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Is home sharing driving up rents? Evidence from Airbnb in Boston

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ABSTRACT

The growth of the sharing economy has received increasing attention from economists. Some researchers have examined how these new business models shape market mechanisms and, in the case of home sharing, economists have examined how the sharing economy affects the hotel industry. There is currently limited evidence on whether home sharing affects the housing market, despite the obvious overlap between these two markets. As a result, policy makers grappling with the effects of the rapid growth of home sharing have inadequate information on which to make reasoned policy decisions. In this paper, we add to the small but growing body of knowledge on how the sharing economy is shaping the housing market by focusing on the short-term effects of the growth of Airbnb in Boston neighborhoods on the rental market, relying on individual rental listings. We examine whether the increasing presence of Airbnb raises asking rents and whether the change in rents may be driven by a decline in the supply of housing offered for rent. We show that a one standard deviation increase in Airbnb listings is associated with an increase in asking rents of 0.4%.

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1. Introduction

The growth of the sharing economy has received increasing attention from economists. Some researchers have examined how these new business models shape market mechanisms (Einav et al., 2015) and, in the case of home sharing, economists have examined how the sharing economy affects the hotel industry (Gutierez et al, 2016; Zervas et al., 2014). There is currently limited evidence on whether home sharing affects the housing market (Lee, 2016; Barron et al., 2017), despite the obvious overlap between these two markets. As a result, policy makers grappling with the effects of the rapid growth of home sharing have inadequate information on which to make reasoned policy decisions. In this paper, we add to the small but growing body of knowledge on how the sharing economy is shaping the housing market by focusing on the short-term effects of the growth of Airbnb in Boston neighborhoods on the rental market, utilizing individual rental listings.[1] We examine whether the increasing presence of Airbnb raises asking rents and, then, examine whether the change in rents may be driven by a decline in the supply of housing offered for rent.

Supporters of Airbnb argue that home sharing allows residents to earn extra income, enabling some to continue to live in rapidly appreciating housing markets and defray other costs of living.[2] Critics of Airbnb claim that in large cities where the majority of residents are renters, home sharing is increasing rents for tenants.[3] In a recent curated debate on this issue hosted by the New York Times, Nicole Gelinas of the Manhattan Institute argues that once landlords become aware that tenants use Airbnb to earn additional income they can quickly 'cut out the middleman' and directly rent out units on a short term basis.[4] Both sides of the argument are lacking unbiased empirical evidence on this new market phenomenon, a gap that we propose to fill.

This paper makes three primary contributions to the existing economic literature. First, we provide a rigorous empirical investigation of how Airbnb is affecting the rental market in Boston, a city where rents have been growing recently at an average of 5% annually and are among the highest in the nation.[5] Second, we conduct this investigation by combining two new sources of big data: weekly rental listings, available only recently as a result of

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[1] We distinguish the "rental housing market," housing occupied by or offered for rent only for more than 30 consecutive days, from the "home sharing market," housing offered for rent for as little as one day, but also recognize that these can be seen as a single market for accommodation differentiated by term.

[2] https://www.airbnbaction.com/wp-content/uploads/2015/10/Middle-Class-Economic-Report-FINAL.pdf.

[3] "San Francisco is ground zero for an Airbnb freakout," Davey Alba, Wired.com, November 2, 2015.

[4] http://www.nytimes.com/roomfordebate/2015/06/16/san-francisco-and-new-york-weigh-airbnbs-effect-on-rent/airbnb-is-a-problem-for-cities-like-new-york-and-san-francisco.

[5] http://www.bostonmagazine.com/property/article/2016/02/21/boston-expensive/.

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the shift of rental listings to the internet, and data on Airbnb listings made available through web scraping technology. Third, we take advantage of the frequency of the observations available from these large data sets to use a fixed effects model to control for unobserved variables allowing for the calculation of precise estimates of the impacts of Airbnb on rents.

The characteristics of Airbnb listings in Boston provide some evidence supporting both sides of the Airbnb debate. For instance, our analysis shows that in Boston on October 5, 2015, 82% of hosts had only one simultaneous listing on Airbnb in Boston, suggesting that most Airbnb hosts are occupants seeking extra income by renting out their own homes. On the other hand, though only 18% of hosts had multiple properties listed simultaneously in Boston, their properties represented almost half of those listed on Airbnb (46%), suggesting that a large proportion of Airbnb's properties in Boston are leased by commercial operators listing properties that would, presumably, otherwise be occupied by local residents. Ultimately, our analysis supports the contention that home sharing is increasing rents by decreasing the supply of units available to potential residents. Using a hedonic estimation, we show that a one standard deviation increase in Airbnb listings relative to the total number of housing units in a census tract, is associated with an increase in asking rents of 0.4%. For those census tracts in the highest decile of Airbnb listings relative to total housing units, this increase in asking rents is equivalent to 3.1%, which equates at the citywide mean monthly asking rent to an increase of as much as $93. We further find evidence that Airbnb is increasing asking rents through its suppression of the supply of rental units offered for rent. Specifically, a one standard deviation increase in Airbnb listings relative to total housing units is correlated with a 5.9% decrease in the number of rental units offered for rent. At the mean number of rental units offered for rent in a given census tract, 75.8, this equates to 4.5 fewer units offered for rent.

This paper proceeds as follows. The following section provides background on home sharing and reviews the relevant economic literature on rental markets to provide a theoretical basis for this paper's model and method. We then discuss theoretical models that illustrate home sharing's potential effect on the rental housing supply and on asking rents. Next we describe the method we use to estimate these effects on rental housing supply and rents. In the following section we present the data on Airbnb in Boston and provide descriptive statistics of our rental housing data. We then present results. Finally, we conclude and provide thoughts on some of the policy implications of this research.

2. Background and literature review

The internet has enabled the creation of what has become known as the sharing economy, a host of firms based on the peer-to-peer business model (Einav et al., 2015). This model is one form of a two-sided market, a term coined to describe businesses which provide a platform to connect market participants. Unlike some two-sided markets, such as credit card companies, sharing economy platforms are intended for nonprofessional users (Li et al., 2015). One of the most visible components of the sharing economy in the popular press is home sharing, web-based firms that provide a platform that charges both those seeking to lease and those seeking to rent housing for periods as short as one night.

Founded in August 2008, Airbnb.com ("Airbnb") is the largest home sharing enterprise in the world, having hosted more than 60 million guests to date; it currently features over 2 million properties for rent in 191 countries.[6] It is growing rapidly; in New York City, for example, the number of Airbnb listings expanded tenfold from 2010 to 2014 (Schneiderman, 2014) and increased by 24% in Boston between January 2015 and January 2016. Airbnb markets itself to potential tenants as a way for visitors to have a more authentic travel experience by staying with local residents and to potential landlords as a way for local residents to earn extra income by renting out some or all of their home when they're not using it.[7] The speed with which this and similar "home sharing" businesses have changed consumer behavior has left researchers—as well as competitors in the traditional hospitality industry, government regulators,[8] and courts[9]—racing to understand its effects.

