treated rental listings relative to their untreated counterparts only after the policy shocks.

[20]The magnitude of the coefficient on our variable of interest, 2.7%, is consistent with Koster, Van Ommeren and Volkhausen (2021) where they find that an STR ordinance in Los Angeles leads to a decrease in rents of 2%.

[Insert Figure 3 & Table 3]

As explained in the previous section, one advantage of our data is that we observe contract rents, which allows us to study the impact of policy on equilibrium rental prices as a market outcome. However, the asking rent is listed by landlords, and is typically larger than the contract rent. We report the summary statistics for listed rentals including both rented and un-rented properties in Appendix Table 1. The sample contains 14,517 closed and non-closed rental listings in Irvine, CA, and its neighboring cities. We note the asking rent is larger than the contract rent at each percentile; on average, it is about 7% higher. Besides, the asking rent is more rigid downwards and less sensitive to market supply and demand and therefore, we may expect that using the asking rent instead of the contract rent would underestimate the STR ordinance effect. To test this hypothesis, we replace the contract rent with asking rent and re-estimate equation (3). Contrary to the findings when using contract rents, we find the STR ordinance has nearly no impact on asking rents across all types of specifications in Appendix Table 2, which is consistent with our argument.

[Insert Appendix Table 1 & 2]

In sum, we estimate the STR ordinance's impacts on rents, and our results indicate that contract rents decrease by 2.7% in the post-treatment period in treated ZIP codes relative to control groups, and such a negative effect does not exist for asking rents.

STR Ordinance on the Number of Rentals

We explain the results by referring to the law of supply and demand in economics. On the one hand, the regulation of STR may force landlords to switch back from supplying the STR market to supplying the market for long-term rentals. On the other hand, the entry of STR platforms creates job opportunities, spurs business growth and increases the local employment rate. The ban on STR may cause some workers to lose their jobs and move out of the city. In that sense, the loss of job opportunities caused by the removal of STR would lead to a decrease in the demand for rentals. The decline of rental prices may be mainly due to either

the increase in rental housing supply or the decrease in demand for rentals. To test which is the main driving force, we design our regression to exploit variation among treated ZIP codes within Irvine that may be more or less impacted by city-level policy implementation following Chen, Wei, and Xie (2022):

$$Rentals_{z,t} = \alpha + \beta \times Airbnb\ Exposure_z * Post_t + \gamma_z + \mu_t + \epsilon_{z,t}. \tag{5}$$

Equation (5) helps us understand which is the main driving force of the rent decline. While we cannot directly separate the demand and supply side for short-term rentals, we can test their net effect. We construct the number of rental contracts $Rental\ Contracts_{z,t}$ at ZIP code z and time t, which reflects the market equilibrium and evaluates the net effects of supply and demand. The main independent variable of interest is the interaction term $Airbnb\ Exposure_z * Post_t$. $Airbnb\ Exposure_z$ is constructed by using the different measures of Airbnb activities or Airbnb penetration, including average monthly number of rental listings, average monthly number of booked listings, average monthly revenue generated from Airbnb operations as well as average monthly number of reversed days per 1,000 local population in certain ZIP codes in the year prior to August 2019, and therefore, it measures the local exposure to Airbnb activities in the pre-implementation period. The associated parameter β measures whether there is any substantial changes in the rental contracts in the ZIP codes where Airbnb listings were more prevalent in the pre-treatment period after the STR ordinance was enacted. The exit of Airbnb may result in an increase in rental supply due to a reallocation effect or a decrease in rental demand due to employment losses. This should be especially true in local areas which face a higher exposure to Airbnb activities.

By testing how the equilibrium number changes, we can shed light on the underlying mechanism through which Airbnb affects rental markets. If the number of rental contracts increases, we can conclude that the supply effect is dominating the demand effect, and the decline in rent is mainly driven by the increase in the supply of rentals. Otherwise, if the

number of rental contracts decrease, then the demand effect is dominating the supply effect and the decline in rent may be mainly driven by the decrease in demand of rentals.

As presented in Panel A Table 4, the positive and significant coefficients across Columns (1)-(4) indicate that the number of rental contracts experience a stronger increase when the local exposure to Airbnb activities is higher after the policy. We can see the marginal positive impact of a 1% higher Airbnb exposure on the total number of rental contract is about 0.08% after the STR ordinance in Column (1) and the magnitudes are quite comparable across Columns (2) to (4). These positive results also inform the net effect of the Airbnb ban: the Airbnb ban has a stronger impact on the rental supply side (reallocation of properties from the short-term to the long-term rental market) compared with rental demand side effects (that result from employment losses caused by exits of STR platforms), which eventually drives an increase in the equilibrium number of rentals and a decrease in equilibrium prices.

To further confirm the role of the supply effect in driving the decline of rents, we construct another variable, the number of rental listings $Rental\ Listings_{z,t}$, which directly measures the supply of rentals. We noticed that the coefficients remain positive and also become larger than the estimation in Columns (1)-(4) when we replace rental contracts with rental listings as reported in Columns (5)-(8) in Table 4, Panel A. Combining these two results, we confirm that the increase in the equilibrium number of rentals is mainly driven by the increase of supply in rentals due to the policy's ban of STR instead of the demand side for long-term rentals.

Since cities in the control groups never implemented an STR ordinance, we expect such a positive effect should not exist in our placebo test. Table 4, Panel B, Columns (1)-(8) show that both the total number of rental contracts and rental listings have no positive and significant changes in control groups after the event date (instead, Columns (5)-(8) shows a marginally significant decrease in the total number of rental listings in the control groups), which again further supports the finding that the policy's enforcement in Irvine has a non-trivial effect on the local supply of rentals.

[Insert Table 4]

4.2. Robustness Tests

We perform several robustness tests to ensure the negative effect on rents is driven by STR regulation and is explained by an increase in the supply of rentals, rather than other confounding factors.

4.2.1. Neighborhood Characteristics

In the baseline regression, we add ZIP code fixed effects to control for time-invariant local economics. There may still be remaining concerns that we omit time-varying local economic factors that may drive the decline in housing rents. To further confirm whether our results are driven by the local economy, we control for time-varying neighborhood characteristics including demographic characteristics (total population, population density, median age, Caucasian ratio, education level and employment rate), economic characteristics (including median household income, PCI, and poverty rate), and housing characteristics (including total housing units, occupied ratio, median housing price) from the Census Bureau. The results are reported in Table 5 Panel A, and we find our coefficients are still robust after controlling for neighborhood time-varying local economic factors when we add each type of neighborhood characteristics separately from Columns (1)-(3) or together in Column (4).

