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SAFETY REVIEWS ON AIRBNB:
AN INFORMATION TALE

Aron Culotta
Ginger Zhe Jin
Yidan Sun
Liad Wagman

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ABSTRACT

Consumer reviews, especially those expressing concerns of product quality, are crucial for the credibility of online platforms. However, reviews that criticize a product or service may also dissuade buyers from using the platform, creating a potential incentive to blur the visibility of critical reviews. Using Airbnb and official crime data in five major US cities, we find that both reviews and personal experiences concerning the safety of a listing's vicinity decrease guest bookings on the platform. Counterfactual simulations suggest that a complete removal of vicinity safety reviews (VSR) could hurt guests if they do not adjust their beliefs accordingly, and such removal can increase revenues from reservations on Airbnb, with positive sorting toward listings formerly with VSR. Conversely, highlighting VSR would generate opposite effects. However, the incentive to suppress VSR can be mitigated if guests have a rational expectation of average vicinity risk after all VSR are removed or if guests can learn from their own vicinity safety experience for a long enough time. Because VSR are more closely correlated with official crime statistics in low-income and minority neighborhoods, our findings suggest that suppressing or highlighting VSR would have different effects on different neighborhoods.

Aron Culotta
Tulane University
aculotta@tulane.edu

Ginger Zhe Jin
University of Maryland, College Park
Department of Economics
and NBER
ginger@umd.edu

Yidan Sun
Illinois Institute of Technology
ysun100@hawk.iit.edu

Liad Wagman
Rensselaer Polytechnic Institute
Lally School of Management
wagman@rpi.edu

1 Introduction

Addressing negative information about product quality is a classic problem facing business managers. For example, tobacco manufacturers were reluctant to reveal the health risks associated with cigarettes, pharmaceutical manufacturers may hesitate to acknowledge side effects found in clinical trials, and SUV producers did not publish detailed data on SUV rollover risks until the government threatened regulation (Juni et al., 2004; Fung et al., 2007). Behind these examples is the concern that negative news about product quality may reduce demand for the focal product or category, and this market-reducing effect may dominate any market-stealing effects one may obtain by being less negative than competitors.

Digital platforms are better positioned to address this thorny problem because they are open to sellers of *all* types of product quality that meet their standard. Since platforms can earn commission from any sales on the platform and consumers are willing to pay more for better quality, platforms have incentives to help consumers discern high-quality products from low-quality ones. This explains why nearly all digital platforms gather consumer feedback in a standardized format, make it available globally, and aggregate it in a way that is salient and easy to digest and search, if they so choose (see reviews by Einav et al., 2016; Tadelis, 2016; Luca, 2017). This, in turn, can attract high-quality sellers to join the platform and encourages on-platform sellers to maintain high quality, forming a virtuous circle.

However, is there a limit to this market driven solution? Is it possible that digital platforms do not always have the incentive to fully reveal and highlight critical feedback of product quality?[1] For example, suppose all consumers expect some minimum quality from every product listed on the platform, but some unlucky consumers have experienced below-minimum quality from a small number of listings. In this scenario, the platform may choose from a spectrum of information policies: At one extreme, it may disallow any critical feedback about the substandard experience in its online review system (while finding non-public ways to compensate the unlucky consumers or punish the sub-standard sellers); if the negative experience is rare enough, other buyers may not find it out by themselves for a long time. At the other extreme, the platform may encourage and broadcast the critical feedback and alert every future consumer of the sub-standard risk. Between the two extremes, the platform may allow critical feedback but make it hard to find, or filter the content of the feedback before posting.

From a platform's perspective, the key economic tradeoff is how surprising the negative experience is and how quickly that experience—if it is reflected in an authentic review—can find its way to influence the platform's future business. Intuitively, the bigger the negative surprise and the more the future readers of the review may extend that negative surprise to other listings on the platform, the more harmful the review could be for the platform. For example, a buyer who gets burned by paying thousands of dollars for a counterfeit product may infer that all sellers that share a certain attribute with the cheating

[1] Recent examples of platform choice of which information to avail to users include YouTube, which has adopted a policy of hiding dislike counts on shared videos (see, e.g., `https://rb.gy/xhhqnd`), and Instagram, which has given users the option of hiding likes (see, e.g., `https://rb.gy/tacuj5`).

seller also sell counterfeits. If this buyer—and everyone else equally alerted by her experience—choose to switch away from the platform rather than switch toward other on-platform sellers that do not share this problematic attribute, the platform could lose significant business in the future.

Conversely, online review systems often suffer from information frictions. The probability of experiencing a negative event may be small for any individual buyer; the degree of the shock may depend on the subjective opinion of the buyer; some burned buyers may be reluctant to leave a negative review (even if they choose to exit the platform); some negative reviews may not be read by all future buyers; and some readers may have difficulty deciphering the real content of a review as they believe some reviews are fake or misleading but cannot tell which is which (Gandhi et al., 2025). When these frictions add up to mute the negative surprise from most future buyers, a profit-maximizing platform may prefer to keep these frictions or even add more obfuscation into the system, as long as it can still maintain sufficient credibility with future buyers.

In short, whether to encourage or discourage critical feedback on a digital platform depends on how much negative information spillover the feedback may generate for the platform—both concurrently and in the future—after taking into account the information frictions in its online review system and the potential of consumers learning from both their own experiences and other channels beyond online reviews.

In this paper, we use safety reviews on Airbnb as an example to understand why and when critical feedback about product quality can create the aforementioned tradeoff for the platform. In particular, we use all Airbnb listings in five major US cities (Atlanta, Chicago, Los Angeles, New Orleans, and New York City) from 2015/7 to 2019/12 and a Lexicon approach to identify safety reviews posted by Airbnb guests. We find that 0.51% of the 4.8 million guest reviews express concerns about safety, among which 48.08% are about safety issues near but outside the focal property (such as local crime, referred to as vicinity safety reviews, or VSR) rather than safety issues inside the property (such as a slippery tub or compromised lock, referred to as listing safety reviews, or LSR). Both VSR and LSR are significantly more negative in sentiment than an average review, which is not surprising as guests that have *chosen* to stay at a dwelling owned or managed by an anonymous host usually assume the neighborhood and property are reasonably safe.[2] A comparison with official crime statistics further suggests that the VSR, though noisy and subjective, do reflect real safety risks in the related zip codes to some degree.

In general, critical consumer feedback may generate at least two information spillovers on a digital platform: first, buyer A's critical feedback on product listing X may deter herself and other buyers from buying X in the future. This "within-listing-cross-buyer" effect is typical in a reputation system and is well-studied.[3] Second, a poor experience with listing X may motivate buyer A to give critical feedback

[2]Almost no hosts would volunteer to discuss safety in their listing descriptions because any mention (even the phrase "perfectly safe") may call guest attention to safety concerns.

[3]See reviews by Bajari and Hortacsu (2004); Tadelis (2016); Einav et al. (2016).

to X and reassess other buyers' similar critical feedback toward other listings or even the whole feedback system. This "cross-listing-within-buyer" effect is often omitted because Bayesian updating assumes that learning from others' experience is the same as learning from self experience if the information has the same accuracy. However, in practice, self experience can be much more salient to an individual. Few researchers have quantified the second spillovers explicitly; one exception is Nosko and Tadelis (2015), who show that buyers that have bought from a more (less) reputable seller on eBay are more (less) likely to return to the platform to transact with *any* sellers, above and beyond the likelihood to transact with the same seller that created that good (bad) experience.

While both VSR and LSR are likely to be feedback that criticizes an Airbnb listing, we highlight their differences in a few ways. By definition, LSR are about safety issues inside the listed property, which is under the control of the host and can be addressed by changing the structure or amenities inside the property. It is hard to imagine that guests would blame the host of listing Y for the LSR of listing X (assuming the hosts of the two listings are unrelated). However, the host cannot do much about safety in listing X's vicinity. The VSR associated with X may inform guests of the vicinity safety risk of nearby listings, which is a built-in spillover due to geographic proximity. In comparison, the "cross-listing-within-buyer" effect may occur regardless of geographic distance. Specifically, buyer A's self experience of vicinity safety issues associated with listing X may lead A to recognize that similar negative shocks may be behind all VSR written by other guests on other listings. Arguably, a similar logic could apply to LSR as well, but the host's ability to address LSR can mitigate the negative spillover of LSR. Over time, guests may recognize that past LSR on a listing are no longer relevant if the host had fixed the issues and subsequent reviews were positive.

Empirical evidence supports the presence of both "within-listing-cross-buyer" and "cross-listing-within-buyer" spillovers. In particular, when we follow the same listings before and after they receive any VSR or LSR, there is a significant drop in the listings' monthly occupancy rates as well as average paid prices per night. The effect on occupancy is stronger for LSR (-2.41%) than for VSR (-1.45%) but the effect on price is comparable (-1.47% for VSR and -1.46% for LSR). Robustness checks that compare similar listings with and without safety reviews confirm that these effects are likely driven by the random arrival time of VSR or LSR, rather than omitted local demand or supply shocks. These findings suggest that prospective guests are concerned about both listing and vicinity safety, and seem more sensitive to LSR than to VSR.

In addition to this classical "within-listing-cross-buyer" effect in listing reputation, we also find significant "cross-listing-within-buyer" effects for VSR and LSR. In particular, we compare the guests that wrote VSR on Airbnb (referred to as VS guests) with the non-VS guests that booked similar listings (in terms of crime and VSR) with similar frequency but never wrote any VSR in our dataset. A difference-in-differences (DID) analysis finds that VS guests are 60.07% less likely than non-VS guests to book future stays on Airbnb after posting the VSR, and when they do book on Airbnb, they tend to book in areas with fewer official crimes, fewer overall VSR, and a lower percentage of listings with any VSR. The learning is weaker if the focal listing that triggered the VS guest's VSR had previously received any VSR from other guests, but even in this case, the VS guests are still 51.62% less likely to book future stays on Airbnb after posting their own VSR. This suggests that self experience is much more salient than reading other guests' VSR; thus, the online review system is not fully effective as far as conveying all the information embedded in VSR. When we conduct a parallel exercise for guests that have written LSR (as compared to similar guests that have not written LSR), we find effects in the same direction but of a lower magnitude, suggesting that both LSR and VSR have a "cross-listing-within-buyer" effect, but the negative spillover of VSR is greater. The finding that VSR have a greater "cross-listing-within-buyer" effect but a lower "within-listing-cross-buyer" effect than LSR suggests that VSR generate a greater negative shock in self experience than LSR.

Given these results, there is a possibility that the second type of information spillover, namely VS guests' stronger reactions to their own vicinity safety experiences (the cross-listing-within-buyer effect), may undermine a platform's incentives to post and highlight VSR as critical feedback. This could occur because the platform's information policy may affect how a VS user's negative self experience may change other guests' belief about the VSR they read on the platform without self experience. Interestingly, in a recent policy change that took effect on December 11, 2019, Airbnb announced that, going forward, guest reviews about listings that include "content that refers to circumstances entirely outside of another's control" may be removed by the platform.[4] This policy change, despite no evidence of strict enforcement, suggests that Airbnb is willing to consider a separate information policy for VSR, apart from the traditional collection and posting policy for LSR and other listing attributes under the host's control.

This consideration, along with the differential information spillovers we have documented for LSR and VSR, motivate us to examine what would happen for guests, hosts, and the platform should Airbnb implement one of four counterfactual information policies for VSR: (i) eliminating all VSR while assuming no belief update among guests ("no disclosure no belief update"), (ii) eliminating all VSR but allowing guests to form rational belief of average VSR risk conditional on observable listing attributes ("no disclosure but with rational belief"), (iii) alerting all guests to the existing VSR and making them as informed as those that have written VSR themselves ("high alert"), and (iv) keeping the information system as is but removing listings with 1+ or 2+ VSR ("listing removal").