Researchers have modeled how the existence of a sharing platform for a good changes both the demand for and the supply of that good (Muller, 2014; Horton and Zeckhauser, 2016). This body of research posits that some utility maximizing consumers who previously chose to own the good in the absence of the sharing marketplace, will choose instead not to own the good, but simply to rent it as needed, when given that option. On the other hand, some consumers that had chosen not to own the good will now buy it, given the opportunity to rent out a portion of it through the sharing marketplace. The net effect on the demand for such goods is therefore indeterminate. The supply for such goods in the newly created sharing market consists primarily of existing resources during periods when such resources are either unutilized, underutilized or when they had previously been utilized for other purposes. Ride sharing companies such as Uber, for instance, have created a market whose supply consists largely of cars during hours when the cars would have otherwise been idle.

This model of the effect of a sharing economy on the demand for the shared good does not adequately represent the effects of home sharing on a local housing market, because for consumers, the home sharing and housing markets are geographically separate. The availability of short-term accommodation through home sharing, which is targeted at those whose permanent housing is located in a geographically separate market, does not impact the consumer's utility for permanent housing in either local housing market. A visitor from New York's decision to rent a room for a night or two in Boston does not make her more or less interested in permanent housing in either city. Instead, it is the source of a home sharing market's supply that might affect that locality's housing market. To the extent that some of the housing offered in the home sharing market would have been offered instead in that locality's housing market, the existence of the home sharing market will affect the supply of housing in that geography.

Empirical research on the effect of home sharing on a local housing market has been limited. Recent work by Coles et al. (2017) documents how Airbnb rentals have spread to a broader set of neighborhoods over time, through the use of data provided directly by Airbnb on New York City neighborhoods, though they find units are still highly concentrated in central city neighborhoods. Additionally, this work finds that Airbnb rentals are less profitable than many assume and have become less so

[6] "About us", Airbnb.com, http://www.airbnb.com/about/about-us, last visited April 20, 2016.

[7] "Airbnb Launches First Global Ad Campaign in Nine Markets," Advertising Age, http://adage.com/article/digital/airbnb-launches-global-ad-campaign-markets/293108/, last visited April 20, 2016.

[8] Pending legislation to regulate home sharing in MA include H 2618, An Act Regulating Short-Term Residential Rentals.

[9] Home sharing's legality varies between jurisdictions and relevant contractual obligations vary between buildings, and even within buildings from unit to unit (Lazarow, 2015). In Boston, some condominium documents forbid leasing units for less than a certain term, often one month, and the Greater Boston Real Estate Board's Standard Form Apartment Lease (Fixed Term) forbids subletting. Despite these legal hurdles, both owners and tenants engage in home sharing, as evidenced by the many websites that offer advice to owners and tenants seeking permission to list on Airbnb, including Airbnb's own site: https://www.airbnb.com/help/article/806/how-should-i-talk-to-my-neighbors–homeowners-association–or-landlord-about-airbnb.

over time.[10] A few researchers have attempted to directly examine how Airbnb is affecting the housing market. Lee (2016) presents a descriptive analysis suggesting that Airbnb is increasing rents in Los Angeles. More recently Barron et al. (2017) use Zillow house price and rental price indices in combination with a panel of Airbnb units they constructed from a set of web scrapes obtained from the website InsideAirbnb.com for a national sample, to examine whether increases in Airbnb units are driving up rents. They find evidence in line with our results, estimating a one standard deviation increase in Airbnb usages increases local rents by 0.6%. We contribute to the literature by relying on individual rental listings data, as well as complete Airbnb web scrapes for a six month period, enabling us to use a hedonic approach to directly estimate the effect of home sharing listings on nearby rents.

Though there is only a small body of empirical research on the home sharing market, there is a broad literature in real estate and urban economics examining determinants of housing price, both purchase prices (Glaeser et al., 2005; Quigley and Rosenthal, 2005; Ihlanfeldt, 2007) and rents (Pagliari et al., 1996; Ambrose et al., 2015; Verbrugge et al., 2016). Researchers typically use hedonic regressions to compare the predictive effect on rents of a variety of unit characteristics, from location to unit age. High quality data on rents has historically been difficult to obtain, but with new sources of big data on rental markets it is easier to learn about this market segment. Researchers have further improved the timeliness of this measure of the flow price of housing by surveying only newly signed lease contracts, rather than the traditional surveys of all existing renters (Glaeser and Gyorko, 2007). Ambrose et al. (2015) found that movements in the widely used Bureau of Labor Statistics' rent index, which is based on a survey of all renters, trailed a rent index based solely on new leases with new tenants by about one year. We build on this approach and use asking rents, which were available at weekly intervals with precise geographic coordinates.

3. Theory

The rental rates for living space exhibits a term structure, with hotels occupying the short end of the rental rate terms structure, weekly furnished housing next and rental housing for residents at the long end.[11] Home sharing targets the short end of the rental rate term structure, competing with hotels, motels and bed and breakfast accommodations on price, convenience, flexibility and opportunities for social connection. Where home sharing offers accommodation at daily rates exceeding those of longer-term rental accommodation, in other words, where there is a home sharing premium, there are several possible outcomes.

First, home sharing could affect only its target market, the short end of the term structure. This would require complete market segmentation; that is, units originally renting at the long end of the term structure cannot be shifted into the short end. But while legal,[12] communication and transactional barriers have traditionally kept these market segments separate, the internet allows home sharing platforms to effectively remove this market segmentation (Schneiderman, 2014).

Second, if home sharing lessors' marginal cost structures and vacancy rates were to allow it, home sharing prices could drop to meet those at the longer end of the residential rent term structure. Data from AirDNA, a firm that assists those listing their homes on Airbnb, suggests that this is not the case, showing that mean Airbnb listing prices have risen in Boston in the year since the start of our study period, August 2015.[13] We find that in October 2015, the mean monthly asking rent for homes requiring a stay of at least a month was $2,972, or $98/night, while the mean asking rent for entire homes listed for rent on Airbnb was $243/night. Thus the Airbnb price premium remains over 100% above the long-term rental market. The average lessor would have to rent out their unit 12 days/month to earn what they would if they had entered into a long-term contract, though recent evidence from Coles et al. (2017) suggests that profits are significantly lower than many expect suggesting units are vacant more than expected.

Third, home sharing could prompt demand substitution. Specifically, some of those who need only sporadic accommodation, perhaps someone who works in town a week or two a month, and previously chose to lease long-term accommodations, could now switch to home sharing which offers a lower total cost to such consumers than previously available short-term options, such as hotels. This is likely a small part of the market for long-term rentals. Even among this small group, this sort of demand substitution is unlikely, given the size of the home sharing premium we discovered in Boston. While there may be some who rent long-term accommodations who only require accommodation in Boston for 11 or fewer nights per month and who, therefore, would reduce the cost of accommodation by shifting from an apartment to Airbnb rentals, the inconvenience and unreliability of this option suggests such demand substitution is rare.

Fourth, the supply of home sharing units could consist solely of vacant units from the longer end of the term structure that are shifted into the home sharing market. With the rental vacancy rate in Boston in 2015 and the first half of 2016 at 3.4%, far below the rate the U.S. Census determined necessary to keep rental rates stable in Boston during that period, which is 5.5%,[14] vacant units are unlikely to comprise a large share of the Airbnb market. However, even if for some reason only owners of vacant units switched their units into the home sharing market, the shift of vacant units down the rental rate term structure would increase pressure on rents just as such a switch of occupied units would, according to the vacancy rate model of rental price changes (which we discuss in more detail below), as it would lead to an even larger gap between the actual and equilibrium rental vacancy rate.