4.2.2. Covid-19 Effects

Given that our sample period covers the Covid-19 pandemic after the implementation of the STR ordinance, we implement two strategies that address the potential confounding effects of Covid-19 on housing markets. First, in our baseline regression, we account for the dynamics of Covid-19 effects by directly controlling for monthly total number of Covid-19

cases per 1,000 residents at each ZIP code. As shown in Columns (1)-(3), Panel B of Table 5, our results are still robust across different specifications after we control for Covid-19 cases. Second, we re-estimate our baseline regression on a different sub-sample (i.e., we remove the time period from March 2020 to May 2020 when California implemented a stay-at-home order (D'Lima, Lopez, and Pradhan, 2022), and find the significant and robust results still hold as shown in Columns (4)-(6), Table 5, Panel B. Taken together, these empirical analyses suggest that the differential effects of Covid-19 do not drive our findings.

[Insert Table 5]

4.2.3. Falsification Test

We emphasize the importance of STR ordinance's enforcement and argue that the STR policy without any enforcement may fail to regulate Airbnb activities. Since Irvine passed its first STR ordinance in April 2018 but did not enforce it in the following year, our setting allows us to do a falsification test that shows what happened to Airbnb listings and rental prices if hosts ignore city rules due to a lack of enforcement. We adopt April 2018 as a false event and re-estimate regressions (1) and (2) based on the sample in a one-year window. We do not find any significant results of policy impacts on Airbnb listings or rental prices as shown in both Panel A and Panel B in Table 6. This result provides further evidence that the STR ordinance does not have any impact if it was enacted without enforcement or any assistance from STR platforms.

[Insert Table 6]

4.3. Heterogeneity Test

We explore heterogeneity results across different characteristics of rentals by estimation depending on the number of bedrooms, property type, and occupancy status. This is motivated by the fact that most of the STR properties in our sample have three or more bedrooms,

belong to the single-family or multi-family type and are listed for the entire unit.[21]

If the STR ordinance forced hosts to switch from supplying the market for short-term rentals to supplying the market for long-term rentals, we may expect rental properties with similar characteristics to Airbnb properties should suffer more from supply pressure due to such switching. Consistent with our hypothesis, we find that compared with Table 7, Columns (1), (3) and (5), rental prices of properties with three or more bedrooms, belonging to single-family or multi-family and exclusively rented experience a larger decline as shown in Table 7, Columns (2), (4) and (6), which indicates the effects on these types of properties are driven by switchers.[22]

Though our data do not contain the size or quality of the Airbnb property, we believe most of the Airbnb properties tends to be large and of high quality since accommodation is the primary product of Airbnb listings and large properties with more bedrooms and amenities are more popular. Our results from Table 7, Columns (7)-(10) indicate that there is a larger decrease in rent prices of larger rental properties with higher quality (proxied by higher rental prices) than their counterparts, further validating the supply pressure hypothesis. We want to note that typically wealthy landlords are more likely to own such larger and more luxurious rentals, and therefore, the above results also indicate that the regulation of Airbnb activities hits most on wealthy groups and in that sense, it may also help reduce wealth inequality.

Lastly, we want to test the heterogeneous effect of the STR ordinance on rents based on rental properties' exposure to Airbnb. We may expect the negative effect on rents to be stronger in areas with a greater share of Airbnb ex-ante based on the findings that a larger supply increase in rentals exists in local areas faced with a greater exposure to Airbnb activities in Section 5.3. As shown in Columns (11) and (12), we find rental prices indeed have a greater and more significant drop in areas with a greater Airbnb exposure in the pre-treatment period,

[21] In our sample, around 82% of Airbnb listings have three or more bedrooms, 72.6% listings belong to single-family or multi-family types and 70% of listings are listed for the entire unit.

[22] Exclusively rented rental means that the entire rental unit is rented out to tenants. On the contrary, partially rented rental means that only one of the bedrooms is rented out and the homeowner will share the entire unit with tenants.

once again consistent with our expectation.

[Insert Table 7]

5. Conclusion and Policy Implications

This paper investigates how Airbnb affects rental markets. To identify these effects our study takes advantage of a policy on short term rentals that was enforced by the municipality of Irvine (CA). Using microdata for rental listings and Airbnb listings, we apply a quasi-experimental method with a hedonic property model.

We find that an STR ordinance significantly reduces Airbnb listings compared to the control group, which confirms that the policy has a meaningful impact on the size of the Airbnb market. Next, we determine if these policy-induced changes to Airbnb have any impact on rents. We document that an STR ordinance leads to a significant 2.7% decrease in contract rents, on average, after its enforcement. We further find that both the number of rental listings and rental contracts experiences a stronger increase when the local exposure to Airbnb activities is greater after policy implementation, which shows that the decline in rents is more likely to be driven by reallocation of rental supply away from prohibited STR toward long-term rentals. Our results are robust when we control for time-varying neighborhood characteristics as well as Covid-19 effects. Lastly, we find there is a larger decrease in rent for rentals with similar characteristics as Airbnb listings and located in areas with a greater exposure to Airbnb activities in the pre-treatment period. This is consistent with the notion that these groups of rentals are affected more severely from supply pressure due to the ban on Airbnb.

The results of this paper contribute to the debate surrounding STR regulation and its impact on housing markets. Our results also have implications for policy makers. STR restriction policies are likely to continue to be on the agenda of local and regional governments. Our

paper highlights the value of enforcement of STR regulations and provides local governments with empirical evidence that only STR regulation policies with enforcement are effective in reducing rents in cities which helps mitigate concerns of housing affordability. Conversely, STR regulations without enforcement will be unlikely to achieve these goals. Finally, the re-allocation mechanism from STRs toward long-term rentals is a critically important aspect to consider for regulation and policy authorities. At the same time, the effect of the regulation of Airbnb activities on rents is not evenly distributed across different rentals. The negative effect on rents is stronger for rental units that have similar housing characteristics to Airbnb listings. Specifically, rentals with more bedrooms, larger size and higher quality experience a larger decline after the ban of Airbnb and those types of rentals are more likely to be owned by wealthy investors. In this sense, the regulation of Airbnb activities may also help reduce wealth inequality.