To conduct the counterfactuals, we incorporate competition between Airbnb and other short-term lodging options, as within- and cross-platform sorting would have different implications for platform revenue. To account for such competition, we use a discrete choice model to estimate consumer utility from each Airbnb entire-home listing, while treating VRBO listings and hotel stays in the same city-month as the outside good. We then use the structural estimates to quantify consumer surplus and Airbnb GBV under the status quo of our sample (i.e., VSR are largely permitted) versus the four counterfactual

[4] See, e.g., `https://rb.gy/0pu5ck` and `https://rb.gy/9y6bum`.

regimes.

Because VS guests are rare and we cannot track these guests in the data over time until they have continued to book on Airbnb and leave another review (with these actions being endogenous), the discrete choice model cannot identify how the self-experience of VSR affects future booking by VS guests. To address this problem, we use our DID estimate of the "cross-listing-within-buyer" effect of VSR to calibrate the coefficient of VSR in the utility function, which measures how much bigger the shock of VSR in self experience must be—relative to reading VSR written by other guests—to justify the future booking behavior of VS guests as observed in the raw data. This calibration enables us to distinguish between the actual utility a guest may obtain from a listing with VSR and the utility that the guest perceives at the time of booking.

Compared to the status quo, we find that not disclosing VSR and no belief updates upon VSR removal would decrease consumer surplus in the market by 1.183% and increase Airbnb's gross booking value (GBV) from the sample cities by 0.327%. This occurs because the no-disclosure policy generates a positive sorting toward listings formerly with VSR, away from listings without VSR and listings off Airbnb. Interestingly, the perverse incentive to suppress VSR can be mitigated if we allow guests to form a rational belief of the average VSR risk conditional on observable listing attributes. In that case, the decline in consumer surplus is less (-0.993%) because VSR removal reminds guests of average VSR risk, which generates a negative information shock to listings without VSR, and motivates guests to shift demand away from Airbnb, although the positive information shock brings more bookings to listings with VSR. In sum, the two countervailing forces reduce Airbnb's overall GMV by 0.047% and thus discourage the platform from adopting a no-disclosure policy. In both no-disclosure regimes (with or without guests' belief updates), the effects can be softened if we allow listings to change their price up to 1%, depending on whether the counterfactual policy brings a negative or positive information shock to specific Airbnb listings.

Conversely, if Airbnb highlights VSR and makes all guests as informed as those that have written VSR themselves, the high alert would increase consumer surplus in the market by 9.599% to 10.340% and decrease Airbnb's GBV by 2.726% to 6.026%, depending on whether we allow listing price to change by 1% in response and whether we assume the high alert on vicinity safety also applies to the VSR for nearby listings. In comparison, removing listings with 1+ or 2+ VSR would reduce consumer surplus by 1.187% to 5.008% and depress Airbnb's GBV by 1.523% to 2.883%. Both consumers and Airbnb suffer from listing removal because it reduces consumer's choice set.

In a dynamic simulation, we also consider a situation where Airbnb keeps the online review system as is (i.e., neither suppress nor highlight VSR) but consumers who experienced VSR become high alert organically even if everyone else with no such self experience continues to hold their perception of VSR as observed in our data. Our simulation suggests a slow process that decays Airbnb GMV but enhances consumer surplus, and its convergence towards platform-wide high alert depends on how much VSR experience is under-reported in our data and how likely consumers staying in VS listings end up with self experiences that are reported as VSR.

In short, we find that the interests of consumers and the platform do not always align, especially with respect to two extreme information policies. At one extreme, where consumers are not aware of the platform's suppression of VSR and do not update their beliefs of vicinity safety accordingly, misalignment could occur because removing VSR encourages more guests to book on Airbnb and facilitates within-Airbnb sorting towards VS listings, although these changes end up hurting some consumers. Fortunately, a few market mechanisms—including consumers learning from self experience and from updating their beliefs upon VSR suppression—help to realign the incentives and discourage the platform from suppressing VSR.

At the other extreme, where Airbnb highlights VSR in a way that makes every potential host as alert as guests that have written VSR themselves, misalignment could occur because such high alert drives consumers away from VS listings, and the sorting towards hotel and non-Airbnb listings may exceed the sorting towards non-VS listings on Airbnb, hurting the overall GMV of Airbnb. While this suggests that Airbnb may lack incentives to adopt a high alert policy right away, we show that consumer self experience alone would push the market towards high alert over time.

Although the overall welfare effects are moderate (because VSR are rare in the data), they mask large distributional effects: more VSR transparency benefits Airbnb listings without VSR, as well as the outside good, at the cost of Airbnb listings with VSR. Because listings with VSR are more likely to locate in low-income or minority neighborhoods, consumer sorting upon VSR transparency would generate sizable revenue shifts across hosts in different neighborhoods. These effects highlight a potential tradeoff as far as generating greater revenues and attracting hosts in low-income and minority areas on the one hand, which can enhance the economic impact of the platform in a city's underserved neighborhoods, and possibly providing additional value to guests on the other.

As detailed below, we contribute to the rising literature on the information design of online platforms and the empirical literature of online feedback and seller reputation. As information intermediaries, digital platforms have more incentives than traditional sellers to alleviate information asymmetries between buyers and sellers. But they are still inherently different from a social planner, because they may place more weight on their own business interests than on the welfare of buyers and sellers on the platform, and they may not fully internalize the impact of their policies on other competing platforms and outside options. Our empirical findings highlight these differences, and quantify the extent to which consumers' self experience and belief update upon review suppression can help to realign the incentives of the platform and consumers. We also document how the impact of a platform's information policy may vary for neighborhoods of different incomes or with different minority representation, as being inclusive could be important for the platform and/or the social planner. These findings can help facilitate ongoing discussions of what role and responsibility digital platforms should have as far as collecting and disseminating quality-related information online.

The remainder of the paper is organized as follows. Section 2 reviews the related literature. Section 3 provides some background on Airbnb's review system. Section 4 describes the dataset, defines VSR and LSR, and provides summary statistics. Section 5 reports reduced-form evidence for the "within-listing-cross-buyer" and "cross-listing-within-buyer" effects of safety reviews. Section 6 incorporates these effects into a structural demand model and predicts how listings' GBV and consumer surplus would change under four counterfactual regimes and a dynamic simulation of the status quo. Section 7 discusses the implications of our findings and concludes with future research directions.

2 Related Literature

Our work is related to three strands of literature. First and foremost, we contribute to the growing literature on information design in online platforms.[5] Because consumer feedback is under-provided and there is a selection against critical feedback, researchers have studied the design of feedback systems as far as who is allowed to provide feedback (Klein et al., 2016; Mayzlin et al., 2014; Zervas et al., 2021), how to improve the authenticity of feedback (Wagman and Conitzer, 2008; Conitzer et al., 2010; Conitzer and Wagman, 2014; Gandhi et al., 2025), what kind of feedback is shown to the public, when to reveal the feedback to the public (Bolton et al., 2013; Fradkin et al., 2021), and how to aggregate historical feedback (Staats et al., 2017; Dai et al., 2018).

Interestingly, some platforms highlight critical consumer feedback, so that future consumers are aware of potential risks associated with the target seller or target product. An economic reason to do so is that many consumers on online platforms tend to be more responsive to critical feedback than to positive feedback (Chakravarty et al., 2010). Highlighting such feedback may hurt the sellers with critical feedback but divert buyers toward other sellers on the same platform with zero or not as much critical feedback. If this sorting effect reinforces the platform's reputation as far as honesty and transparency, attracts higher quality sellers to join the platform, and generates more revenue for the platform, the platform would have an incentive to highlight critical feedback.

In our setting, we offer a counterexample where a platform's review policy has the potential to discourage buyers from providing a specific type of critical feedback. The discouragement can occur when a platform hides, obfuscates, or deletes critical feedback. To be clear, there are legitimate reasons to do so in some situations: for example, a platform may find certain feedback fake, abusive, or misleading ex post; omitting such feedback could make the information system more authentic and informative for both buyers and sellers (Luca and Zervas, 2016; Mayzlin et al., 2014; Gandhi et al., 2025).

At the same time, prior theoretical work has shown that platforms may be strategically motivated to omit certain information, including critical feedback. For instance, Kovbasyuk and Spagnolo (2018)

[5]Bergemann and Morris (2019) offer a general review of information design, including, but not limited to, online platforms.

explain why platforms may sometimes seek to erase certain historical bad records of sellers, in order to increase matching rates. Romanyuk and Smolin (2019) show that platforms such as Uber and Lyft may seek to hide some buyer information (say, destination) prior to completing a buyer-seller match, because doing so may avoid sellers waiting for a specific type of next buyer, which would reduce the overall matching rate on the platform. These two papers differ in the direction of information withholding: the former withholds seller-relevant information from future buyers, while the latter withholds buyer-relevant information from future sellers. Both suggest that the party from whom the information is kept hidden may be worse off and the platform has an incentive to trade off their welfare loss against the welfare gain of the other side of the platform and the platform's overall matching rate.

In a different setting (online advertising auctions), Decarolis et al. (2023) use q-learning simulations to show that search engine platforms (such as Google and Bing) can increase their auction revenue by withholding bidding information from advertisers that bid repeatedly via AI algorithms. Using similar simulations, Banchio and Skrzypacz (2022) show that the platform's gain from withholding bidding information occurs in second-price auctions but not in first-price auctions. Empirically, Blake et al. (2021) show that an online platform that matches buyers and sellers of the secondary-market sales of event tickets can increase the volume and quality of tickets sold by obfuscating the full purchase price to buyers until the final checkout step.

Our paper presents an empirical example of highlighting or withholding product *quality* information instead of *price* information. As shown in our counterfactual analysis, the platform may have economic incentives to downplay VSR in some situations, because VSR may generate negative information spillovers to the rest of the platform. The bigger the negative shock that VSR can generate in self experience, the more likely the other guests are to be as alerted about vicinity safety as VS guests, the lower the matching rate for the broader platform. In theory, such negative effects could be dominated by a sorting effect, if posting or highlighting VSR would direct buyers toward safer listings on the same platform and motivate safer listings to increase their prices sufficiently to compensate for the platform's loss from a lower matching rate. Conversely, the negative effects of highlighting VSR may overwhelm the within-platform sorting effect, as shown in our counterfactual analysis. In addition, the low probability of self experiencing VSR, and the information frictions present in the current feedback system (such as buyer reluctance to post any critical feedback), could serve as natural information barriers to limit the negative spillovers of VSR and therefore encourage a platform to maintain the status quo rather than remove these information barriers for the benefits of consumers. On the positive side, we also find that a few market mechanisms—including consumers learning from self experience and belief updating upon VSR suppression—help to realign the incentives of the platform and consumers. These market mechanisms counter the platform's incentive to suppress or downplay VSR, especially if the platform values its business in the long run.

The second literature to which we contribute is about online feedback and seller reputation. Our findings on the "within-listing-cross-buyer" effect of VSR and LSR confirm the classical literature of online seller reputation (see reviews by Bajari and Hortacsu, 2004; Tadelis, 2016; Einav et al., 2016) and consumer response to critical feedback in particular (Chakravarty et al., 2010).

In addition, to our knowledge, we are among the few that attempt to quantify cross-listing spillover effects of critical feedback. By definition, VSR may generate spillovers among listings in nearby geographies, should guests infer the overall safety of the vicinity from multiple nearby listings. While this spillover is specific to the nature of vicinity safety (and difficult to distinguish from common shocks to listings in the same area), the cross-listing-within-buyer effect of VSR and LSR is more generalizable to other online platforms. As shown by Nosko and Tadelis (2015), buyers that had a good (bad) experience with a reputable seller on eBay are more (less) likely to return to eBay for sales with *any* sellers. Similarly, we show that having a negative safety experience tends to motivate a guest to subsequently avoid booking *any* listings on Airbnb in our sample cities, and, if they book again at all, to avoid both the listings and the areas that have any safety reviews. Compared to Nosko and Tadelis (2015), we show that the cross-listing-within-buyer spillover is not only limited to the extensive margin (whether to return to the platform for future transactions); but it also motivates the experienced buyer to be more discerning and adjust how they interpret the presence of safety reviews in other listings.