Finally, the home sharing premium could decline and eventually disappear as long-term accommodation prices rise, either as a result of a decreasing supply of or an increasing demand for such housing. We focus our inquiry here. We examine vacant units at the moment would-be landlords choose their preferred point on the rental rate term structure by examining asking rents rather than the rents of existing tenants. Utility maximization theory dictates that if the utility of the owner of a residential housing unit is greater as a result of listing the unit in the home sharing market than as a result of renting in the long-term rental market or leaving the unit unrented, the owner will rent the property in the home sharing market (Muller, 2014).[15] If so, it can be assumed that

[10] Other analyses have focused on describing the types of neighborhoods that benefit from the growth of Airbnb (Quattrone, 2016), identifying the externalities associated with Airbnb (Filippas and Horton, 2017), the appropriate response for planners to the arrival of Airbnb rentals (Gurran and Phibbs, 2017) and the impact of a host's race on the listing price of an Airbnb unit (Kakar et al, 2016).

[11] Massachusetts law allows for a range of terms for residential leaseholds, from licensed rooming or lodging houses with terms of one week, to tenancies established by force of law in the absence of a written lease, so-called tenancies at will, whose imputed term is usually 30 days, to written leases that may specify longer terms, typically one year (M.G.L.c. 186).

[12] This includes both private contractual restrictions, such as lease provisions and condominium rules, and a wide variety of state and local laws, such as M.G.L.c. 140, the state law which licenses hotels, as well as building code requirements, zoning ordinances and tax laws.

[13] https://www.airdna.co/sample/us/massachusetts/boston.

[14] "The Greater Boston Housing Report Card 2016," p. 49, The Boston Foundation, citing U.S. Housing Vacancy Survey Historical Data. http://www.tbr.org/~/media/TBFOrg/Files/Reports/2016%20Housing%20Report%20Card.pdf.

[15] Along with rent, relative market values of these two options would take into account transaction and operating costs such as cleaning the unit, depreciation from

some portion of the housing stock listed on Airbnb would otherwise have been occupied by residents, thereby decreasing the supply and increasing the price of the rental housing units listed for rent. Since Airbnb allows both owners and tenants of a home to list the home for short-term rental,[16] this theory suggests that owners' or tenants' expectations of being able to earn income by subletting their unit through home sharing[17] will increase the demand for long term rental housing.[18] Some owners or tenants will obtain housing in excess of the amount that would have maximized their utility in the absence of the home sharing market and will value units based on the units' perceived marketability in the home sharing market. Because Airbnb allows owners and tenants to offer some or all of their homes for lease,[19] our data does not allow us to identify owners' listings solely with effects on rental housing supply and tenants' listings solely with effects on rental housing demand. A tenant's decision to list one bedroom in his unit on Airbnb prevents that unit from being occupied by a long-term roommate, thereby reducing the supply of residential rental housing. Similarly, an owner may decide to purchase a two bedroom, with the hope of earning extra income renting out the second bedroom, may then decide to post on Airbnb rather than renting out the second bedroom, thereby impacting rental housing supply.

Our hypothesis is that the existence of the home sharing market operates either through changes in the demand for or in the supply of housing, or likely both, to decrease the supply of rental units listed for rent and, thereby, to increase the asking rents of available units.[20] In a partial equilibrium competitive model of rental housing, either the rightward shift of the demand curve for rental housing caused by the potential to earn income from listing a unit with a home sharing site or the leftward shift of the supply curve for rental housing caused by owners' removal of some units from the rental housing market for rent in the home sharing market increases the price of housing, ceteris paribus.[21]

Modeling the effect of home sharing on mean residential asking rents, therefore, requires changing one of the assumptions commonly used by housing economists to study the effects of demand variation on price: that housing supply changes so slowly that it can be assumed to be static when studying short-term effects (Blank and Winnick, 1953). The emergence of the home sharing market represents a significant new source of short-term housing supply variation, at least in some local markets. In fact, the velocity of the aggregate supply variation resulting from the decision of owners to list units for home share rather than rent may exceed that of the standard housing demand variation that results from changes in mean income, family size, etc. In this empirical study, we do not create a model to separately quantify the demand and supply effects of home sharing on the rental market. Instead, we briefly review vacancy rate and search-and-matching models of the housing market to illustrate the assumptions upon which our research is based and to suggest how the new market mechanisms represented by home sharing might fit into existing scholarship.

Models of the effects of changes in excess rental housing demand on mean rents, first developed by David Blank and Louis Winnick (1953) and refined by others (Rosen and Smith, 1983; Gabriel and Nothaft, 2001; Hagen and Hansen, 2010), argue that the mechanism for this effect is the movement of the actual vacancy rate of rental housing relative to the equilibrium vacancy rate. This vacancy rate model relies on the assumption of static supply to derive the actual vacancy rate, AVR, solely from the housing demand function:

$$\mathrm{AVR}_t = 1 - \frac{(d_t(R, U, Y, P, Z))}{S}$$

where demand for rental housing is a function of the price of housing per unit, R; the user cost of homeownership, U; real income per household, Y; the general price level, P; and demographic variables, Z, all at time t, and S is the supply of rental housing, assumed fixed.

We assume instead that both supply and demand are affected by home sharing:

$$\mathrm{AVR}_t = 1 - \frac{(d_t(R, U, Y, P, Z + \theta \mathrm{Airbnb}))}{(S_{t-1} + \mathrm{NC}_t - \delta \mathrm{Airbnb}_t)}$$

where θ is a proportion of Airbnb listings, reflecting the demand effects in the rental market of changes in demand in the home sharing market; δ is the proportion of Airbnb units offered in the home sharing market that would have been offered instead in the rental housing market; and Airbnb is the number of units listed with Airbnb at time t. With the addition of short-term supply variation to the model, we also believe it is necessary to account for changes in housing supply as a result of demolition or new construction since time $t-1$, represented in the model as NC.

Modeling the effect of home sharing on mean residential asking rents also requires accounting for market imperfections, so-called search frictions. The application of search theory, first developed by, among others, Diamond (1982), Mortensen (1982) and Pissarides (1985), to housing provided a theoretical basis for estimating the effect of market changes on price, which some considered insufficiently specified in the vacancy rate model (Wheaton, 1990). Researchers have used search theory to model the sensitivity of housing prices and sales volume to demand and/or supply conditions given imperfect information (Head et al., 2014), as well as to account for the role of brokers (Yavas, 1994). Researchers have also extended this model to rental housing (McBreen et al., 2009). Typically, this research suggests that market tightness, the ratio of vacant homes offered for sale/rent to those seeking to buy/rent, is one of the mechanisms through which demand or supply changes affect price (Novy-Marx, 2009). A decrease in the number of homes offered for sale/rent, relative to the number of individuals seeking to buy/rent, for example, increases the rate of matching for sellers/landlords and decreases the rate of matching for buyers/renters. In this way, an increase in market tightness puts upward pressure on price. Again, we believe home sharing increases market tightness both by decreasing the number of homes offered for rent, as units are shifted from the rental to the home sharing market, and by increasing the housing demanded as a result of the income opportunity offered by home sharing.