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Table 1 Summary Statistics

	mean	sd	p5	p25	p50	p75	p95
Dependent Var							
Contract Rent($)	3,749	1,638	2,195	2,895	3,400	4,000	6,600
ln(Contract Rent)	8.16	0.34	7.69	7.97	8.13	8.29	8.79
Rentals Characteristics							
House Size	1,833	737	923	1,330	1,684	2,156	3,232
Number of Beds	3	1	2	2	3	4	5
Number of Baths	3	1	1	2	3	3	4
Number of Garages	2	0	1	2	2	2	3
Property Age (Years)	27	19	2	9	22	42	59
Neighborhood Characteristics							
Demographics Characteristics							
Total Population	37,748	15,031	19,558	24,694	33,234	48,997	62,437
Population Density	5,549	2,608	1,523	2,575	5,652	6,953	9,947
Median Age	38	7	30	34	38	40	46
Ratio of Caucasian	52.63	15.88	35.70	40.00	48.40	56.00	87.60
Education Level	63.50	12.10	37.10	63.50	67.80	69.60	77.20
Employment Rate	95.66	1.17	94.00	94.90	95.70	96.50	97.40
Economic Characteristics							
Household Income	106,617	21,361	74,672	100,745	107,353	115,826	146,505
PCI	55,051	15,520	38,719	46,478	52,388	56,365	85,281
Poverty Rate	10.81	6.16	5.90	7.90	9.00	11.70	29.00
Housing Characteristics							
Total Housing Units	14,953	5,341	8,039	9,893	14,438	20,140	22,844
Occupied Ratio	92.13	5.05	83.40	90.40	93.30	95.40	97.00
Owner Occupied Ratio	49.82	12.48	31.10	39.20	47.70	62.30	66.60
Median House Price	924,790	304,706	635,800	768,800	852,600	925,400	1,668,800
N	11,608						
ZIP-code Level (Aggregated)							
Number of Rental Listings (MLS)	24	23	3	8	19	31	69
Number of Rental Contracts (MLS)	14	17	0	0	9	20	48
Airbnb Information (AirDNA)							
Total Active Listings	136	155	19	49	82	158	449
Total Booked Listings	101	128	8	35	57	116	343
Total Revenue	438,102	965,507	14,868	72,102	140,125	337,939	2,079,482
Total Reserved Days	1,471	1,960	95	477	828	1,629	5,119
N	800						

Notes: This table provides summary statistics for the key variables used in the paper. The first panel reports summary statistics for properties that are rented. Contract Rent is the rental price signed on the lease between the landlord and tenant. ln(Contract Rent) is the natural logarithm of the rental price. Property-level characteristics and neighborhood characteristics are also reported in the first panel. The second panel reports the summary statistics at the ZIP code level, including rental information from CoreLogic MLS data and Airbnb information from AirDNA data.

Table 2 Impact of STR Ordinance on Airbnb Activities

	(1)	(2)	(3)	(4)
	ln(Active Listings)	ln(Booked Listings)	ln(Revenue)	ln(Reservation Days)
Treated*Post	-0.231***	-0.361***	-0.352***	-0.367**
	(-3.41)	(-4.19)	(-3.14)	(-2.59)
ZIP FE	Yes	Yes	Yes	Yes
Year Month FE	Yes	Yes	Yes	Yes
N	800	800	800	800
Adj. R^2	0.962	0.933	0.921	0.882

Notes: This table shows the regression results of the impact of the STR ordinance on Airbnb activities from Equation (1). The dependent variable is Airbnb activities measured by total number of active listings in Column (1), total number of booked listings in Column (2), total revenue generated from Airbnb operations in Column (3) and total number of reservation days in Column (4). The independent variable of interest in is the interaction term between Treated (Treated is equal to 1 if the Airbnb listing is located in Irvine), 0 otherwise) and Post (Post is equal 1 if the Airbnb activities are counted after August 2019). For each regression, we add ZIP code fixed effects and time (Year Month) fixed effects. *, **, and *** denote statistical significance at the 10, 5, and 1 percent levels, respectively. Standard errors are clustered at the ZIP code level.

Table 3 Impact of STR Ordinance on Contract Rent

	(1)	(2)	(3)	(4)
	ln(Contract Rent)			
Treated*Post	-0.024*	-0.029***	-0.030***	-0.027***
	(-1.81)	(-3.29)	(-3.52)	(-3.02)
ln(House Size)		0.696***	0.492***	0.474***
		(27.38)	(12.35)	(11.91)
Beds			0.050***	0.055***
			(5.71)	(5.83)
Baths			0.039***	0.031***
			(4.96)	(2.86)
Garage			0.051***	0.058***
			(3.01)	(3.68)
Property Age				-0.006***
				(-5.44)
Property Age^2				0.000***
				(4.52)
ZIP FE	Yes	Yes	Yes	Yes
Year Month FE	Yes	Yes	Yes	Yes
N	11,608	11,608	11,608	11,608
Adj. R^2	0.201	0.737	0.751	0.760

Notes: This table shows the regression results of the impact of the STR ordinance on contract rents from Equation (3). The dependent variable is ln(Contract Rent). The independent variable of interest is the interaction term between Treated (Treated equals 1 if the rental is located in Irvine) and Post (Post is equal to 1 if the contract is signed after August 2019). For each regression, we add ZIP code fixed effects and time (Year Month) fixed effects. Column (1) gives a result without any housing characteristics as controls. Column (2) shares the result with house size as a control. Column (3) lists results with house size, number of bedrooms/bathrooms/garages as controls. Column (4) reports results with all housing characteristics as controls. *, **, and *** denote statistical significance at the 10, 5, and 1 percent levels, respectively. Standard errors are clustered at the ZIP code level.