The difference between VSR and LSR also allows us to separately identify the "cross-listing-within-buyer" effects of VSR and LSR. Their relative magnitudes suggest that VSR may generate a larger negative shock than LSR in self experience, although the classical within-listing-cross-buyer effect of VSR is smaller than that of LSR. This difference highlights the importance of paying attention to the information spillovers of consumer feedback that tends to be missing in the classical seller reputation literature.

The cross-listing-within-buyer effect of consumer feedback could apply to many other platforms beyond eBay and Airbnb. For example, buyers of processed food may worry about contamination in food preparation, parents may worry about unsafe toys from countries of poor quality control standard, consumers of moving services may worry about road delays, and restaurant patrons may worry about difficulty to find parking. Some of these risks may be avoidable by the seller if she has full information and expertise to screen the supply chain, but often individual sellers cannot change the production environment of their country of origin, cannot easily change the location of their business, and have little control over road conditions. Yet consumers have legitimate concerns in these risky dimensions although the risk is usually not observable until the small probability of negative outcomes manifests in practice. Once the negative outcome occurs in self experience or is made equally known to consumers, consumers may quickly attribute the risk to sellers who receive similar critical feedback and intentionally avoid them. In some cases, wary consumers may even begin to watch out for the risk among all sellers on the platform. These potential negative effects present a dilemma to the platform: should the platform highlight such negative information at the risk of losing buyers and sellers, or should the platform withhold action and then act to minimize the impact of the negative outcomes when they occur? As previously indicated, this dilemma is not dissimilar to the dilemma facing tobacco, pharmaceutics, and SUV manufacturers, but the extent of the problem and the market-driven incentives to address it depend on the nature and impact of negative information for the whole platform, as well as changes in consumer information through self experience and belief updating.

Of course, the cross-listing-within-buyer spillovers are not necessarily limited to specific seller attributes. In our analysis, we assume the presence of LSR or VSR is the only inference linkage between listings. In practice, a buyer that experiences a listing safety or vicinity safety issue with listing X may infer that other listings that locate in another neighborhood with similar demographics as the focal listing carries a similar LSR or VSR risk even if these listings and their nearby listings do not have LSR or VSR at all. Since it is impossible to list all the potential inference linkages that an affected buyer may use to expand their safety experience to the safety risk of other listings, we restrict our estimate to the inference linkage based on the presence of LSR or VSR in different listings. In doing so, we provide a conservative estimate for the impact of hiding or highlighting safety reviews because the more linkages a buyer uses, the bigger the cross-listing-within-buyer spillovers there should be.

Another contribution we make to the literature of online seller reputation is highlighting some long-run consequences of rare critical feedback, especially on product quality that is out of the control of sellers (vicinity safety). Because vicinity safety is a small probability event and buyers may be reluctant to submit critical feedback, VSR on any Airbnb listing accumulate slowly over time, which could affect their overall informativeness. As we later show, between 2015 and 2019, we observe a growing rank correlation between a zip code's normalized cumulative VSR count and the zip code's normalized official crime statistics in low income and minority areas. This suggests that cumulative VSR do contain useful information regarding a zip code's actual safety status, and its informativeness may increase over time because of the law of large numbers. Furthermore, the rarity of VSR highlights the importance of the platform's information policy, because it affects the dissemination of the cross-listing-within-buyer effect from rare self experience hence the informativeness of the gradually accumulated VSR. In comparison, a few studies argue that online feedback systems may become less informative over time because of feedback bias (Barach et al., 2020; Klein et al., 2009; Hui et al., 2021). Most of these studies infer feedback informativeness from the content of feedback or policy variations within the feedback system. Our approach is different, as we compare online feedback with a completely independent data source and highlight that self experience of vicinity safety issues can be much more salient than reading VSR written by other guests.

Finally, we are not the first to study safety issues regarding online short-term rental platforms. Suess et al. (2020) find that non-hosting residents with a higher emotional solidarity with Airbnb visitors are more supportive of Airbnb hosts, and residents hold different views about safety ("stranger danger") and Airbnb depending on whether they have children in the household. Local planners pay attention to the impact of online short-term rentals on neighborhood noise, congestion, safety, and local housing markets

(Gurran and Phibbs, 2017; Nieuwland and Van Melik, 2020; Kim et al., 2017). Zhang et al. (2021) shows that regulations that negatively affect Uber/Lyft services may also negatively affect the demand for Airbnb. Han and Wang (2019) document a positive association between commercial house-sharing and the rise of crime rate in a city, while non-commercial house-sharing does not have this association. A number of studies find that an increase in Airbnb listings—but not reviews—relates to more neighborhood crimes in later years (Xu et al., 2019; Maldonado-Guzmán, 2020; Roth, 2021; Han et al., 2020; Filieri et al., 2021). More specifically, Airbnb clusters are found to correlate positively with property crimes such as robbery and motor vehicle theft, but negatively with violent crimes such as murder and rape. Also, Airbnb listings of the type in which guests may share a room with other unrelated guests are found to be more related to crimes (Xu et al., 2019; Maldonado-Guzmán, 2020) and to skirting local regulations (Jia and Wagman, 2020). A recent study of Chicago's short-term rental (STR) regulation finds that the incidence of burglaries has declined near buildings that prohibit STR listings (Jin et al., 2024).

Our study complements this growing literature, by highlighting safety reviews, distinguishing vicinity and listing safety reviews, and documenting consumer responses to safety reviews or experiencing safety issues. Although we cannot identify the effect of Airbnb on local crime rates, our work helps quantify guest preferences regarding safety, as well as clarify how the interests of guests, hosts, and the platform may diverge with respect to the disclosure of VSR. As shown in our counterfactuals, disclosing and highlighting VSR can encourage guests to shy away from potentially unsafe listings and disproportionately affect hosts in certain areas.

3 Background of Airbnb's Review System

Over the past decade, short-term rental markets have quickly expanded worldwide. Airbnb, the leading home-sharing marketplace, now offers 6.6 million active listings from over 4 million hosts in more than 220 countries and regions.[6] As with any lodging accommodation, the specific location of a listing can affect the experience of its guests. For instance, if a property is located in a relatively unsafe area, crimes such as carjacking or burglary may be more likely. In Los Angeles, the number of victims to crimes such as theft or burglary at short-term rental lodgings reportedly increased by 555% in 2017-2019.[7] As is common in the lodging industry, guests, who may be traveling outside their home towns and are therefore less familiar with local neighborhoods, are responsible for their own safety in the areas in which they choose to stay. In particular, as with hotels, guests receive little to no protection from rental platforms as far as crimes they may experience in a listing's vicinity.[8]

However, prior to making a reservation, potential guests may refer to a number of sources to gauge

[6] See Airbnb's official statistics as of December 31, 2022 available at `https://news.airbnb.com/about-us/#:~:text=Airbnb%20was%20born%20in%202007,every%20country%20across%20the%20globe`.

[7] See, e.g., `https://rb.gy/1eohbw`.

[8] See, e.g., `https://rb.gy/nwetrv` and `https://rb.gy/wrqvy4`.

the safety of a listing's area—these sources include local news, crime maps, websites that summarize neighborhoods[9], and perhaps most readily linked to each listing, the listing's reviews from prior guests.[10] Airbnb enables guests and hosts to blindly review each other after a guest's stay.[11] In an effort to appease hosts, and perhaps to encourage more listings across a larger number and variety of neighborhoods, a recent Airbnb policy effective December 11, 2019 announced that, going forward, guest reviews about a listing that include "content that refers to circumstances entirely outside of another's control" may be irrelevant and subject to removal.[12] This policy change implies that reviews about the safety of a listing's vicinity ("vicinity safety reviews" or VSR) may be deemed irrelevant and subject to removal, since such a safety aspect is outside the control of the host. The policy does not apply to "listing safety reviews" (LSR), because these reviews are about the safety within the listed property, which presumably can be more readily controlled and improved by the listing's host.

It is difficult to pin down exactly why Airbnb adopted this new review policy in December 2019. If Airbnb believes that the main role of online reviews is to motivate hosts to provide high-quality services to guests, review content regarding something outside the host's control may not help in that regard. Anecdotes suggest that hosts have complained about the harm they suffer from "irrelevant" reviews about the vicinity of their listings,[13] and this policy change could be a way to address these complaints. Another reason might be concerns over review accuracy: arguably, vicinity safety is a subjective feeling, which is subject to the reviewer's prior and interpretation, and it is often difficult to prove correct or wrong. However, similar accuracy concerns could apply to other review content, though the degree of objectiveness may vary. A third reason may have something to do with the aspiration of being inclusive. Airbnb has advocated for inclusive design, which is defined as "consciously designing products, services, and environments that don't create barriers to belonging."[14] The same aspiration may have motivated Airbnb to adopt an anti-discrimination policy, establish a permanent anti-discrimination team, and encourage designs and services friendly to users with disabilities. To the extent that VSR are more present in low-income or minority neighborhoods, the new review policy could be another effort to make the platform friendlier to hosts in economically disadvantaged neighborhoods.

The frequency of VSR in our raw data from mid 2015 to December 2020 presents no evidence indicating that Airbnb has enforced this policy post December 2019 as far as vicinity safety is concerned. However, anecdotes suggest that some reviews that touched on neighborhood safety had been removed.[15] Our

[9] See, e.g., `https://www.neighborhoodscout.com/`.

[10] Reviews have been well established as having a potential effect on buyer decisions and sellers' reputations, particularly in the tourism industry (Schuckert et al., 2015). The literature also suggests that critical information in reviews in particular can have an effect on guest decisions and be useful to platforms in distinguishing seller and product quality (Jia et al., 2021).

[11] If one side does not review the other, the other's review becomes visible after 14 days.

[12] See, for example, `https://rb.gy/0pu5ck` and `https://rb.gy/9y6bum`.

[13] Nina Medvedeva, "Airbnb's Location Ratings as Anti-Black Spatial Disinvestment in Washington D.C." Platypus: The CASTAC Blog (March 16, 2021), accessed at `https://rb.gy/ottzf9`.

[14] See, e.g., `https://rb.gy/eq7ltv`.

[15] For example, on Jan. 27, 2020, a tweet by user "PatrickR0820" stated: "I used @Airbnb when we went to Atlanta for the Panthers game. In my review I left numerous things that could be fixed as well as 'the area that it is located in, is

work does not depend on whether and how Airbnb enforces this policy, as our analysis sample ends in December 2019 (to avoid potential market shifts due to the COVID pandemic). Nevertheless, this new policy suggests that Airbnb is willing to consider different feedback policies depending on whether the focal issue is under the control of the host or not. This motivates us to distinguish between LSR and VSR, and explore why these two types of buyer feedback may introduce different incentives for the platform's information design.

To be clear, Airbnb has adopted other methods to address neighborhood safety directly. For example, Airbnb introduced a neighborhood support hotline in December 2019,[16] around the same time that Airbnb adopted the new review policy. This hotline is primarily intended to be a means for neighbors of Airbnb listings to contact the platform in certain situations (e.g., in the event of a party taking place at a listed property). In addition, since our main analysis sample ends in December 2019 and we do not know how many guests that left VSR in our sample would have used the hotline should the hotline have existed at the time of the review, we cannot predict how the hotline may counter some of the effects shown in our analysis. That being said, hotline usage is ex post and is not visible to future guests; hence, its impact on guests can be fundamentally different from the impact of reviews visible under each listing on Airbnb.