4. Methodology

We are interested in estimating the impacts of Airbnb on both rents and the number of rental units available for rent, to see

extra use, resolving disputes, etc., as well as the fee charged by a rental broker or by the marketplace, in this case, Airbnb. We call the residential real estate a housing unit, even though some spaces listed on Airbnb are rooms, not whole units.

[16] Our data does not distinguish between those Airbnb listings posted by owners versus those posted by tenants.

[17] In the case of tenants, they would be considering either listing a portion of the unit, or listing the entire unit when they are away.

[18] This potential demand effect is not trivial: in New York City, for instance, Airbnb estimates that a typical host's annual earnings from using the service is equivalent to 21% of the rent due for the unit listed (Lazarow, 2015).

[19] Our research found that 41.6% of Airbnb listings in Boston in October 2015 consisted of one bedroom or a shared room, rather than the entire home.

[20] An increase in the demand for rental housing may decrease the number of rental units offered for rent by decreasing or eliminating the period a unit remains on the market. Where, as here, the number of units offered for rent is measured weekly, a shorter time on the market reduces the total multi-week count of units offered for rent.

[21] We examine short-term effects. Given the supply restrictions in Boston, we do not attempt to estimate the timing or extent of possible adjustments to decreases in housing supply.

whether Airbnb affects rents through constraining the supply of available rental units. We create a measure of Airbnb 'density' for each census tract in Boston, by dividing the number of Airbnb listings in a census tract by the total number of housing units in that census tract. This approach follows that of Susin (2002) and Sinai and Waldfogel (2005) as they examine the impacts of public rental housing subsidies on the private rental market. In this way we are controlling for differences between tracts in both population and the housing market.

Researchers examining both housing supply and price changes have utilized many different geographies. While some researchers looking at the effect of vacancy rates on rents between cities rely on citywide data, those examining intracity effects often compare neighborhoods, and define 'neighborhoods' to match available demographic, price, vacancy or other data (Dow, 2011; Fujii et al., 2012). Though some have argued that neighborhoods, as measured by census tracts, maybe be too small a geography at which to measure the full market response to a supply constraint (Glaeser and Ward, 2009; Sinai and Waldfogel, 2005) we choose to focus on the census tract to better identify the immediate impacts of Airbnb, understanding that it may not capture the full impact. In addition, recent researchers have found price impacts of housing demand or supply changes at relatively small geographies such as census tracts and have ascribed this to the now widespread use of the internet for home search (Piazzesi et al., 2015). They believe internet home search allows buyers or renters to more narrowly tailor searches to desired geographies.

Research examining the effect of changes in the demand for or supply of housing on residential rents had traditionally used a one year lag between demand/supply changes and changes in rent (Rosen and Smith, 1983; Saiz, 2007). More recently, researchers have examined shorter time frames, given the increased availability of rental data. For instance, Edelstein and Tsang (2007) used quarterly data, while Hagen and Hansen (2010) examined the effect of changes in vacancy rates on rents with a six-month lag. In the years since that research, however, the widespread adoption of the internet by landlords to advertise vacant apartments and by potential tenants to search for homes to lease[22] has increased match efficiency, leading to shorter times on the market (Carillo, 2008), and may have shortened the time necessary for rents to adjust to changes in housing supply. For example, Kashiwagi's (2014) recent model of U.S. housing market dynamics assumes rents adjust substantially in the month following a change in housing supply. With potential landlords widely determining market prices from on-line sites which continuously add new rental listings, we will test the effect of Airbnb use on the asking rents of units listed for rent since our last Airbnb measurement, one month on average.

To estimate the effect of home sharing on mean asking rents we use a hedonic estimation, examining whether Airbnb presence is associated with a higher asking rent in the next time period. We include fixed effects at the census tract level, so that our comparisons are made within census tracts over the six month time period, to control for unobserved neighborhood effects, such as location and demographic characteristics.

We estimate the following regression:

$$\begin{aligned}\mathrm{LnRent}_{it+1c} = {} & \alpha + \beta_1 \mathrm{Airbnb}_{tc} + \beta_2 \mathrm{Bed}_{it+1c} + \beta_3 \mathrm{Bath}_{i+1tc} \\ & + \beta_4 \mathrm{Sqft}_{it+1c} + \beta_5 \mathrm{NC}_{tc} + \delta \mathrm{Month}_t + \eta \mathrm{Tract}_c + \varepsilon_{itc}\end{aligned} \tag{1}$$

where i indexes each unit, t represents the period between Airbnb measurements and c the census tract. LnRent_{it+1c} represents the natural log of the asking rent of the unit, in the period after the observed Airbnb listing. Airbnb_{tc} is the Airbnb density, calculated as the number of units listed on Airbnb divided by the total number of housing units in the given census tract.[23] Bed_{it+1c}, is the listing's number of bedrooms and Bath_{it+1c} is the listing's number of bathrooms. NC_{itc} is the number of newly constructed rental units with the tract which received their certificate of occupancy from the City of Boston in the same time period in which Airbnb units are measured. We also include a set of additional neighborhood characteristics which could have an impact on short term rents. Specifically we include measures of tract level crime, building permit issuances (which are required both for new construction and all but the smallest renovation projects) and restaurant license issuances, as these are all neighborhood amenities that change in a short time period and could also be driving changes in rents. We also include month fixed effects (Month_t) and tract fixed effects (Tract_t).

To estimate whether increases in rents were driven by constraints in the supply of rental housing, we test for a correlation between the mean weekly number of units listed for rent in a given Airbnb measurement period and the Airbnb density measured at the end of that period. The term of residential lease agreements in Boston generally end on the last day of the month and, therefore, require landlords to advertise their units weeks before the day the landlord desires to start a new tenancy. But the term of Airbnb rentals is daily, allowing owners to list their units much closer to the day the landlords' desire an Airbnb customer to occupy the unit. As a result, we anticipate that a landlord's decision to list her unit on Airbnb rather than in the rental market will likely affect the number of units listed for rent in the weeks leading up to listing the unit on Airbnb, not afterward.

Therefore, to estimate the effect of home sharing on the quantity of rental housing offered for rent, we employ the following tract level fixed effects model:

$$\mathrm{LnCountR}_{tc} = \alpha + \beta_1 \mathrm{Airbnb}_{tc} + \beta_2 \mathrm{NC}_{tc} + \delta \mathrm{Month}_t + \eta \mathrm{Tract}_c + \varepsilon_{itc} \tag{2}$$

where $\mathrm{LnCountR}_{tc}$ represents the mean weekly number of units in a census tract offered for rent in the same time period in which we observe Airbnb listings, and all other variables are as described above.

Use of census tract fixed effects removes the effect of static rent differentials between census tracts. In addition, our use of asking rents from the period immediately following each measure of Airbnb density minimizes the risk of reverse causation that could result from simultaneity of Airbnb listings and rents. While relative changes across census tracts in the net revenue differentials between renting and Airbnb listing are assumed to affect owners' decisions whether to rent or list on Airbnb, and thereby affect Airbnb density, this effect should appear in the subsequent Airbnb measure rather than the preceding Airbnb measure.