Table 4 Mechanism Analysis

Panel A: Analysis Within Irvine

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ln(Number of Rental Contracts)				ln(Number of Rental Listings)			
ln(Active Listings)*Post	0.082***				0.154***			
	(6.53)				(8.20)			
ln(Booked Listings)*Post		0.090***				0.147***		
		(11.96)				(7.72)		
ln(Revenue)*Post			0.059***				0.097***	
			(11.28)				(8.49)	
ln(Reservation Days)*Post				0.063***				0.099***
				(10.27)				(6.40)
ZIP FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	256	256	256	256	256	256	256	256
Adj. R2	0.772	0.773	0.774	0.774	0.908	0.907	0.907	0.907

Panel B: Analysis Within Control Cities

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ln(Number of Rental Contracts)				ln(Number of Rental Listings)			
ln(Active Listings)*Post	-0.023				-0.070*			
	(-0.97)				(-1.83)			
ln(Booked Listings)*Post		-0.023				-0.067		
		(-0.90)				(-1.70)		
ln(Revenue)*Post			-0.013				-0.053**	
			(-1.14)				(-2.18)	
ln(Reservation Days)*Post				-0.018				-0.062*
				(-0.97)				(-1.88)
ZIP FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	544	544	544	544	544	544	544	544
Adj. R2	0.849	0.848	0.849	0.849	0.804	0.803	0.806	0.804

Notes: This table reports the regression results of the impact of the STR ordinance on the number of rental listings or rental contracts depending on the level of Airbnb exposure in the pre-treatment period from Equation (5). The dependent variable is ln(Number of Rental Contracts) from Columns (1) to (4) and ln(Number of Rental Listings) from Columns (5) to (8), respectively. The independent variable of interest in is the interaction term between Airbnb exposure in the pre-treatment period (measured by average monthly number of rental listings, average monthly number of booked listings, average monthly revenue generated from Airbnb operations as well as average monthly number of reserved days in a certain ZIP code in the year prior to the event) and Post (Post is equal to 1 if the contract is signed after August 2019). For each regression, we add ZIP code fixed effects and time (Year Month) fixed effects. Panel A reflects the analysis within Irvine, while Panel B shows the analysis within control cities. *, **, and *** denote statistical significance at the 10, 5, and 1 percent levels, respectively. Standard errors are clustered at the ZIP code level.

Table 5 Robustness Test

Panel A: Adding Neighborhood Characteristics as Controls

	(1)	(2)	(3)	(4)
	ln(Contract Rent)			
Treated*Post	-0.023**	-0.026**	-0.028***	-0.022**
	(-2.39)	(-2.33)	(-3.32)	(-2.09)
ZIP FE	Yes	Yes	Yes	Yes
Year Month FE	Yes	Yes	Yes	Yes
House Size	Yes	Yes	Yes	Yes
Num. Beds/Baths/Garages	Yes	Yes	Yes	Yes
Property Age	Yes	Yes	Yes	Yes
Neighborhood Demographics	Yes	No	No	Yes
Neighborhood Economics	No	Yes	No	Yes
Neighborhood Housing	No	No	Yes	Yes
N	11,608	11,608	11,608	11,608
Adj. R^2	0.761	0.760	0.760	0.761

Panel B: Rule out the Covid-19 Effects

	(1)	(2)	(3)	(4)	(5)	(6)
	ln(Contract Rent)			ln(Contract Rent)		
Treated*Post	-0.030***	-0.031***	-0.028***	-0.029***	-0.031***	-0.028***
	(-3.29)	(-3.58)	(-3.17)	(-3.25)	(-3.50)	(-3.03)
Covid Cases	-0.142	-0.199	-0.341*			
	(-0.68)	(-1.03)	(-2.04)			
ZIP FE	Yes	Yes	Yes	Yes	Yes	Yes
Year Month FE	Yes	Yes	Yes	Yes	Yes	Yes
House Size	Yes	Yes	Yes	Yes	Yes	Yes
Num. Beds/Baths/Garages	No	Yes	Yes	No	Yes	Yes
Property Age	No	No	Yes	No	No	Yes
N	11,608	11,608	11,608	11,182	11,182	11,182
Adj. R^2	0.737	0.751	0.760	0.736	0.751	0.760

Notes: This table conveys the regression results for robustness tests surrounding the impact of the STR ordinance on contract rents. Panel A reports the results when adding each type of neighborhood characteristic including demographic characteristics, economic characteristics and housing characteristics separately from Columns (1)-(3) and together in Column (4). Panel B reports how Covid-19 affects the results. Columns (1)-(3) provide the results when controlling for monthly total number of Covid-19 cases per 1,000 residents at each ZIP code, and Columns (4)-(6) report the results when removing the time period from March 2020 to May 2020 when California implemented a stay-at-home order. *, **, and *** denote statistical significance at the 10, 5, and 1 percent levels, respectively. Standard errors are clustered at the ZIP code level.

Table 6 Falsification Test

Panel A: Impact of Non-enforced STR Ordinance on Airbnb Activities

	(1)	(2)	(3)	(4)
	ln(Active Listings)	ln(Booked Listings)	ln(Revenue)	ln(Reservation Days)
Treated*Post	-0.042	-0.019	-0.098	-0.089
	(-0.74)	(-0.29)	(-1.26)	(-1.19)
ZIP FE	Yes	Yes	Yes	Yes
Year Month FE	Yes	Yes	Yes	Yes
N	325	325	325	325
Adj. R^2	0.988	0.972	0.966	0.953

Panel B: Impact of Non-enforced STR Ordinance on Contract Rent

	(1)	(2)	(3)	(4)
	ln(Contract Rent)			
Treated*Post	0.016	0.009	0.009	0.012
	(0.76)	(0.97)	(1.02)	(1.31)
ln(House Size)		0.717***	0.552***	0.541***
		(22.60)	(13.66)	(13.05)
Beds			0.034***	0.036***
			(4.22)	(3.99)
Baths			0.036***	0.031***
			(4.72)	(3.10)
Garage			0.048***	0.055***
			(3.96)	(4.21)
Property Age				-0.005***
				(-5.32)
Property Age^2				0.000***
				(4.08)
ZIP FE	Yes	Yes	Yes	Yes
Year Month FE	Yes	Yes	Yes	Yes
N	3,521	3,521	3,521	3,521
Adj. R^2	0.194	0.788	0.797	0.804