Airbnb's review system also allows guests to leave a 1-5 star rating by specific categories (cleanliness, accuracy, check-in, communication, location, and value), in addition to leaving an overall rating and detailed review. According to Airbnb's response to a host's question, location rating is meant to "help future guests get a sense of the area and tends to reflect proximity to nearby destinations."[17] Hence, the location rating could capture many location-specific aspects such as local transit, nearby stores, neighborhood walkability, and noise, and may not be directly related to vicinity safety.

When potential guests search on Airbnb, the platform may not provide the precise address of each listing and depicts nearby listings on the same map. This setting makes it simple to identify nearby listings; thus, a guest observing VSR on Airbnb listing X can extend the vicinity safety concern to all nearby Airbnb listings on the same map. However, the lack of an exact address makes it more difficult to (i) combine the listing information on Airbnb with external information sources such as local news and crime statistics, and (ii) extend the same concern to listings on VRBO or other short-term rental platforms. Guests may not be familiar with streets and neighborhoods in the destination city, which further exacerbates the challenges with drawing connections among listings on different platforms, especially given that platforms may not provide precise addresses. Guests may also not always be able to tell whether two listings on Airbnb and VRBO are in fact the same listing. These information frictions

pretty sketchy.' My review and 4 other similar recent reviews were deleted because it wasn't relevant." Another tweet by "AveryBrii" on May 18, 2021 stated: "@Airbnb is such a joke!!! we literally had a car stolen at the place we stayed at, didn't get refunded (which wahtever) & then i try to leave a review to inform others that it clearly was not a safe area (cops told us this & other info that i tried to include) & they didn't post." A journalist also describes his experience on Bloomberg Opinion: "Airbnb Took Down My Negative Review. Why?" (May 26, 2021 by Timothy L. O'Brien), accessed at `https://rb.gy/dxfkxw` on November 26, 2021.

[16]See, e.g., `https://rb.gy/sykoim`.

[17]See, e.g., `https://rb.gy/qs13gh`.

imply that the potential spillover from one listing's VSR to nearby listings is more salient for nearby listings on Airbnb than for potentially nearby listings on VRBO.

4 Data

We use several data sources to track short-term rental listings, official crime statistics, and some fundamentals of the short-term lodging market in each sample city. We describe each data source separately.

Data on short-term rental listings. The main dataset we use has information on short-term rental listings that had been advertised on Airbnb from 2015/7 to 2019/12, and on VRBO from 2017/6 to 2019/12, in five US cities (Atlanta, Chicago, Los Angeles, New Orleans, and New York). The data was acquired from AirDNA, a company that specializes in collecting Airbnb and VRBO data. For Airbnb listings, this dataset includes the textual contents of all Airbnb listing reviews in those cities. We have no access to reviews on VRBO. The original data from AirDNA extends to 2020/12 but demand for short-term rentals subsequently changed dramatically because of the COVID-19 pandemic, so our main analysis uses data up to 2019/12.

Each listing is identified by a unique property ID and comes with time-invariant characteristics such as the listing zip code, listing property type (entire home, private room, shared room, or hotel room), as well as the host's unique identifier. Listings also have time-variant characteristics, including average daily rate,[18] the number of reservations, days that are reserved by guests, occupancy rate,[19] number of reviews, overall rating scores,[20] the listing's Superhost status,[21] the listing's guest-facing cancellation policy,[22] the average number of words in the listing's reviews, the number of listings in the same zip code, and whether the listing is cross-listed on VRBO.[23] Although Airbnb and VRBO only provide proxy longitude and latitude for each listing, we are able to compare the proxy and actual locations in a few example listings, based on our own or our friends' real Airbnb bookings. We find that the proxy location is usually within 150 meters of the actual location; thus, we treat the zip code corresponding to a listing's proxy longitude and latitude as its actual zip code, and we use proxy locations to define whether two

[18]Average daily rate (ADR) is calculated by dividing the total revenue, including both nightly rates and cleaning fees, earned by the host from reservations over a given month by the total number of nights in that month's reservations.

[19]Occupancy rate is calculated by dividing the number of booked nights by the sum of the available nights and booked nights.

[20]Overall rating scores are normalized to 0-10 range. Our dataset also includes location star ratings. Adding it as an extra control variable does not change our main results, so we do not report it in this paper. Results are available upon request.

[21]Superhost refers to a status badge related to metrics concerning a listing's performance. Hosts who meet the following criteria, evaluated quarterly, receive a Superhost designation: (i) Completed at least 10 reservations in the past 12 months; (ii) maintained a high response rate and low response time; (iii) received primarily 5-star reviews; (iv) did not cancel guest reservations in the past 12 months.

[22]Cancellation policy could be strict, moderate, flexible. For simplicity, we use a dummy variable to indicate whether a listing's cancellation policy is strict or not.

[23]Only listings with entire home that could be both listed on Airbnb and VRBO. The co-listing indicator is a variable created by AirDNA, it is unclear to what extent an individual guest searching on Airbnb and VRBO can tell whether two listings are the same listing co-listed on both platform because neither platform provides precise address of a listing until the guest has booked and paid for the listing.

listings are within each other's 0.3-mile radius.

Our unit of observation is listing-month. We focus on "active listings" (listings whose calendars are not indicated as 'blocked' in the dataset for an entire month), and exclude observations with an ADR of over $1000, as some hosts may set their rates prohibitively high in lieu of blocking their calendars. We use regular monthly scrapes between 2015/7 and 2019/12 on Airbnb (2017/6 to 2019/12 for VRBO). In total, the sample comprises 2,866,238 listing-months observations on Airbnb, and 201,718 listing-months observations on VRBO.

Definition of safety reviews on Airbnb. Because we only observe guest reviews on Airbnb, we can only define LSR and VSR on Airbnb. LSR are those reviews that describe issues pertaining to safety within a listing (e.g., "the listing is unsafe because there are fire hazards," "the listing is unsafe because of the slippery tub," or "we saw mice in the kitchen three times during our stay"). VSR contain information pertaining to the safety of the nearby vicinity or neighborhood of the listing (e.g., "the neighborhood is not safe," "shady neighborhood," or "unsafe area"). While there is considerable research regarding the use of machine learning for automated content analysis, these methods typically require a large number of hand-labeled examples for training. We instead use a lexicon approach due to its simplicity and transparency. Lexicons are also found to have high levels of precision as compared to machine learning approaches (Zhang et al., 2014; Hutto and Gilbert, 2014), and have been used extensively in the literature (Monroe et al., 2008; Dhaoui et al., 2017).

To identify a suitable set of keywords, we use an iterative approach, starting with terms such as "unsafe," "dangerous," and "scary" and all of their synonyms, to obtain an initial keyword set; next, we manually inspect reviews containing such keywords so as to identify additional keywords. We then select keywords based on the accuracy of safety reviews.

More specifically, we conduct two iterations of manual labeling. In the first iteration, three research assistants (comprising male and female as well as different ethnicities) labeled 1.4K reviews that were generated from the Lexicon approach algorithm with the initial keyword set for both LSR and VSR. While labeling, for each review the reviewers identified (i) whether the review pertains to neighborhood and/or listing safety, (ii) whether the review has a negative sentiment with respect to neighborhood and/or listing safety, and (iii) three specific keywords that supported the reviewer's decision in (i) and (ii). With these human-labeled keywords, we obtain an updated list of vicinity and listing safety keywords such that the percentage of critical reviews regarding vicinity safety (listing safety) in the 1.3K sample with such a human-selected keyword is greater than 0% (10%).

In the second iteration of labeling, two research assistants (male and female) with different ethnicities labeled 3.1K reviews that were generated from the Lexicon approach algorithm with the updated keyword set for both LSR and VSR, such that 5 reviews associated with each keyword were randomly selected. In this iteration, reviewers labeled whether each review pertains to negative sentiment about vicinity and/or listing safety. The final set of keywords is the one where each vicinity safety (listing safety) keyword has a percentage of negative-sentiment vicinity safety (listing safety) reviews greater than or equal to 60% from both reviewers' second-iteration labeling results. After two iterations, we expanded the list to 41 vicinity safety keywords and 50 listing safety keywords, as delineated in Appendix Table A1.[24]

The keyword lists developed above are not the only inputs we use to define vicinity or listing safety reviews. As far as VSR, to improve precision and to ensure that the text is indeed describing issues pertaining to the safety of a listing's vicinity and not other aspects of a listing, we identified a list of 24 location keywords that tend to indicate a statement about the surrounding area (e.g., "neighborhood," "area," "outside") in Appendix Table A1. We then categorized the matching reviews into those in which the vicinity safety keyword occurred within 20 words of a location keyword as vicinity safety reviews, and those in which the listing safety keyword occurred outside of the 20-word context as listing safety reviews.[25] Next, we selected 13 'negative' keywords, and filtered out double-negative reviews where the keyword occurs within 5 words of a safety keyword. The whole procedure of our VSR and LSR definition is illustrated by Figure A1 in Online Appendix A.

Overall, our approach resulted in 11.8k matched VSR and 12.8k matched LSR across the 5 sample cities. In total, they account for 0.25% and 0.27% of all the observed Airbnb reviews respectively. From 2015/7 to 2019/12, only 4.43% of listings ever had any VSR, 4.95% ever had any LSR, and 8.49% ever had any safety reviews (VSR or LSR). Conditional on having any VSR by 2019/12, 81.04% of listings have one VSR, 11.96% have two VSR, and the remaining 7% have 3+ VSR. Conditional on having any LSR by 2019/12, 86.46% of listings have one LSR, 10.71% have two LSR, and the remaining 2.83% have 3+ LSR.

As shown in Appendix Figures A2 and A3, the top matching vicinity safety keywords are "unsafe" (4,519), "homeless" (3,398), "yelling" (854), and "uneasy" (733), and the top matching listing safety keywords are "worst" (1,803), "mold" (1,350), "stained" (1,172), and "filthy" (1,135). As an additional validation check, we sampled several thousand matches at random, and manually labeled them as relevant or not, finding 78.21% and 75.64% accuracy for vicinity safety keywords and listing safety keywords, respectively.[26] The mislabeled data often used figurative language ("scary how perfect this neighborhood is") or used safety words in other contexts (e.g., "watched a scary movie on Netflix"). While any such method will be imperfect, we did not find any evidence suggesting that the error rates were systematically biased for some neighborhoods over others. However, we did restrict our keywords to English, so the

[24] Most of the keywords appear relatively infrequently, and removing any one of them alone has little effect on the results. For example, one may argue that "government housing" suggests a low-income area rather than vicinity safety issues. Including it in our vicinity safety keyword list would only identify three more vicinity safety reviews and removing the keyword has no qualitative impact on the results.

[25] While the 20-word window is arbitrary, a sensitivity analysis suggests no qualitative difference when using a slightly longer or shorter window. Moreover, the average review had roughly 50 words, so this seemed to restrict to the 1-2 sentences around the keyword match.

[26] This indicates a 21.79% false-positive error rate for vicinity safety reviews (24.36% for listing safety reviews). Since our lexicon approach aims to minimize the false-positive rate while allowing false negatives, the safety reviews identified by this approach tends to make the estimated impact of safety reviews more conservative than the true effect.

method will be less effective in areas with many non-English reviews.

To check whether the safety reviews defined above are indeed critical feedback, as we intended to identify, we employ a pre-trained NLP model from Hugging Face to determine the sentiment score of all reviews.[27] According to the analysis, the overall average sentiment score across all available reviews is 0.79. Specifically, VSR show a relatively neutral average sentiment score of 0.06, while sentences containing VSR safety keywords tend to have a negative average sentiment score of -0.31. In comparison, LSR demonstrate a lower average sentiment score of -0.41, and sentences with LSR safety keywords have the most negative average sentiment score of -0.76. By contrast, the non-VSR or non-LSR reviews have an average sentiment score matching the overall average of 0.79. These patterns suggest that our Lexicon approach has successfully captured the negative sentiment when guests comment on listing or vicinity safety issues during their stay.