5. Data

We obtained rental data from Rainmaker Insights, Inc., a service that aggregates listings of housing for rent. These data include a weekly count of each housing unit offered for rent in Boston from September 2015 through January 2016. The dataset includes asking price, square footage, number of bedrooms and bathrooms, location and, in some cases, additional unit characteristics and is obtained from over 5,000 sources including property management companies, rental brokers, newspapers' on-line listings and rental

[22] Piazzesi et al. (2015) cite the National Association of Realtors in stating that 90% of homebuyers reported using the internet in 2013, a figure that seems likely to hold for renters as well and has likely continued to increase since that time.

[23] We have also run this analysis using counts of Airbnb units in a tract and find similar results.

Table 1
Descriptive statistics on rental units.

	Mean	Standard deviation	Count
Price	$2,972	$1,130	113,409
Bedrooms	1.7	1.0	113,409
Bathrooms	1.2	0.4	113,409
Square feet	1,005	471	113,409

Source: Data from Rainmaker Insights, Inc., February 2016.

listing websites that list homes for rent in the U.S. The vast range of sources from which Rainmaker Insights draws suggests that this list is comprehensive throughout our study period. Given the importance of including square footage in our price regression, we have limited our sample for our primary hedonic regressions to those observations where this information was available, which total 113,409 listings. Table 1 shows us that the mean rent during our study period was almost $3,000 with a standard deviation of over $1,000.

To more accurately measure changes in housing supply we use data on new construction, specifically the number of new housing units, which we obtained from the Boston Redevelopment Authority ("BRA"). The BRA data records the date that the City of Boston issued a certificate of occupancy[24] for a new housing unit or that an existing housing unit was deemed no longer available for occupancy as a result of construction.

We also use data from the City of Boston to calculate tract level crime rates, the rate of issuance of building permits, and the rate of issuance of restaurant licenses. Crime rates were calculated using the Boston Police Department's database of incident reports, which represent each report filed by a law enforcement officer for an incident of whatever nature. There were 62,573 incidents during our study period. Building permits are required in Boston both for new construction and for all but minor renovations to existing buildings, both residential, commercial, institutional, etc. There were 32,035 building permits issued by the City's Office of Inspectional Services during our study period. Establishments selling food for immediate consumption are required to obtain a restaurant license. There were 193 issued during our study period. We use the 2010–2014 American Community Survey (ACS) to obtain the population and total number of housing units per census tract.[25]

We obtained data on Airbnb listings in Boston from September 2014 to January 2016 using web scrapes of Airbnb.com, some that we conducted ourselves and some conducted by InsideAirbnb.com and/or its researchers, who obtain and provide data to the public for research purposes. These web scrapes provided the following data: the price and the type of real estate listed (either a room or an entire apartment/home), locational data, in the form of longitude and latitude coordinates, and the Airbnb-assigned identification code for the property and for the lessor. The October 2015 web scrape also provides additional details about listings and hosts. We have limited our regressions to the web scrapes conducted on August 22, September 25, October 3, November 31, December 14, 2015 and January 21, 2016.[26] Table 2 summarizes these data by census tract. We see that the average tract in our sample has 1,600 housing units, 76 rental units listed for rent and 12 Airbnb listings.

Airbnb entered the Boston market in 2009[27] and by the second half of 2015 it averaged over 2,000 listings. Table 3 provides monthly totals for Airbnb listings, measured on a single day each month, and the weekly averages of each month's housing units offered for rent.[28] As of January 2016, Airbnb listings were growing in Boston by 24%, year on year. Fig. 1 shows that with the exception of outer neighborhoods, such as West Roxbury, listings were common across the city.

Airbnb listings, however, are unevenly distributed across census tracts, both in absolute terms and as measured in relation to total rental units.[29] To illustrate this point, we present Airbnb density by decile in Table 4. We measure Airbnb density by dividing the number of Airbnb units listed by the total number of housing units in the tract. Across Boston, Airbnb listings by census tract ranged from zero listings to a maximum of 5% of all housing units.

Using the more detailed October 2015 data, Table 5 describes the units and hosts for Airbnb listings in Boston, averaged across neighborhoods. The first panel of Table 5 shows that most (58%) of the units listed on Airbnb in Boston that month offered the entire home for rent, either free standing house, apartment or condominium, while 39% offered a private room in a home and a mere 2% offered shared space, such as sleeping on a fold out couch in a living room. Even partial unit listings have some potential to impact the City's rental market, as a fraction of a unit might have been occupied by a tenant (an additional roommate) had it not been switched to the home sharing market. The second panel of Table 5, shows that the majority of these units are posted for more than 200 days of the year. These are the units with the greatest potential to impact the long term rental market, as they are units that are decreasing the supply of units available for long term rentals.

One of the most contentious points in the debate over home sharing's effect on housing has been whether these companies merely offer residents a chance to earn extra income by renting out all or a portion of their home that they would not otherwise rent to residential tenants or whether they offer residents a chance to earn more money than they would by leasing or subleasing to residential tenants, thereby reducing the supply of rental housing. The third panel of Table 5 shows that in Boston in October 2015, almost 82% of Airbnb hosts had only a single listing and a mere 3% of hosts had four or more listings. On the other hand, the fourth panel of Table 5 shows that hosts with multiple listings (which some would call commercial hosts), though they comprise a small share of all hosts, listed nearly half, or 46%, of all the units listed for rent on Airbnb. While the data cannot prove the point, it seems likely that a host with two homes for rent on Airbnb in the same city is listing at least some space which would otherwise be rented to residential tenants.

6. Results

We begin by presenting results for Eq. (1), estimating the impacts of Airbnb density on asking rents, in Table 6. In Column 1, Airbnb density is the number of Airbnb listings of all types in the census tract as measured in the Airbnb web scrape immediately preceding the long-term rental unit offered for rent, divided by

[24] Required prior to occupancy by Section 111.1 of the Massachusetts Building Code.

[25] We exclude from our analysis those census tracts within the 9800 code range, which the Census Bureau uses to designate areas with little or no residential population, mostly parks or open water. U.S. Census Bureau, 2010 Census Redistricting Data (Public Law 94-171) Summary File, http://www2.census.gov/geo/pdfs/reference/GTC_10.pdf.

[26] The scrapes conducted in July, August, September come from InsideAirbnb. The scrapes conducted in October, November, December and January were conducted by us. In order to ensure that our methodology matched that of InsideAirbnb, we consulted with Tom Snee of InsideAirbnb to try to replicate his approach as closely as possible.

[27] Airbnb.com. http://blog.airbnb.com/airbnbs-positive-impact-boston/?_ga=1.15, accessed on 11/9/2015.

[28] We present weekly averages as November includes 5 weeks, whereas all other months include only 4 weeks.

[29] Because the number of total rental units is surveyed between 2010 and 2014, a period of some renewed growth of residential housing in Boston after the 2008 recession, these ratios may be slightly overstated.

Table 2
Descriptive statistics on Airbnb and rental units by census tract.

	Mean	Standard deviation	Count
Total housing units	1,638	618	832
# of Airbnb listings	11.7	13.5	832
Newly constructed units	1.4	16.4	832
# of rental units listed for rent (weekly)	75.8	100.5	832
Airbnb density	0.007	0.007	832

Airbnb Density = # of Airbnb listings by census tract/# of housing units in that census tract.
By the authors from Airbnb data from Insideairbnb.com, January 2016, http://www.insideairbnb.com/get-the-data.html and original data and from housing unit data from the United States Census Bureau/American FactFinder. B25001: Housing Units." *2010–2014 American Community Survey*. U.S. Census Bureau's American Community Survey Office, 2015. Web. 31 January 2016. http://factfinder2.census.gov.