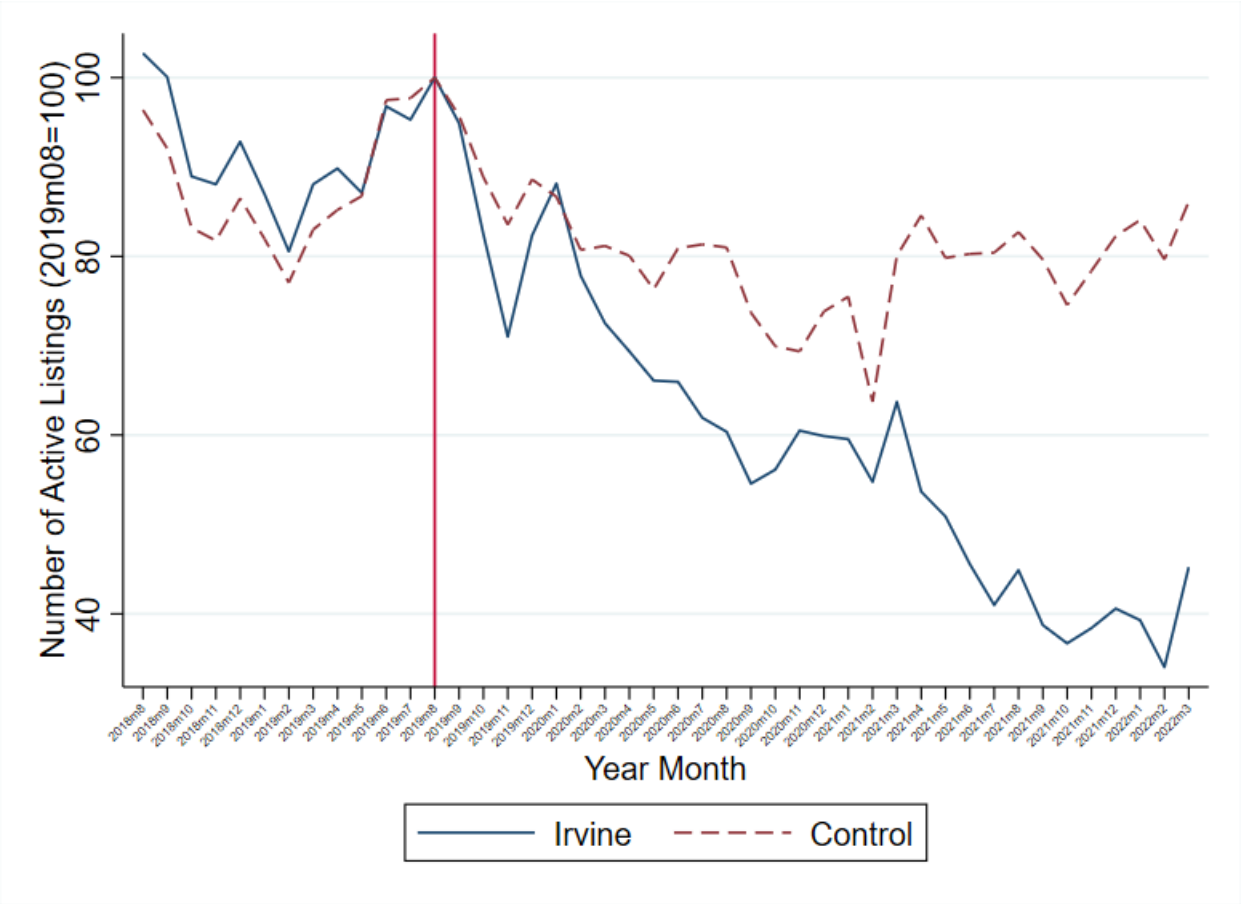
Notes: This table shows the regression results of falsification tests: the impact of the non-enforced STR ordinance on Airbnb activities in Panel A and contract rents in Panel B. We re-define the event date as April 2018 since Irvine passed its first STR ordinance in April 2018, but never enforced it in the next one year and re-estimate regression (1) and (2) based on the sample in a one-year window. For each regression, we add ZIP code fixed effects and time (Year Month) fixed effects. *, **, and *** denote statistical significance at the 10, 5, and 1 percent levels, respectively. Standard errors are clustered at the ZIP code level.

Table 7 Heterogeneity Test

Dependent Variable	ln(Contract Rent)					
	Bedrooms		Property Type		Rental Type	
	(1) Two or Less	(2) Three or More	(3) Non-Dominating	(4) Dominating	(5) Partially Rented	(6) Exclusively Rented
Treated*Post	-0.021***	-0.030**	-0.009	-0.037***	-0.009	-0.032***
	(-2.95)	(-2.37)	(-0.92)	(-2.95)	(-0.65)	(-3.12)
ZIP FE	Yes	Yes	Yes	Yes	Yes	Yes
Year Month FE	Yes	Yes	Yes	Yes	Yes	Yes
House Size	Yes	Yes	Yes	Yes	Yes	Yes
Num. Beds/Baths/Garages	Yes	Yes	Yes	Yes	Yes	Yes
Property Age	Yes	Yes	Yes	Yes	Yes	Yes
N	3,273	8,332	4,880	6,703	2,587	8,861
Adj. R^2	0.636	0.683	0.718	0.735	0.810	0.746
	House Size		Rental Price		Pre-Airbnb Share	
	(7) Low	(8) High	(9) Low	(10) High	(11) Low	(12) High
Treated*Post	-0.023***	-0.027*	0.005	-0.048***	-0.019*	-0.055**
	(-3.71)	(-1.77)	(0.76)	(-3.41)	(-1.74)	(-2.58)
ZIP FE	Yes	Yes	Yes	Yes	Yes	Yes
Year Month FE	Yes	Yes	Yes	Yes	Yes	Yes
House Size	Yes	Yes	Yes	Yes	Yes	Yes
Num. Beds/Baths/Garages	Yes	Yes	Yes	Yes	Yes	Yes
Property Age	Yes	Yes	Yes	Yes	Yes	Yes
N	5,127	6,481	5,144	6,464	5,484	6,124
Adj. R^2	0.661	0.644	0.697	0.584	0.798	0.727

Notes: This table shows the regression results associated with heterogeneity test of the impact of the STR ordinance on contract rents at the property level. We split the sample into two groups based on number of bedrooms in Columns (1)-(2), property type in Columns (3)-(4), rental type in Columns (5)-(6), size in Columns (7)-(8), quality of the Airbnb property in Columns (9)-(10) and rental properties' exposure to Airbnb in the pre-treatment period in Columns (11)-(12). *, **, and *** denote statistical significance at the 10, 5, and 1 percent levels, respectively. Standard errors are clustered at the ZIP code level.