Sensitivity Test on Safety Review Definitions. Because the sets of safety keywords are selected based on manual labeling, we conduct a sensitivity check. In particular, at the end of the first round iteration, we refined our keyword selection by focusing on the keywords for which the percentage of critical reviews regarding vicinity safety (listing safety) in the 1.3K keyword sample is greater than 50% (50%) rather than 0% (10%). This means we included only those with higher relevance and more critical sentiment for the second-round iteration. As a result, the alternative definition identified 32 vicinity safety keywords (e.g., "homeless," "drugs") and 47 listing safety keywords (e.g., "mold," "stained"), as shown in Appendix Figures A6 and A7. This refined set of keywords resulted in 5,272 VSRs and 12,150 LSRs, which are roughly 55% and 5% less than what we find in the main definition. Consequently, 1.82% of listings had any VSR, and 4.71% had any LSR, as compared to 4.43% and 4.95% in the main definition. Despite these differences, we find similar results in the listing-level regressions (defined in Section 5.1). In particular, the coefficients reflecting the effects of a listing's VSR and LSR on its own price and occupancy become stronger in magnitude (in the same direction as using the main definition of VSR and LSR), likely because the VSR and LSR under the alternative definition have a higher probability of capturing actual and severe safety issues.[28]

Official crime and demographic statistics. A second dataset we collect covers official crime records from databases tracking crimes in Chicago,[29] New Orleans,[30] New York City,[31] Atlanta,[32] and Los Angeles.[33] These databases cover different types of crimes, including property-related crimes and

[27]The utilized model is a fine-tuned checkpoint of DistilBERT-base-uncased, accessible at `https://huggingface.co/distilbert-base-uncased-finetuned-sst-2-english`. It demonstrates a noteworthy accuracy of 91.3% on the development set. The sentiment scoring system ranges from -1 to 1, where a score of -1 indicates an extremely negative sentiment, and a score of 1 indicates an extremely positive sentiment.

[28]To save space, we omit the table of results for these alternative regressions; they are available upon request.

[29]Official crime data in Chicago: `https://rb.gy/atjsss`.

[30]Official crime data in New Orleans: `https://rb.gy/4vue82`.

[31]Official crime data in New York City: `https://rb.gy/iwrwp2`.

[32]Official crime data in Atlanta: `https://rb.gy/96txbl`.

[33]Official crime data in Los Angeles: `https://rb.gy/tebnla`.

violent crimes. In terms of the geographical granularity of crimes, we consider crime events at the zip code level. We also obtain median income and other demographic information at the zip code level from 2014, one year before our Airbnb sample period begins, from the United States Census Bureau.[34] We make the assumption that the income and demographic information did not change significantly over our sample period. Throughout the paper, we refer to a zip code as high-income (H) or low-income (L) according to whether its average income is above or below the median of the city in which it is located. Similarly, we refer to a zip code as minority (M) or white (W) as a function of whether the percentage of its population that is identified as minority is below or above the city median.

Hotel Lodging Data, Air Travel Data, and Zillow Home Value Index. To capture potential competition with Airbnb and VRBO in the short-term lodging market, we use two supplemental datasets to define market size. First, we obtain from Smith Travel Research data on total hotel booking volume and revenue by zip code and month from 2015 to 2019 in our sample cities. This data does not contain hotel-specific information, so we cannot distinguish among different types of hotels within the same zip code. It turns out that only 24.6% of zip codes in our data have any hotel data, because hotels tend to concentrate in the commercial areas of a city while Airbnb and VRBO listings can be spread out in all kinds of neighborhoods throughout the city. About 40% of the Airbnb listings we observe in the AirDNA data are located inside these hotel-present zip codes. Second, we use the US Department of Transportation's T100 data to calculate total incoming air travelers (domestic and international) per city-month.

If we define the short-term lodging market by city-month, we can measure the market size by (a) the total number of occupancy in hotels, Airbnb, and VRBO; or (b) the total count of incoming air travelers. The latter is 5-9 times bigger than the former on average, because many incoming air travelers may live in the city or leave the city on the same day. Nevertheless, the two measures are highly correlated, with a correlation coefficient ranging from 0.5 to 0.9 across the five sample cities.

An alternative way of defining the short-term lodging market is by zip code and month. This detailed definition may better capture the head-to-head competition within each zip code, but given the fact that most zip codes do not have any hotels, VRBO would be the only outside option competing with Airbnb in these markets. This is imperfect because VSR of an Airbnb listing may remind guests of the potential vicinity safety risk of nearby listings on VRBO, although the lack of precise addresses may make it difficult to pin down exactly what VRBO listings are close to the focal listing on Airbnb. In Section 6, we check how sensitive our structural estimation results are to the market definition (city-month or zip code-month), and to the definition of market size (Airbnb+VRBO, hotel+Airbnb+VRBO, and incoming air travelers).

As detailed in Section 6, we use Zillow's Home Value Index (ZHVI, by zip code and month) to construct instruments for listing price. Zillow defines ZHVI as a measure of the typical home value and

[34]See, e.g., `https://www.census.gov/data.html`.

market changes across a given region and housing type. It reflects the typical value for homes in the 35th to 65th percentile range. While ZHVI is an imperfect measure of the cost of running Airbnb listings in a particular zip code-month, it embodies property tax, property maintenance costs, and the opportunity costs of using the property for alternative uses. We download the seasonally adjusted version of ZHVI[35] and merge it to other data by zip code and month.

Appendix Table A2 defines the key variables we use, including listing attributes (such as price, occupancy rate, safety reviews, and ratings) and neighborhood attributes (such as income, population, and crime statistics by zip code).

Summary of VSR and LSR on Airbnb. Table 1 summarizes the data at the listing-month level, where vicinity safety (VS) Airbnb listings are defined as observations that have a positive number of vicinity safety reviews (VSR) before the reporting month, while non-VS Airbnb listings do not have any VSR before the reporting month. As the table indicates, about 4% of the total observations are VS listings. On average, VS listings have a higher occupancy rate, a higher number of reservations, a higher fraction of Superhosts, and a higher number of reviews than non-VS listings. In contrast, the nightly rates and overall rating of VS listings are lower on average than non-VS listings. The mean number of cumulative VSR (aggregated up to the reporting month) is 0.06 across all Airbnb listings, and the mean number of cumulative listing safety reviews (LSR) is 0.06. Appendix Figures A4 and A5 demonstrate the distribution of VS keywords for four groups of zip codes (high-income, low-income, white, and minority). Comparing the high-income with low-income (or white with minority) groups, it appears that the low-income (minority) group dominates the volume of VSR.

How do VSR correlate with official crime statistics? We normalize the total number of reported crime cases in a zip code-month by population size in that zip code. The Pearson correlation between this normalized crime flow and the flow of all VSR reported in a zip code-month is low (0.04). If we count VSR cumulatively from 2015/7 to the focal month,[36] and correlate it with the flow of official crime counts, the correlation increases to 0.08. If we use cumulative counts in both, the correlation is 0.14.

While the Pearson correlation between VSR and total crime counts is fairly low at the zip code-month level, the ordinal order of vicinity safety across zip codes in the same city might be more informative than the absolute magnitude of either statistics. This motivates us to compute the *rank* correlation between the two. In particular, for crime counts, we rank the normalized flow crime data per zip code within each city-month, and determine the percentile crime rank of the zip code for that month. For VSR, we use the percentile rank of the number of flow VSR in the zip code in the reporting month within each city. The correlation between these two ranks is 0.32. If we compute the percentile rank of VSR by the number of *cumulative* VSR in the zip code up to the reporting month within each city, its correlation with the

[35]ZHVI data is available at https://www.zillow.com/research/data/

[36]We assume VSR begin with clean slate (0 records) as of the beginning of our dataset.

Table 1: Summary Statistics of Airbnb Listings (2015/7-2019/12, unit of observation=listing-month)

	All listings (N=2,866,238)		VS listings (N=126,868)		Normal listings (N=2,739,370)	
VARIABLES	mean	p50	mean	p50	mean	p50
Occupancy rate (0 to 1)	0.56	0.64	0.68	0.78	0.56	0.64
1 if any occupancy in the month	0.85	1.00	0.95	1.00	0.85	1.00
Price (average daily rate $)	164.69	125.51	134.15	106.31	166.10	126.67
# of reservations in the month	3.77	3.00	5.76	5.00	3.68	3.00
# of reservation-days in the month	14.16	14.00	18.56	21.00	13.95	14.00
1 if any VSR since 2015/7 to last month	0.04	0.00	1.00	1.00	0.00	0.00
1 if any LSR since 2015/7 to last month	0.05	0.00	0.20	0.00	0.04	0.00
# of VSR since 2015/7 to last month	0.06	0.00	1.34	1.00	0.00	0.00
# of LSR since 2015/7 to last month	0.06	0.00	0.26	0.00	0.05	0.00
% of any VSR within 0.3-mile radius	0.07	0.04	0.10	0.07	0.07	0.03
Overall ratings (1-10)	9.18	9.60	9.09	9.20	9.18	9.60
# of reviews	33.71	15.00	93.02	70.00	30.96	14.00
# of listing within zip code	540.67	449.00	554.66	481.00	540.02	447.00
1 if cross-listing on VRBO	0.02	0.00	0.03	0.00	0.02	0.00
1 if super host	0.23	0.00	0.26	0.00	0.23	0.00
1 if strict cancellation policy	0.50	0.00	0.58	1.00	0.49	0.00
Avg word count in a review since 2015/7	53.83	50.43	57.49	53.91	53.66	50.20
Median income in zip code ($)	57,187	50,943	42,645	34,432	57,861	51,427
Population in zip code	48,158	45,747	42,514	36,654	48,419	46,025
% white in zip code	0.53	0.59	0.41	0.38	0.53	0.60
1 if zip code is high income	0.52	1.00	0.29	0.00	0.53	1.00
1 if zip code is white	0.60	1.00	0.44	0.00	0.61	1.00
Normalized crime reports in zip code since 2015/7	0.86	0.21	1.69	0.33	0.83	0.20

Note: This table summarizes Airbnb listings from 2015/7 to 2019/12 in the five sample cities. The variable for crime reports is reported by zip code-year-month and normalized by the population of the zip code.

percentile rank of flow crime data is 0.58, and its correlation with the percentile rank of cumulative crime data is 0.59. These numbers suggest that it is more important to capture VSR in cumulative counts because VSR is rare, while whether to use flow or cumulative measures for normalized crime data is less crucial. In our reduced-form and structural analyses, we always use the raw data of VSR (at the listing-month level) and crime reports (at the zip code-month level), not their percentile ranks, and therefore do not have a collinearity problem given their low correlation in the raw data.

To explore how VSR and crime statistics correlate differently for different types of demographic areas, we compute the percentile rank correlation index between the zip code-level VSR count (cumulative) and crime count (flow) data in each month, for the whole sample and the four groups of zip codes (high-income, low-income, white, and minority) separately. Figure 1 indicates that the percentile rank correlation exhibits an increasing trend, especially in low-income and minority groups, suggesting that the percentile rank of cumulative VSR in a zip code has increasingly more power, reflecting the actual flow of crime reports over time in these areas.