Table 3
Airbnb listings and housing units offered for rent (by month).

Date	Airbnb	Units for rent (weekly average)	Mean asking price/night
July 2015	2,058		
August 2015	1,794		
September 2015	2,187	15,102	$2,750
October 2015	2,316	12,957	$2,786
November 2015	2,033	12,468	$2,811
December 2015	1,803	11,740	$2,824
January 2016	2,143	10,783	$3,028

By the authors from Airbnb data from Insideairbnb.com, January 2016, http://www.insideairbnb.com/get-the-data.html and from the authors.
The count for Units for Rent are the sums of four weekly readings each month.

Table 4
Airbnb density (by decile).

Decile	Airbnb density
1st	0.003
2nd	0.005
3rd	0.007
4th	0.009
5th	0.011
6th	0.014
7th	0.016
8th	0.018
9th	0.021
10th	0.050

Airbnb Density = # of Airbnb listings by census tract/# of housing units in that census tract.
By the authors from Airbnb data from Insideairbnb.com, January 2016, http://www.insideairbnb.com/get-the-data.html and original data and from housing unit data from the United States Census Bureau/American FactFinder. B25001: Housing Units." *2010–2014 American Community Survey*. U.S. Census Bureau's American Community Survey Office, 2015. Web. 31 January 2016. http://factfinder2.census.gov.

Table 5
Description of Airbnb listings (October 2015).

Room type	# of listings	Column%	Mean price/night
Entire home/apartment	1,345	58.4%	$226
Private room	913	39.4%	$96
Shared room	50	2.2%	$70

Listings by # days available	# of listings	Column%
≤100 days	682	26.7%
101–200 days	310	12.1%
>200 days	1,566	61.2%

Host's by # of listings	# of hosts	Column%
1 listing	1,246	81.7%
2 listings	163	10.7%
3 listings	16	3.7%
≥4 listings	44	2.8%

Listings by type of host	# of listings	Column%
Host w/1 listing	1,246	53.8%
Host w/2 listings	326	14.1%
Host w/3 listings	171	7.4%
≥4 listings	574	24.8%

By the authors from data drawn from Insideairbnb.com, January 2016, http://www.insideairbnb.com/get-the-data.html.

the total number of housing units in that tract. This is followed by characteristics of the long-term rental unit: the unit's total square footage in thousands, its number of bedrooms and its number of bathrooms. New construction represents the total number of units that received their municipally-issued occupancy permits in that census tract during the period between the previous two Airbnb scrapes in hundreds of thousands. We include both time and tract fixed effects, in order to control for any time trends or tract level unobservable characteristics. The standard errors are clustered at the tract level.[30]

We find evidence that Airbnb density does appear to raise rents. Specifically, to describe the magnitude of the 0.627 coefficient on Airbnb density, a one standard deviation increase in Airbnb den-

[30] We have constructed a similar analysis using Zillow rental price indices, relying on the September 2014 and September 2015 Airbnb web scrapes and find similar results. Given our small sample size, of 54 observations and 27 zip codes, results from this analysis are not statistically significant. These results, though not statistically significant, are consistent with the estimates of Barron et al. (2017) who use a national dataset over a longer time period and find that a one standard deviation increase in the presence of Airbnb raises the rental price index by 0.6%.

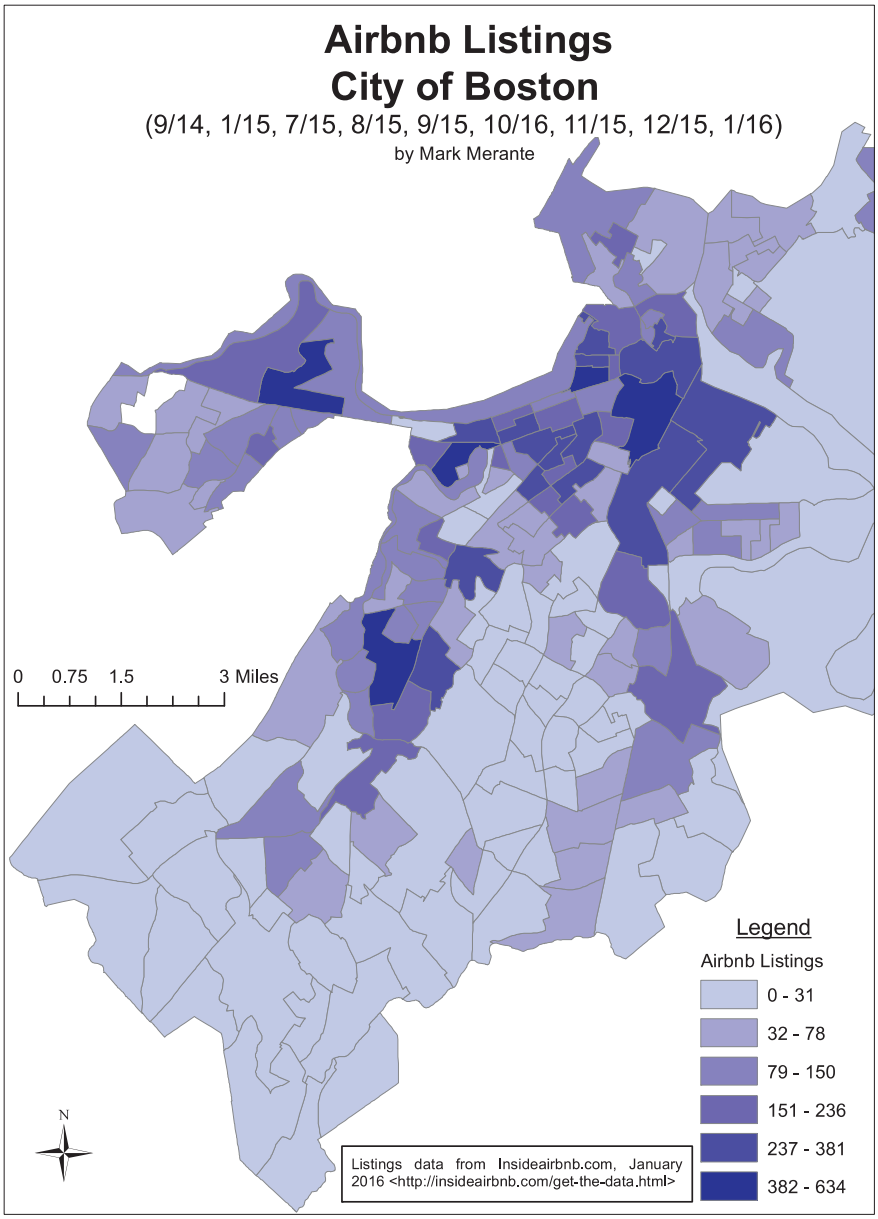

Fig. 1. Map of Airbnb listings by census tract.

sity in a given census tract raises asking rents by 0.4%. For those census tracts in the highest decile of Airbnb listings relative to total housing units, this is an increase in asking rents of 3.1%, which equates at the citywide mean monthly asking rent of $2,972 to an increase of as much as $93 in mean monthly asking rent. As expected, unit characteristics have large effects on asking rents, with each additional bedroom increasing asking rents by 17% and each additional bathroom increasing asking rents by 11%.