Figure 1. Illustration of STR Ordinance Effect in Irvine vs. Control Cities

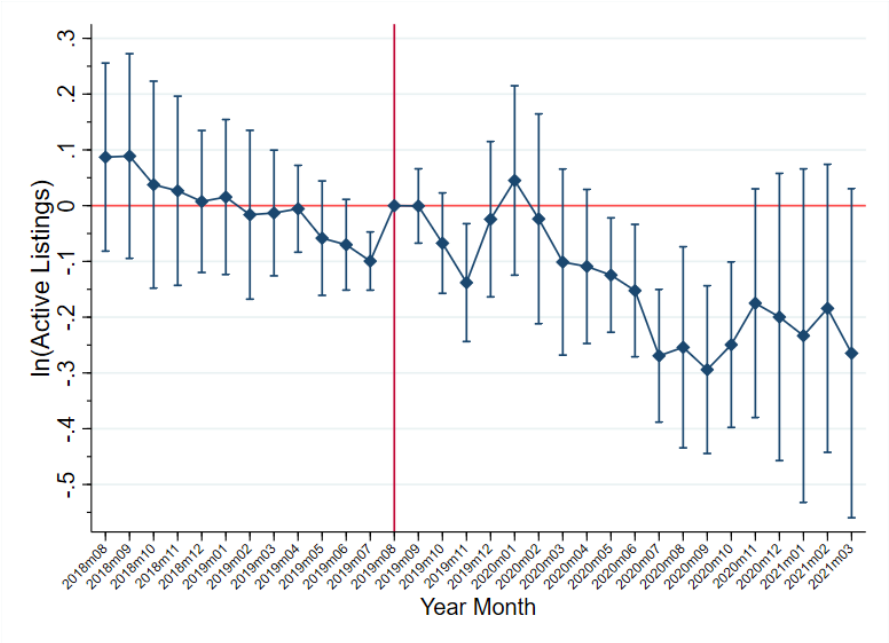


Notes: This figure shows the number of active Airbnb listings in Irvine vs. control cities. The sample period is from August 2018 to March 2022 (one year prior to the event date and up to the most recent date we have). The number of active listings is shown in log form and is normalized at the event time.

Figure 2. Impact of STR Ordinance on Airbnb Activities

(a) Parallel Trends

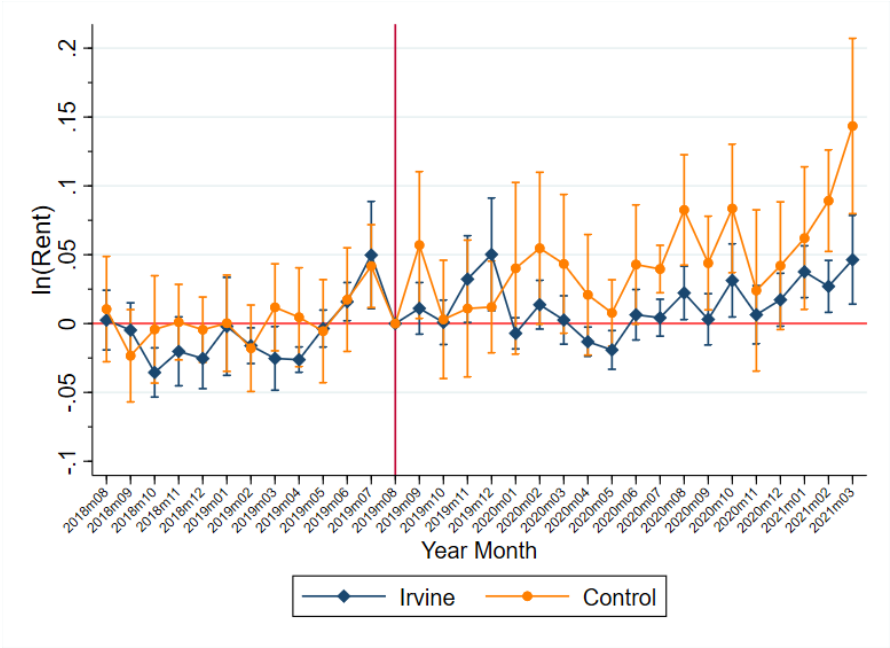
(b) Coefficient Plot



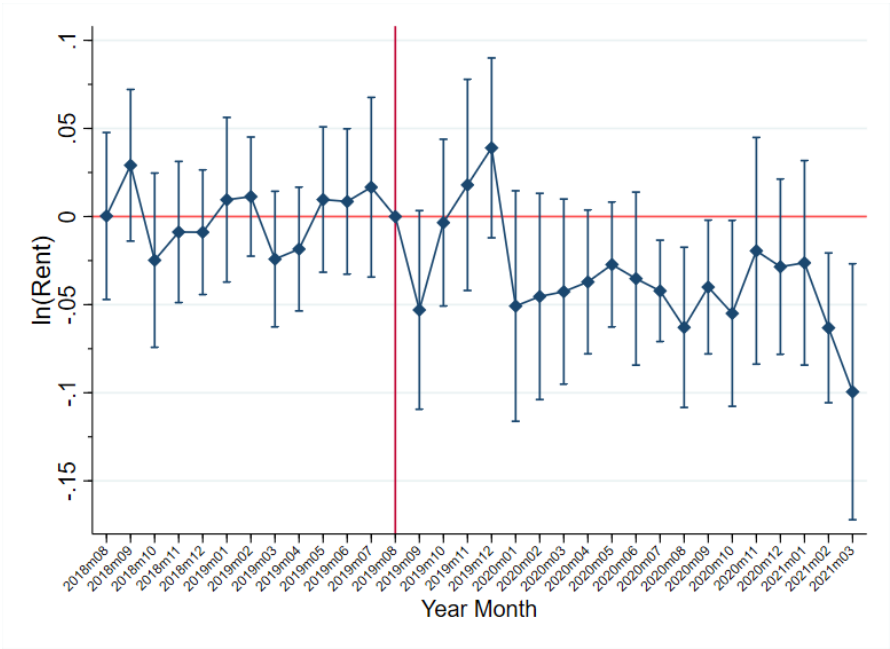
Notes: Figure (a) shows changes in the number of active Airbnb listings in the treated and control groups before and after the STR ordinance. Figure (b) reveals the coefficient plot from the Difference-In-Difference regression from Equation (2).