Heterogeneity by type and area of listings. Appendix Table A3 provides summary statistics based on the type of an Airbnb listing. The majority of listing-months in our whole sample are entire-home listings (60.9%), which tend to charge a much higher daily average price ($212.81) than private-

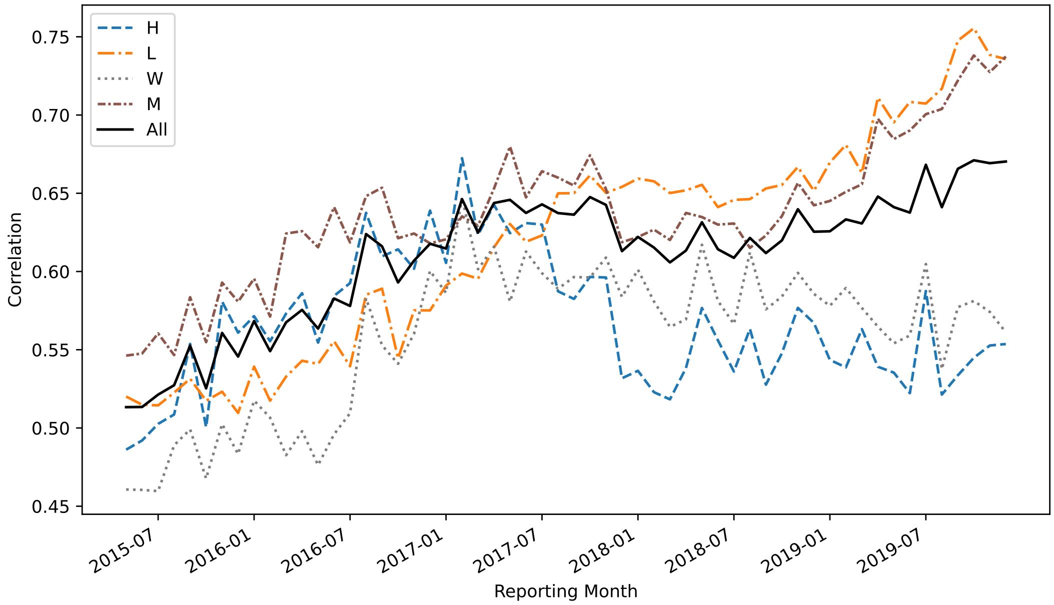


Figure 1: Percentile rank correlation between normalized crime flow and cumulative VSR per zip code (ranks are computed within each city-month)

room (\$91.67) and shared-space (\$58.23) listings. Some hotels are listed on Airbnb as well; their daily price (\$197.16) is similar to that of entire-home listings, but hotel listings only account for 0.3% of all listing-month observations in our sample. Hotel and entire-homing listings are more likely to have any VSR (cumulative since 2015/7) than private-room and shared-space listings, but the likelihood of having any LSR (cumulative since 2015/7) is the highest among entire-home listings, followed by private-room listings and hotel listings, and the least in shared-room listings. For non-hotel listings, the average of the cumulative number of VSR and LSR are similar to the dummy of having any VSR or LSR, because most listings with any VSR or LSR tend to have one rather than multiple such safety reviews. The average cumulative number of VSR for hotel listings is higher than the average of having any VSR, likely because each hotel listing may correspond to multiple hotel rooms.

Appendix Table A3 provides summary statistics based on whether a listing is located in a high-income (H) or low-income (L), and white (W) or minority (M) zip code. The number of listing-months is comparable between H and L, but higher in W than in M. Listings in L and M areas are much more likely to have any VSR and any VSR nearby than those in H and W. These differences are typically between 0.06-0.07 in L and M versus 0.02-0.03 in H and W. However, the likelihood of having any LSR is comparable across L, M, H, and W (all around 0.05). The cumulative crime counts, normalized by zip code population, are of a completely different scale, with an average of 0.56 in H and 1.19 in L. While the average normalized crime counts is higher in W than in M (1.10 vs. 0.51), the median is higher in M than in W (0.23 vs. 0.19). This suggests that the normalized crime count in W is more skewed than that in M.

5 Reduced-form Effects of Safety Reviews

We first present reduced-form evidence from listing-level and guest-level analyses. The listing-level analysis documents the within-listing-cross-buyer effects of VSR and LSR. It also explores the possibility that VSR of nearby listings could affect the focal listing's price and occupancy. The guest-level analysis aims to capture the cross-listing-within-buyer effects of VSR and LSR.

5.1 Listing-Level Analysis

Baseline results. We begin by assessing the effects of VSR and LSR by listing-month. Our hypothesis is that if potential guests view VSR and LSR as a proxy for safety around or within a listing, such reviews would reduce the guests' willingness to book the listing. Our base specification is given by:

$$y_{j,t} = \alpha_j + \alpha_{k,t} + \delta X_{j,t} + [\beta_1 Crime_{j,t-1}] + \\ \beta_2 LSR_{j,t-1} + \beta_3 VSR_{j,t-1} + \beta_4 VSRADIUS_{j,t-1} + \epsilon_{j,t}, \quad (1)$$

where j denotes a listing j-month t observation, and $Crime_{j,t-1}$ is a log transformed variable that indicates the normalized number of cumulative official crime reports since the start of the sample period for the zip code where listing j is located. $LSR_{j,t-1}$ and $VSR_{j,t-1}$ are two dummy variables that equal 1 if the listing has at least one LSR and VSR, respectively, before month t. $VSRADIUS_{j,t-1}$ is the percentage of listings that have at least one VSR within a 0.3-mile radius of listing j prior to month t, $X_{j,t}$ are listing-level controls (logged except for dummy variables), including the number of reviews, overall ratings, cancellation policy, number of listing in the same zip code, cross-listing status (i.e., whether the listing is also listed on VRBO), and whether the listing is hosted by a Superhost. The dependent variable $y_{j,t}$ is either the log of listing j's average daily rate (price) in month t, or the log of listing j's monthly occupancy rate (calculated as log of 1 plus the occupancy rate).[37] Coefficient α_j denotes listing fixed effects; and $\alpha_{k,t}$ denotes city-year-month or zip code-year-month fixed effects as we experiment with various controls for local shocks. Standard errors are clustered by Airbnb property ID. The primary assumption is that, within a listing, the presence and timing of safety reviews are correlated with the true safety condition around or inside the listing and do not reflect selective reporting, fake reviews, or other strategic reasons once we control for other time-varying listing attributes.

Panel A of Table 2 presents three versions of the OLS results: Columns 1-4 control for city-year-month fixed effects, with and without $Crime_{j,t-1}$ on the right hand side; Columns 5-6 control for zip code-year-month fixed effects, which automatically absorb $Crime_{j,t-1}$. We prefer Columns 5-6 because

[37] Some listing-month observations have an occupancy rate of 0 and consequently are missing an average reserved daily rate in the dataset for those months, though the dataset does offer a separate "listing price" (i.e., a base rate) for those listings. To extrapolate the ADR of these listings in the months in which they are missing, we calculate the mean ratio of their ADR to their listing price in the months in which they are available, and multiply this average by the listing price in the missing months (if available, or by using the listing price from the nearest month in which it is available).

it controls for arbitrary local demand or supply shocks at the zip code level and addresses the concern that official crime statistics may include safety issues related to past Airbnb activities and therefore be endogenous and confound the interpretation of other coefficients.

Across all columns, we observe that having any VSR or LSR on the listing is associated with a significant decrease in a listing's price and occupancy. Specifically, according to Columns 5-6, for an average Airbnb listing in our sample, having any VSR before the study month is associated with a 1.45% reduction in the listing's monthly occupancy rate and a 1.47% reduction in its average price per reserved night; having any LSR is associated with a 2.41% drop in occupancy and 1.46% in price. LSR thus have a larger effect on occupancy than VSR. The coefficient on $VSRADIUS$ is negative and significant in Columns 1 and 2, but become less significant after we control for $Crime$ in Columns 3, and statistically non-distinguishable from zero after we control for zip code-year-month fixed effects in Columns 5 and 6. These results suggest that, while nearby listings' VSR could have a negative spillover on the focal listing, it is difficult to distinguish this effect from zip code-year-month shocks that apply to focal and nearby listings at the same time.

Because Equation 1 includes listing fixed effects and defines VSR and LSR cumulatively since 2015/5, their coefficients capture the within-listing changes of occupancy and price before and after the listing receives its *first* VSR or LSR. We choose this definition because most listings that have any VSR (LSR) have only one VSR (LSR), hence this margin is the most salient variation in our data. Results are similar if we exclude listings with 2+ VSR or 2+ LSR from the sample.

Still, a curious question is when the effects of VSR and LSR kick in and persist over time. To answer it, we redefine VSR and LSR as having any VSR/LSR within the past 12 months, more than 12 months ago, within the past 6 months, or more than 6 months ago. As reported in Columns 1-2 of Table 2 Panel B, when we only define VSR and LSR as having any VSR/LSR within the past 12 months (while controlling for zip code-year-month fixed effects and thus absorbing $Crime$), the coefficients of VSR and LSR have the same sign and significance as what we obtain by using cumulative measures, but the magnitudes are smaller, especially when the dependent variable is occupancy rate. In Columns 3-4, we further control for having any VSR or LSR more than 12 months ago, and the coefficients of VSR and LSR variables are much more similar in magnitude to what we obtain by using cumulative measures. In particular, the VSR or LSR coefficients on price are stable but the coefficients on occupancy suggest that the negative impacts of VSR and LSR on occupancy are strengthened over time within a listing. Same patterns occur when we redefine VSR/LSR as having any VSR/LSR in last 6 months and more than 6 months ago. In an unreported table, we have tried to rerun the regressions in Table 2 Panel B, excluding listings with 2+ VSR or 2+ LSR. The same pattern remains, suggesting that the strengthened effect of having any VSR or LSR is not driven by listings accumulating more VSR/LSR over time.

The growing impact of VSR/LSR on a listing is somewhat surprising: by default Airbnb presents consumer reviews by recency and thus a review posted months ago may become less visible to prospective

Table 2: Baseline Results of Reduced-form Listing-level Analysis of Airbnb Listings

Dep. Variable	(1) log occupancy rate	(2) log(price)	(3) log occupancy rate	(4) log(price)	(5) log occupancy rate	(6) log(price)
	Panel A: Cumulative VSR, LSR, VSRADIUS and Crime					
Any VSR since 2015/7 to last month	-0.0171***	-0.0156***	-0.0160***	-0.0154***	-0.0145***	-0.0147***
	(0.00140)	(0.00219)	(0.00140)	(0.00219)	(0.00136)	(0.00209)
Any LSR since 2015/7 to last month	-0.0253***	-0.0156***	-0.0249***	-0.0155***	-0.0241***	-0.0146***
	(0.00135)	(0.00210)	(0.00135)	(0.00210)	(0.00130)	(0.00200)
% of Any VSR within 0.3-mile radius	-0.00593**	-0.0107***	-0.00323	-0.0103***	-0.00228	-0.00224
	(0.00253)	(0.00393)	(0.00252)	(0.00390)	(0.00239)	(0.00377)
log(crimes in zip code since 2015/7 to last month)			-0.0720***	-0.0107	absorbed	absorbed
			(0.00950)	(0.0152)		
Property ID FE	yes	yes	yes	yes	yes	yes
City-year-month FE	yes	yes	yes	yes	no	no
Zip code-year-month FE	no	no	no	no	yes	yes
Observations	2,866,238	2,866,238	2,866,238	2,866,238	2,866,238	2,866,238
R-squared	0.559	0.928	0.559	0.928	0.566	0.929
	Panel B: More detailed lags of VSR and LSR					
Any VSR in last 12m	-0.00371***	-0.00905***	-0.00918***	-0.0135***		
	(0.00111)	(0.00166)	(0.00122)	(0.00185)		
Any VSR more than 12m ago			-0.0205***	-0.0163***		
			(0.00195)	(0.00329)		
Any LSR in last 12m	-0.0101***	-0.0111***	-0.0187***	-0.0147***		
	(0.00108)	(0.00152)	(0.00120)	(0.00175)		
Any LSR more than 12m ago			-0.0336***	-0.0145***		
			(0.00202)	(0.00330)		
Any VSR in last 6m					-0.00393***	-0.0129***
					(0.00118)	(0.00171)
Any VSR more than 6m ago					-0.0204***	-0.0141***
					(0.00165)	(0.00264)
Any LSR in last 6m					-0.0136***	-0.0160***
					(0.00117)	(0.00164)
Any LSR more than 6m ago					-0.0317***	-0.0127***
					(0.00165)	(0.00266)
Log(lagged crimes in zip code)	absorbed	absorbed	absorbed	absorbed	absorbed	absorbed
Property ID FE	yes	yes	yes	yes	yes	yes
Zip code-year-month FE	yes	yes	yes	yes	yes	yes
Observations	2,866,238	2,866,238	2,866,238	2,866,238	2,866,238	2,866,238
R-squared	0.566	0.929	0.567	0.929	0.567	0.929

Note: This table reports the baseline results following Equation 1. The sample consists of all Airbnb listings from 2015/7 to 2019/12 in the five sample cities. All regressions control for Property ID fixed effects, and listing attributes including # of reviews, star ratings, whether the listing is a super host, whether the listing is cross-listed on Airbnb and VRBO, whether the listing offers a strict cancellation policy, and the number of Airbnb listings in the same zip code. Panel A Columns 1-4 control for city-year-month fixed effects, Panel A Columns 5-6 and Panel B Columns 1-6 control for zip code-year-month fixed effects. Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

guests if the listing accumulates a large number of reviews over time. However, Airbnb expands rapidly during our sample period, and media reports on safety and community concerns of Airbnb listings have grown over time. It is possible that newer guests are more wary about safety issues and pay more attention to safety reviews. Past critical feedback like VSR or LSR may act as an "anchor" for interpreting subsequent reviews even if newer reviews don't mention safety issues directly. It is also possible that consumer reviews (including safety reviews) play some role in Airbnb's sorting and recommendation algorithms and thus listings with VSR/LSR are less discoverable by guests over time, which hurts the listings' occupancy.