Our approach of using individual rental listings offered for rent in the time period immediately following the Airbnb scrapes in combination with tract fixed effects allows us to closely identify the relationship between Airbnb listings and asking rents. This approach also helps us rule out many threats to identification, such as larger changes occurring at the city level, as we rely on neighborhood level variation for our identification. Where our approach may suffer from omitted variables bias is if other neighborhood characteristics are changing at the same time that Airbnb listings are changing, and thus our Airbnb density coefficient could be identifying these other neighborhood level changes rather than the causal impact of Airbnb on asking rents.

Perhaps the most likely source of omitted variable bias is change in neighborhood popularity, real or perceived. If, for example, a neighborhood's desirability increases due to improving amenities this may increase demand at both ends of the residential rate term structure, as both visitors and long-term residents are attracted to a location by the same nearby amenities. To control for this potential source of endogeneity, we include three indicators of neighborhood change. Recent research suggests that falling crime rates are among the most powerful factors in attracting new residents to inner city neighborhoods, at least for high income and college educated Americans (Ellen et al., 2016). Therefore, we first calculate a monthly crime rate for each census tract using Boston Police Department incident reports. We measure crime as the total number of incident reports in each census tract between the previous two Airbnb scrapes, divided by the number of days in that period, then divided by the census tract's total population. Second, we track neighborhoods' physical improvements by calculating the

number of building permits per resident for each census tract. Here, permits are for both new construction and all but the smallest renovation projects for both commercial and residential property.[31] Building permits is the number of building permits issued by the City in the period between the same two Airbnb scrapes, divided by the number of days in that period and, finally, divided by the census tract's number of total housing units. Third, we track an important urban neighborhood amenity, nearby restaurants, using data on the City's issuance of restaurant licenses. Restaurant permits is the number of restaurant permits issued by the City in the period between the same two Airbnb scrapes, divided by the number of days in that period and, finally, by the census tract's total population.

We present these results in Column (2) of Table 6. We see that with these additional controls the coefficient on Airbnb density is slightly larger and still significant at the 5% level, further building confidence that we are isolating the relationship between Airbnb presence and asking rents. Of course there are still other changes that could be taking place at the neighborhood level which we cannot measure that could be biasing these results, though we believe these are the most salient.[32]

Another important feature of Airbnb listings is that they may offer a single bedroom for rent, rather than an entire unit. By definition, none of these single bedroom listings impact the long-term market for studio apartments and few if any impact the one bedroom market: it would be unusual to rent out the bedroom in a one bedroom unit rather than the entire unit. As 39.4% of Airbnb listings in our sample offer only a room for rent, rather than the whole home, our theory predicts that this significant share of Airbnb listings has little if any effect on the long-term studio and one bedroom market. Units with at least two bedrooms, however, are impacted by both single bedroom and entire unit listings. As a result, the long-term market for homes of two or more bedrooms is potentially impacted by all Airbnb listings, whereas that for studios and one bedroom units are potentially impacted only by a portion of Airbnb listings, namely those offering entire homes for rent.

In Columns 3 and 4, we examine the relationship between Airbnb listings and asking price for two groups of units for rent: studio and one bedroom units (column 3) and units with two or more bedrooms (column 4). In Column (3) we see that the relationship between Airbnb density and the asking prices of studio and one bedroom units is no longer statistically significant (though it is marginally significant at the 15% level), while that between Airbnb density and the asking prices of two or more bedroom units is both larger than that for all units (column 1) and is now statistically significant at the one percent level. It is important to note that the size of the coefficients and the standard errors in these two regressions are only slightly different, and therefore we must be careful drawing too strong a conclusion from this variation.[33]

As a further robustness check we test for the possibility of reverse causality between rents and Airbnb listings. As rents rise, as they did in Boston during this period, it's possible area residents become more likely to seek additional income by renting some or all of their homes on Airbnb, thus it is possible that our results are picking up the impacts of rising rents on usage of Airbnb rather than the other way around. As a test of this, we regress Airbnb density on log of asking rent as measured in the web scrape that follows that rental listing, both one month and two months later, and present results in Table 7. In column (1) we measure Airbnb density in the month following the rental listings, and find no statistically significant correlation between asking rents and subsequent Airbnb listings. In column (2) we include our additional set of neighborhood controls, and again find no statistically significant relationship. In column (3) we measure Airbnb density two months following the rental listings, to see if there is a longer lead time between increasing rents and number of Airbnb listings and again find no statistically significant relationship here. In column (4) we again include the full set of neighborhood controls and continue to find no statistically significant relationship. Again, this builds further confidence that the relationship is working through the mechanisms we describe above.

Next, we examine our proposed mechanism for the relationship between Airbnb density and rents; that this relationship is the result of Airbnb listings leading to a reduction in the supply of rental housing offered for rent. We construct a census tract level dataset for this piece of the analysis, and add back in all units provided by Rainmaker Insights, including those with missing data on unit square footage, bedrooms or bathrooms. We then create a count of the total number of units listed for rent in each census tract in the same time period we measure Airbnb density. We regress the natural log of the total number of rental units offered for rent in the period since the previous Airbnb measurement on Airbnb density, again incorporating both time and tract fixed effects. The standard errors are clustered at the tract level. We present results in Table 8.

Based on our estimates from columns (1) we find that a one standard deviation increase in Airbnb density is correlated with a 5.9% decrease in the number of rental units offered for rent. At the mean weekly number of units offered for rent per census tract, this represents a reduction of 4.5 units. This matches the reduction in rental units caused by Airbnb use that our breakdown of Airbnb units predicts. There, we found that 46.3% of the units on Airbnb are listed by residents with more than one unit listed for rent on Airbnb in Boston at the same time. If every one of those units would have been offered for rent in the absence of Airbnb, this would predict a mean reduction of 5.4 units. In column (2) we present results with our full set of neighborhood controls, again finding similar results. And in columns (3) and (4) we split our sample of rental units by 0–1 bedroom units and 2+ bedroom units, just as we did in Table 6, and again find that effects are stronger for the 2+ bedroom segment of the market, though again coefficients and standard errors for these two markets are quite similar, so we cannot put too much weight on these differences.

These results confirm a relationship between Airbnb use and the supply of long-term housing offered for rent, one similar to that suggested by two descriptive New York[34] and San Francisco[35] reports. In general, Airbnb use in Boston is smaller than that in New York and San Francisco, in both absolute terms and relative to each city's total housing supply. For example, in New York City, researchers found that the number of Airbnb listings in four of that city's zip codes exceeded 20% of the total number of housing units. In Boston, no census tract had Airbnb listings greater than 5% of that tract's total housing units. Given the more limited use of Airbnb in Boston, therefore, our results likely present a lower

[31] The City of Boston issues certificates of occupancy (COO) to buildings, not the individual housing units therein. Therefore, our Newly Constructed Units variable counts the number of newly constructed residential rental units in buildings that have received COOs while our Building Permits variable includes all COOs (residential, commercial, mixed, etc.).