Figure 3. Impact of STR Ordinance on Contract Rent

(a) Parallel Trends



(b) Coefficient Plot



Notes: Figure (a) shows the changes in contract rents in the treated and control groups before and after the STR ordinance. Figure (b) shares the coefficient plot from the Difference-In-Difference regression from Equation (4).

6. Appendix

Table A1 Summary Statistics for Listed Rentals

	mean	sd	p5	p25	p50	p75	p95
Dependent Variable							
Asking Rent($)	4,008	1,959	2,250	2,995	3,500	4,400	7,500
ln(Asking Rent)	8.22	0.36	7.72	8.00	8.16	8.39	8.92
Rentals Characteristics							
House Size	1,863	758	934	1,344	1,703	2,200	3,298
Number of Beds	3	1	2	2	3	4	5
Number of Baths	3	1	1	2	3	3	5
Number of Garages	2	0	1	2	2	2	3
Property Age (Years)	26	19	2	9	22	42	59
N	14,517						

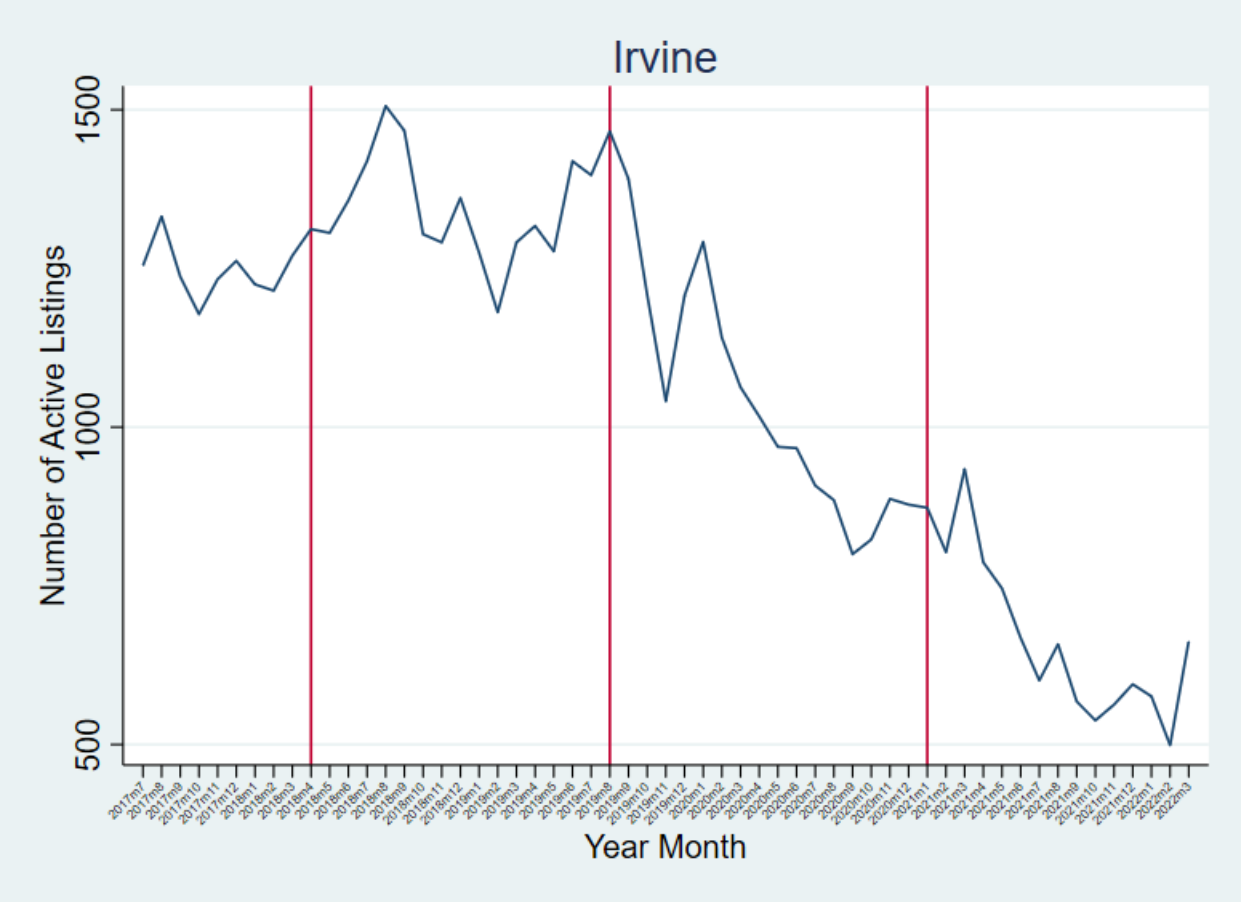
Note: This table provides summary statistics for properties listed in the rental markets (include both rented and un-rented properties). Asking Rent is the rental price listed by the landlord. ln(Asking Rent) is the natural logarithm of the asking price. Property-level characteristics are also reported in the table.

Table A2 Impact of STR Ordinance on Asking Rent

	(1)	(2)	(3)	(4)
	ln(Asking Rent)			
Treated*Post	0.007	0.002	-0.000	0.003
	(0.37)	(0.11)	(-0.01)	(0.19)
ln(House Size)		0.718***	0.549***	0.523***
		(24.86)	(14.04)	(12.39)
Beds			0.037***	0.047***
			(4.01)	(4.34)
Baths			0.039***	0.027**
			(5.59)	(2.69)
Garage			0.042**	0.049***
			(2.36)	(2.93)
Property Age				-0.007***
				(-5.97)
Property Age^2				0.000***
				(4.91)
ZIP FE	Yes	Yes	Yes	Yes
Year Month FE	Yes	Yes	Yes	Yes
N	14,517	14,517	14,517	14,517
Adj. R^2	0.204	0.706	0.715	0.725