Alternative Specification (DID+Matching). Admittedly, the baseline specification assumes that *when* safety reviews (LSR or VSR) appear in the online review record of an Airbnb listing is random and independent of time-varying demand shocks to that listing, once we control for listing fixed effects, zip code-year-month fixed effects, and observable listing attributes. However, listings vary in many ways; their different experience and history on Airbnb could affect the occurrence of safety review(s) as well as today's occupancy rate and price regardless of LSR or VSR.

To address this concern, we identify 1,566 listings that have any VSR in our data (hereafter "VS Listings"); for each of them, we use propensity score matching to find another two non-VS listings that never receive any VSR but look most similar to the treated listing up to the month before the VS listing received its first VSR. The variables we use to match VS and control listings include listing type, number of bedrooms, log of average number of reviews, log of rating score, superhost status, cancellation policy, cross-listing status, average zip code category (high-income and white majority), and log of average number of listings in the zip code. Because different VS listings may receive their first VSR at different times, we organize VS listings into cohorts by the month of their first VSR and perform the aforementioned matching for each cohort separately. To measure the matching quality between VS and control listings, Appendix Figure A8 shows that the propensity score distribution is well overlapped between these two groups and Table A4 shows that the two groups are well balanced in listing attributes.

Pooling the observed months for the 1,566 VS listings and the corresponding 3,132 matched control listings, we run a difference-in-differences (DID) specification:

$$y_{jt} = \alpha_t + \alpha_j + \beta_1 \cdot VS\_listing_i + \beta_2 \cdot post\_1st\_VSR_{p,t} + \beta_3 \cdot VS\_listing_j \times post\_1st\_VSR_{p,t} + \epsilon_{j,t}, \quad (2)$$

where j denotes listing, p denotes the treatment-control pair, $VS_{listing}$ is a dummy of whether the listing is VSR treated, and $post\_1st\_VSR$ is a dummy indicating that t is after the first VSR of the treated listing (or the matched treated listing if j is a control listing), and the DID coefficient of the interaction captures how the listing's occupancy or price changes after it receives the first VSR as compared to similar control listings. We control for listing fixed effects and city-year-month fixed effects. Standard errors (in parentheses) are clustered by treatment-control pair.

As shown in Table 3 Panel A Columns 1-2, the estimated DID coefficients are negative and significant with 99% confidence, confirming that listings receiving any VSR do suffer from a decrease in occupancy and price.

We repeat the exercise by identifying 1,759 listings that have received any LSR (hereafter LS listings), and matching each of them with two control listings that have no LSR but are most similar to the LS listing in observable attributes. The matching quality between LS listings and their corresponding controls is presented in Appendix Figure A9 and Table A5. Pooling the observed months of 1,759 LS listings and 3,518 corresponding control listings, we estimate a parallel DID specification:

$$y_{jt} = \alpha_t + \alpha_j + \beta_1 \cdot LS\_listing_j + \beta_2 \cdot post\_1st\_LSR_{p,t} + \beta_3 \cdot LS\_listing_j \times post\_1st\_LSR_{p,t} + \epsilon_{j,t}, \quad (3)$$

where $LS\_listing$ is a dummy indicating whether j is a LS listing, p denotes the treatment-control pair, $post\_1st\_LSR$ is a dummy indicating whether t is after j (or the LS listing paired with j if j is a control listing) has received its first LSR, and the DID coefficient of the interaction term captures the average impact of LSR on the performance of LS listings. We control for listing fixed effects and city-year-month fixed effects. Standard errors are clustered by treatment-control pair.

The estimated DID coefficients are reported in Table 3 Panel B Columns 1-2. Again, both of them are negative and significant with 99% confidence, confirming the OLS finding that a listing tends to suffer in price and occupancy after it starts to receive any LSR.

Note that for occupancy, the DID coefficients based on the matched samples (Table 3) are of greater magnitudes than the coefficients of VSR and LSR in the baseline OLS regressions (Table 2 Panel A Columns 5-6). We can think of two reasons: First, the DID samples compare VSR and LSR listings to a selected group of control listings that look most similar to them in observable attributes, hence the DID+matching design is more immune to potential confounding factors in the whole-sample OLS regression. In this sense, the DID coefficients should be closer to the true effect of VSR or LSR. Second, the treated and control definitions in the DID samples are based on a single binary indicator, and the DID coefficient can only identify the effect of this single binary variable switching from 0 to 1. In practice, multiple "treatments" may occur simultaneously or sequentially: a listing can have both VSR and LSR, and a listing with VSR may also have other nearby listings with VSR. To the extent that these "treatments" are positively correlated, the DID coefficients may end up capturing the sum of all of them.

For both DID analyses, Table 3 Columns 3-4 explore how the DID coefficients change 1-3, 4-6, 7-12 and 13+ months after the listing receives its first VSR or LSR. Consistent with the baseline OLS results Table 2 Panel B, we observe the effects of VSR and LSR occur soon after their presence in a listing, this effect is stable for price, but somewhat strengthened over time for occupancy. The event-study plots for these DID analyses (Appendix Figures A10 and A11) confirm this pattern.

In short, the DID+matching results give us confidence with regards to the negative impact of VSR and LSR on the performance of Airbnb listings, but the OLS estimates in Table 2 provide us with a more comprehensive picture of how VSR, LSR and VSRADIUS relate to listing performance. They further allow us to distinguish the within-listing-cross-buyer effects of VSR and LSR from a possibility that VSR of nearby listings may raise a vicinity safety concern regarding the focal listing. Thus, in the remainder of Section 5.1, we use OLS estimates with zip code-year-month fixed effects and cumulative measures of VSR and LSR (Table 2 Panel A Columns 5-6) as the baseline results to explore mechanisms and heterogeneous effects.

Table 3: DID Results of Matched Airbnb Listings with/without VSR or LSR

Dependent Variable	(1) log (occupancy rate)	(2) log (price)	(3) log (occupancy rate)	(4) log (price)
	Panel A: Matched Sample by ever VSR			
VS listing × post 1st VSR	-0.0273***	-0.00697***		
	(0.00177)	(0.00201)		
VS listing × 1-3m post 1st VSR			-0.0195***	-0.00927***
			(0.00300)	(0.00340)
VS listing × 4-6m post 1st VSR			-0.0321***	-0.00942***
			(0.00305)	(0.00347)
VS listing × 7-12m post 1st VSR			-0.0278***	-0.0101***
			(0.00264)	(0.00299)
VS listing × 13+m post 1st VSR			-0.0366***	0.00252
			(0.00245)	(0.00278)
No. of observations	147,576	147,576	147,576	147,576
R-square	0.446	0.927	0.447	0.927
	Panel B: Matched Sample by ever LSR			
LS listing × post 1st LSR	-0.0363***	-0.0107***		
	(0.00178)	(0.00202)		
LS listing × 1-3m post 1st LSR			-0.0237***	-0.0164***
			(0.00298)	(0.00339)
LS listing × 4-6m post 1st LSR			-0.0443***	-0.0127***
			(0.00305)	(0.00347)
LS listing × 7-12m post 1st LSR			-0.0337***	-0.0168***
			(0.00263)	(0.00300)
LS listing × 13+m post 1st LSR			-0.0503***	0.00603***
			(0.00254)	(0.00289)
No. of observations	161,427	161,427	161,427	161,427
R-square	0.454	0.925	0.455	0.925

Note: This table reports the DID results at the listing level. The sample in Panel A consists of Airbnb listings that ever have VSR and the control listings that are similar to them in observable attributes and Airbnb history before the first VS review occurs. The sample in Panel B consists of Airbnb listings that ever have LSR and the control listings that are similar to them in observable attributes and Airbnb history before the first LS review occurs. All regressions control for listing fixed effects, city-year-month fixed effects, and the post dummy itself. Standard errors (in parentheses) are clustered by treatment-control pair. Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Mechanisms. To explore whether the baseline effects are driven by the extensive or intensive margins, Column 1 of Table 4 considers as the dependent variable a dummy that equals 1 when a listing's occupancy rate is positive and 0 otherwise. Column 2 reruns the OLS baseline specification (Equation 1), conditional on a listing's occupancy rate is positive. The coefficients of VSR ad LSR are always negative and significant in these two columns, as in the baseline results. This robustness suggests that these two variables are negatively correlated with listing performance on both the extensive and intensive margins. As in the baseline results, once we control for zip code-year-month fixed effects, the coefficient of $VSRADIUS$ is statistically insignificant from zero and $Crime$ is absorbed by the fixed effects.

Table 4: Mechanisms for Reduced-form Listing Level Analysis of Airbnb Listings

	(1)	(2)	(3)	(4)
Sample	whole	occupancy>0	# reviews<=13	# reviews>13
Dependent variable	occupancy rate dummy	log occupancy rate	log occupancy rate	log occupancy rate
Any VSR since 2015/7	-0.00883***	-0.0107***	-0.0164***	-0.00764***
to last month	(0.00153)	(0.00115)	(0.00498)	(0.00144)
Any LSR since 2015/7	-0.0118***	-0.0201***	-0.0350***	-0.0154***
to last month	(0.00148)	(0.00109)	(0.00419)	(0.00137)
% of Any nearby VSR w/in	-0.00254	-0.00237	-0.00150	0.000663
0.3-mile radius	(0.00400)	(0.00228)	(0.00350)	(0.00335)
R-squared	0.429	0.509	0.576	0.535
Dependent Variable		log (price)	log (price)	log (price)
Any VSR since 2015/7		-0.0110***	-0.00413	-0.0110***
to last month		(0.00189)	(0.00659)	(0.00221)
Any LSR since 2015/7		-0.0105***	-0.00223	-0.0116***
to last month		(0.00179)	(0.00617)	(0.00210)
% of Any nearby VSR w/in		-0.00176	0.00306	-0.00786*
0.3-mile radius		(0.00325)	(0.00563)	(0.00453)
R-squared		0.945	0.933	0.940
log(lagged crimes)	absorbed	absorbed	absorbed	absorbed
Property ID FE	yes	yes	yes	yes
Zip code-year-month FE	yes	yes	yes	yes
Observations	2,866,238	2,441,566	1,370,655	1,495,583

Note: This table explores mechanisms behind the baseline results in Table 2 Panel A Columns 5 and 6. The whole sample in Column (1) consists of all Airbnb listings from 2015/1 to 2019/12 in the five sample cities. Columns (2), (3) and (4) use sub-samples. The occupancy and price regressions in the same column use the same sub-sample. All regressions control zip code-year-month fixed effects, Property ID fixed effects, and listing attributes including # of reviews, star ratings, whether the listing is a super host, whether the listing is cross-listed on Airbnb and VRBO, whether the listing offers a strict cancellation policy, and the number of Airbnb listings in the same zip code. Standard errors (in parentheses) are clustered by Property ID. Standard errors in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1.