[32] We have also created an additional control for Airbnb density in bordering census tracts, and find that our results are consistent and standard errors slightly narrower when we include this variable. The coefficient on Airbnb density in bordering census tracts, however, is never statistically significant.

[33] We have also run our analysis for quintiles and terciles, by bedroom type, and find no evidence that this relationship is driven by a particular price point in the housing market.

[34] "Airbnb in NYC Housing Report, 2015," New York Communities for Change. Real Affordability for All, nycommunities.org.

[35] *Policy Analysis Report*, Budget and Legislative Analyst's Office, Board of Supervisors, City and County of San Francisco, May 23, 2015.

Table 6
Regression of log of asking rents on Airbnb density.

	(1) All units	(2) All units	(3) 0–1 BR units	(4) 2 + BR units
Airbnb density	0.627** (0.306)	0.704** (0.300)	0.588 (0.418)	0.877*** (0.310)
Bedrooms	0.171*** (0.009)	0.171*** (0.009)	0.125*** (0.016)	0.154*** (0.008)
Bathrooms	0.112*** (0.010)	0.112*** (0.010)	0.0769* (0.042)	0.107*** (0.012)
Sqft. (per 1000)	0.132*** (0.019)	0.132*** (0.019)	0.124*** (0.040)	0.123*** (0.019)
New construction (per 100,000 units)	−0.742 (2.318)	−0.381 (2.343)	−0.459 (4.717)	−1.473 (1.846)
Crime (per resident)		0.021 (0.049)		
Building permits (per housing unit)		−0.002 (−0.019)		
Restaurant licenses (per resident)		0.295 (0.412)		
Constant	7.373*** (0.015)	7.368*** (0.018)	7.471*** (0.053)	7.413*** (0.017)
N	113,409	113,409	50,306	63,103
Month fixed effects	X	X	X	X
Census tract fixed effects	X	X	X	X

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Sources: Airbnb data from Insideairbnb.com, January 2016, http://www.insideairbnb.com/get-the-data.html and from the authors. New construction data from the Boston Redevelopment Authority. Rental listing data from Rainmaker, Insights, Inc. Crime, building permit and restaurant license data from the City of Boston, December 2016, https://data.cityofboston.gov/.

Table 7
Regression of Airbnb density on log of asking rents.

	(1) Airbnb density + 1 month	(2) Airbnb density + 1 month	(3) Airbnb density + 2 month	(4) Airbnb density + 2 month
Log of asking rent	0.0001 (0.0001)	0.0001 (0.0001)	−0.00001 (0.0001)	−0.00001 (0.0001)
Constant	0.010*** (0.001)	0.010*** (0.001)	0.013*** (0.001)	0.010*** (0.001)
N	103,881	103,881	78,743	78,743
Month fixed effects	X	X	X	X
Census tract fixed effects	X	X	X	X
Unit controls	X	X	X	X
New construction	X	X	X	X
Neighborhood controls		X		X

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Notes: Unit controls include number of bedrooms, bathrooms and unit square footage. Neighborhood controls include crime, building permits, and restaurant licenses.
Sources: Airbnb data from Insideairbnb.com, January 2016, http://www.insideairbnb.com/get-the-data.html and from the authors. New construction data from the Boston Redevelopment Authority. Rental listing data from Rainmaker, Insights, Inc. Crime, building permit and restaurant license data from the City of Boston, December 2016, https://data.cityofboston.gov/.

Table 8
Regression of log of number of units for rent on Airbnb density.

	(1) All units	(2) All units	(3) 0–1 BR units	(4) 2 + BR units
Airbnb density	−8.366** (4.040)	−7.303* (4.180)	−6.379 (4.217)	−8.882** (4.282)
Constant	2.947*** (0.034)	2.850*** (0.072)	1.925*** (0.039)	2.458*** (0.039)
N	832	832	832	832
Month fixed effects	X	X	X	X
Census tract fixed effects	X	X	X	X
New construction	X	X	X	X
Neighborhood controls		X		

Standard errors in parentheses
*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$
Notes: Neighborhood controls include crime, building permits, and restaurant licenses.
Sources: Airbnb data from Insideairbnb.com, January 2016, http://www.insideairbnb.com/get-the-data.html and from the authors. New construction data from the Boston Redevelopment Authority. Rental listing data from Rainmaker, Insights, Inc. Crime, building permit and restaurant license data from the City of Boston, December 2016, https://data.cityofboston.gov/.

bound on the impacts of Airbnb on local rental markets for cities like San Francisco and New York where Airbnb use is greater as a share of total housing supply. Importantly, these results are in line with those presented by Barron et al. (2017), which also makes a serious effort to identify the causal impacts of Airbnb on the rental market relying on a national sample.

7. Conclusions

This paper makes three contributions to the existing literature. First, it provides one of the first rigorous empirical explorations of an interesting new feature of the housing market, home sharing. Second, it relies on a novel use of two forms of big data to examine the impacts of home sharing on the rental housing market, weekly rental listings and Airbnb listings. Third, it relies on the short time frames that are possible when using new sources of big data to use a fixed effects model to identify potentially casual links between Airbnb use and the rental housing market. Specifically, we find a one standard deviation increase in Airbnb density leads to a 0.4% increase in local rents.

It is important to highlight that though we do our best to identify whether the relationship between Airbnb usage and rents is causal, through relying on a short time frame in conjunction with big data, the use of tract fixed effects, the inclusion of additional

neighborhood level controls and a direct test of reverse causality, there are still many sources of bias we cannot rule out. It is possible that other factors could be driving both Airbnb usage and increases in neighborhood rents, but we have done our best to rule out those causes most often cited, specifically decreasing crime, increasing development and residential improvements, as well as increasing presence of restaurants which act as a signal of the overall desirability of the neighborhood.

If Airbnb growth persists at current growth rates, use will double in Boston in a little more than three years. We do not attempt to predict the duration of the correlations between Airbnb and either the asking price or the supply of long-term housing offered for rent, this will depend largely on how the city responds to growth in Airbnb. As noted, our results do not allow us to distinguish between the supply and demand effect of Airbnb on either the asking prices or on the supply of long-term housing offered for rent. Further research that separates the demand and supply effects may help to predict the duration of these effects. In a long run perfectly competitive market, home sharing driven rental housing price increases would lead to increases in supply. But residential housing supply is severely restricted by limited resources, both of developable land, construction materials and labor and by Boston's notoriously restrictive land use regulations. The price effect of either decreasing supply or increasing demand in Boston's imperfectly competitive housing market, therefore, may be persistent. In a city where the demand for rental housing is outpacing supply and pushing up rents quickly, home sharing is contributing to this dynamic and deserves both further research and policy attention.

As policy makers consider whether and how to respond to the rapid rise of home sharing, these findings provide evidence that home sharing is both a personal and a commercial enterprise and should be regulated and taxed as such. Several jurisdictions have recently adopted or considered legislation that seeks to differentiate between these categories of home sharing providers in order to regulate and/or tax commercial users. For cities particularly concerned about the availability and/or price of residential housing, these results will strengthen the arguments for using such regulation and/or taxation, or alternative methods, to limit home sharing activity in certain neighborhoods. On the other hand, these results emphasize the need for both further theoretical and empirical analysis of the social welfare implications of home sharing, such as whether Airbnb enables middle income families to remain in their homes in rapidly appreciating housing markets.

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