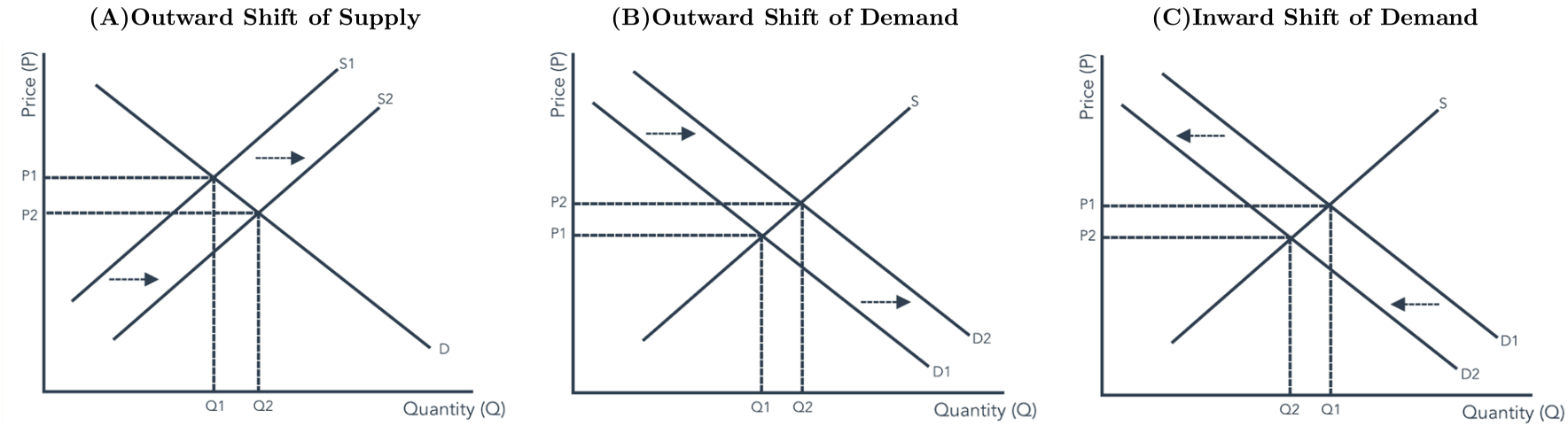
Notes: This table shows the regression results of the impact of STR ordinance on contract rents from Equation (3). The dependent variable is ln(Asking Rent). The independent variable of interest is the interaction term between Treated (Treated is equal to 1 if the rental is located in Irvine) and Post (Post is equal to 1 if the contract is signed after August 2019). For each regression, we add ZIP code fixed effects and time (Year Month) fixed effects. Column (1) shows results without any housing characteristics as controls. Column (2) provides results with house size as a control. Column (3) conveys findings with house size, number of bedrooms/bathrooms/garages as controls. Column (4) lists output with all housing characteristics as controls. *, **, and *** denote statistical significance at the 10, 5, and 1 percent levels, respectively. Standard errors are clustered at the ZIP code level.

Figure A1. Airbnb Listings in Irvine



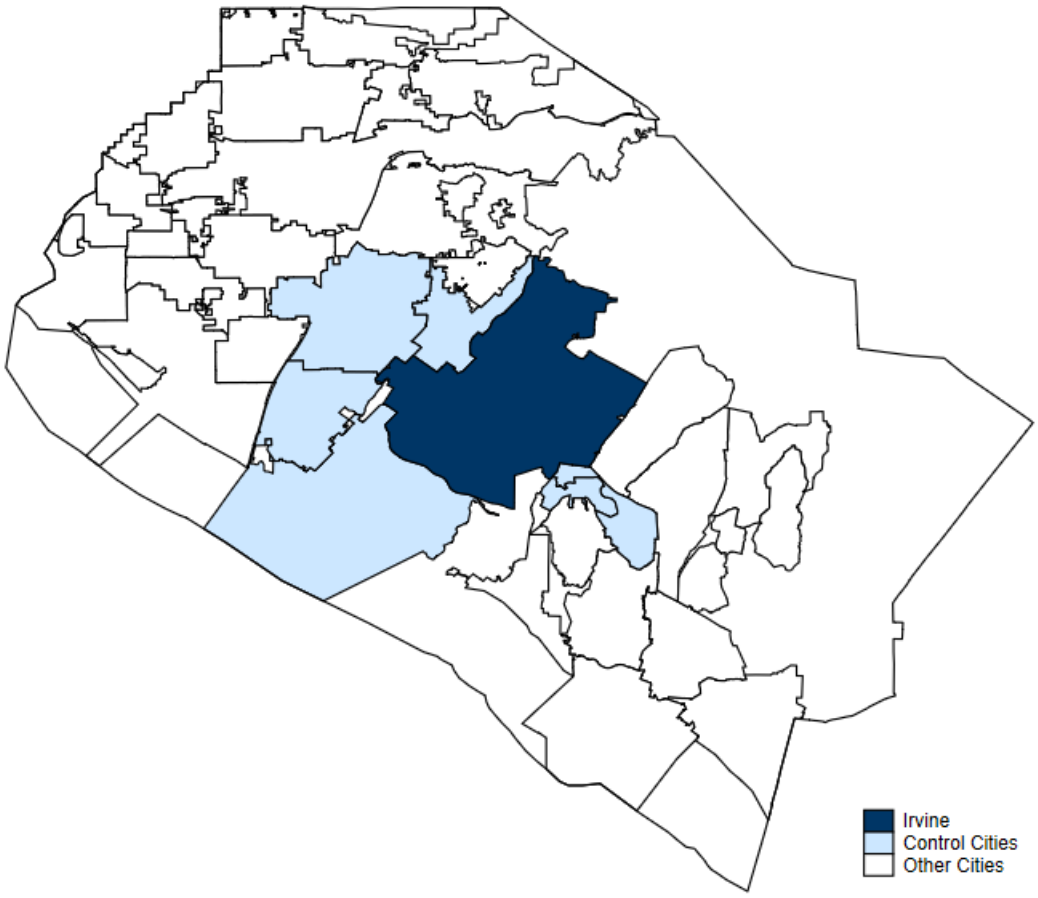
Notes: This figure shows the number of active Airbnb listings in Irvine from July 2017 to March 2022. We mark the passage dates of three STR ordinance in Irvine, including April 2018, August 2019 and January 2021.

Figure A2. Driving Force of The Rental Prices



Notes: Figure (a) shows the decline in rent is driven by the supply side. Figure (b) shows the decline in rent is driven by the demand side.

Figure A3. Treated vs. Control Cities



Notes: This figure shows the treated vs. control cities. The treated city refers to Irvine, CA, while the control groups are neighboring cities to Irvine, including Tustin, Santa Ana, Costa Mesa, Laguna Woods, Laguna Hills and Newport Beach.