Another mechanism we explore is whether the baseline results are driven by the visibility of VSR or LSR to potential guests. To do so, we split the sample by whether a listing-month has more than 13 reviews, where 13 is close to the median in the sample, recognizing that prospective guests are more likely to notice safety reviews (both VSR and LSR) when listings have a lower number of reviews.

Indeed, Columns 3 and 4 of Table 4 report that in the subsample of listings with 13 or fewer reviews, the negative effects of having any VSR and LSR on occupancy rate (1.64% for VSR and 3.5% for LSR) are higher than the corresponding negative effects for listings with more than 13 reviews (0.764% for VSR and 1.54% for LSR). When the dependent variable is listings' log price, the coefficients of VSR and LSR remain negative in both subsamples but they are of a larger magnitude and more significant for listings with more than 13 reviews, possibly because hosts of newer listings may still be in the process of identifying their pricing for those listings. The results are similar if we add additional controls for the average word count or average sentiment of a listing's review.[38]

Heterogeneous effects. Table 5 reports the baseline results for high-income (H), low-income (L), white (W) and minority (M) zip codes separately. While having any VSR or LSR has negative effects on occupancy rate and price across all four subsamples, this negative effect tends to have a slightly higher magnitude in H and W than in L and M. One potential explanation is that guests may have different prior beliefs and different sensitivities to safety issues, and perhaps more so if their search targets a specific area that they believe is relatively safe. The coefficient of $VSRADIUS$ is statistically zero except for high-income zip codes in the occupancy regression.

Appendix Table A8 consider subsamples comprising different listing types (entire home, private room, shared space, and hotel room). Additional heterogeneous effects may arise here because, for instance, for guests who seek non-entire dwellings (private room, shared space) within an accommodation, safety issues may be more salient. Results in Table A8 confirm this prior: the magnitude of the negative effects from having any VSR and LSR on occupancy are larger for private rooms and shared spaces (1.58% and 2.28% for VSR and 2.83% and 2.35% for LSR, respectively) in comparison with entire-home listings (1.34% for VSR and 2.19% for LSR).

5.2 Guest-Level Analysis

The baseline results demonstrate a robust negative within-listing-cross-buyer effect of VSR and LSR on listing price and occupancy, but do not capture the cross-listing-within-buyer effects of safety reviews because the baseline regressions track listings but not guests. To capture the within-buyer effects, we need to track individual guests over time. In particular, we need guest-level analysis to test whether guests who leave any VSR (henceforth, VS guests) or any LSR (henceforth, LS guests) act differently before and after they post their first VSR or LSR in comparison to otherwise similar guests who did not leave any VSR or LSR. Because VSR and LSR are rare, we conduct the analysis for them separately.

Guest-level VSR analysis. We assume that the first VSR that a VS guest posts for one of the listings in our sample (i.e., covering Airbnb listings in the five cities we consider, with reviews beginning

[38]These results are available upon request.

Table 5: Reduced-form Listing-level Analysis of Airbnb Listings By Four Area Types

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sample	H	L	W	M	H	L	W	M
Dependent Variable	log occupancy rate	log occupancy rate	log occupancy rate	log occupancy rate	log (price)	log (price)	log (price)	log (price)
Any VSR since 2015/7 to last month	-0.0163***	-0.0137***	-0.0150***	-0.0142***	-0.0165***	-0.0136***	-0.0159***	-0.0135***
	(0.00249)	(0.00162)	(0.00209)	(0.00178)	(0.00368)	(0.00254)	(0.00313)	(0.00281)
Any LSR since 2015/7 to last month	-0.0250***	-0.0231***	-0.0233***	-0.0251***	-0.0173***	-0.0120***	-0.0174***	-0.0105***
	(0.00189)	(0.00180)	(0.00172)	(0.00199)	(0.00271)	(0.00292)	(0.00258)	(0.00315)
% Any nearby VSR w/in 0.3-mile radius	-0.00705**	-0.00123	-0.00471	-0.00069	0.00197	-0.00537	0.00486	-0.00681
	(0.00346)	(0.00328)	(0.00366)	(0.00315)	(0.00556)	(0.00510)	(0.00562)	(0.00503)
log (lagged crimes)	absorbed	absorbed	absorbed	absorbed	absorbed	absorbed	absorbed	absorbed
Observations	1,484,474	1,381,764	1,716,774	1,149,464	1,484,474	1,381,764	1,716,774	1,149,464
R-squared	0.558	0.575	0.557	0.581	0.923	0.926	0.921	0.927

Note: This table reports explore heterogeneous effects behind the baseline results in Table 2 Panel A Columns 5 and 6. The whole sample consists of all Airbnb listings from 2015/7 to 2019/12 in the five sample cities. All regressions control zip code-year-month fixed effects, Property ID fixed effects, and listing attributes including # of reviews, star ratings, whether the listing is a super host, whether the listing is cross-listed on Airbnb and VRBO, whether the listing offers a strict cancellation policy, and the number of Airbnb listings in the same zip code. Standard errors (in parentheses) are clustered by Property ID. *** p $<$ 0.01, ** p $<$ 0.05, * p $<$ 0.1.

in May 2015) is the first VSR that this guest posted. Guests that never posted any VSR, referred to as "non-VS" users, are the potential control group for VS users. To ensure that we can match VS and non-VS users in their Airbnb experience prior to leaving any VSR, we focus on the subset of VS users that left at least two reviews in the five sample cities before leaving their first VSR.

In order to match VS users with non-VS users, we use propensity score matching with K-nearest neighbor (KNN) to select the two most similar non-VS users for each VS-user. Note that our setting is different from the typical propensity score matching scenario for two reasons: (a) the treatment (when a VS user wrote her first VSR) is staggered at different calendar times; and (b) the starting time of each guest in our data (when a user started to write her first review on Airbnb) can differ greatly. The recent econometrics literature reviewed by Roth et al. (2023) has provided a few new ways to address (a) but they usually require a balanced sample in which researchers can observe both treated and control units from the same beginning and end periods while treated units may get treated at different times. In our case, a balanced sample is difficult to achieve because of (b).

One potential way to address this challenge is only matching VS and non-VS guests up to a common calendar time t_0 (e.g., prior to any VSR appearing in our sample of VS guests). This leads to a compromise in matching quality, because a VS guest that wrote her first VSR at t_i may end up matching with a non-VS user that differs significantly from her between t_i and t_0, although they look identical up to t_0. Another potential solution is lining up every VS guest's treatment time (time of writing their first VSR) as 0 and randomly assigning time 0 for every non-VS guest. This way, we may have a good match for the VS guest's historical experience up to time 0 but the matched non-guest could have a seemingly similar experience from a very different calendar time. Given that Airbnb has expanded quickly throughout the US in our sample period, the public's general expectation of price and quality from Airbnb listings may change drastically over time, thus the mismatch in calendar time is not ideal either.

In light of these challenges, we conduct our propensity score matching for each cohort of VS guests separately. In particular, we group VS guests that wrote their first VSR in the same year-month as the same cohort. For all cohort-k VS guests that wrote their first VSR in month t_k^0, we can compute their average attributes up to t_k^0; for all non-VS guests, we also compute their average attributes up to t_k^0. This gives us a snapshot of VS guests and non-VS guests as of t_k^0. For this snapshot, we regress the dummy of a user being a VS guest on a list of user attributes up to t_k^0. The pre-treatment user attributes we use include the number of reservations the user made on Airbnb, the average normalized crime reports in the cities in which the user stayed (based on their prior reviews), the average number of VSR for listings for which the user left reviews, the average percentage of overall VS listings in the same zip codes as well as in the 0.3-mile radius area as listings for which the user had previously left reviews, and the average number of words for the reviews that the user posted before. This procedure gives us two nearest non-VS guests for each VS guest in cohort k. Repeating this process for all cohorts of VS guests,[39] we identify 2,252 VS users and 4,504 matched non-VS users. Appendix Table A6 reports that the VS users and their matched non-VS users are similar as far as the characteristics considered in the KNN method; the two user groups also have similar propensity scores, as shown in Appendix Figure A12.

Following each VS user and their matched non-VS users over time (by the reviews they wrote on Airbnb), our panel data includes which users are paired, their user IDs, and the time and attributes of the listings they book on Airbnb. To test whether VS users behave differently in terms of subsequent reservations on Airbnb after their first VSR (as exhibited by their subsequent listing reviews), we run the following DID regression:

$$y_{it} = \alpha_t + \alpha_p + \beta_1 \cdot VS\_user_i + \beta_2 \times post\_1st\_VSR_{pt} + \beta_3 \cdot VS\_user_i \times post\_1st\_VSR_{pt} + \epsilon_{i,t}, \qquad (4)$$

where the subscript p denotes the treatment-control pair identified in the sample construction and the dummy $post\_1st\_VSR$ indicates whether t is after the time of the first VSR of the VS user herself or the VS user with whom the non-VS user is matched.

We construct several measures for the dependent variable y_{it}: the first is the number of reviews that user i wrote in month t. We use it as a proxy of user i's Airbnb reservations in t, which can be zero and thus captures both the extensive and intensive margins. Because it is a count variable, we use a Poisson regression instead of ordinary least squares. The other measures of y_{it} include the normalized cumulative count of officially reported crimes in the zip codes of user i reserved listings in month t, the number of VSR in i reserved listings, the percentage of VS listings in the zip codes as well as in the 0.3-radius area of the i reserved listings, and whether the reserved listings have any VSR. These variables capture the types

[39] We did the matching with replacement, thus it is possible that the same non-VS guest is matched with two VS guests in two different cohorts. In that case, we include this non-VS guest twice in the DID sample, with different pair ID and pseudo-treatment time corresponding to the VS guest to which she matches.

of listings that i books on Airbnb conditional on her booking at all (the intensive margin). The dummy VS_user_i equals 1 for VS users and 0 otherwise, and the dummy $post_t$ equals 1 if t is after the time of the first VS review of VS user i. The key variable is the interaction between VS_user_i and $post\_1st\_VSR_{pt}$. in year-month fixed effects α_t. Treatment-control pairs fixed effects are denoted by α_p. Standard errors are robust and clustered by treatment-control pairs.

In Panel A of Table 6, Column 1 reports results from a Poisson model based on an unbalanced monthly panel data, indicating that VS users tend to book fewer reservations (as evidenced by subsequent reviews) after posting their first VS review. In particular, the average monthly number of subsequent reviews is expected to be 60.07% lower for VS users in comparison with normal users.[40] Columns 2-6 assess whether VS users are more sensitive to safety information when booking subsequent Airbnb listings after posting their first VS review. Results suggest that the subsequent listings chosen by VS users tend to locate in zip codes that have fewer normalized crime reports, are less likely to have VSR, and are less likely to locate in zip codes that have a higher overall percentage of VSR or a higher percentage of other listings with VSR. This suggests that VS users, relative to normal users, are more sensitive to safety information after posting their first VS review.

We note that our DID specification assumes every matched non-VS user has no VS experience in their Airbnb stays. This assumption may not hold if some guests experienced VS issues but chose not to mention it in consumer feedback. Given the fact that 44.56% of Airbnb stays in our sample result in a consumer review and buyers tend to under report critical feedback on the internet, the DID effect reported in Table 6 may under-state the true effect. In particular, if the fraction of encountering a VS issue and writing about it in VSR is x and the probability of writing any review after a stay (regardless of the nature of experience) is δ, then the fraction of having a VS experience (regardless of writing about it or not) would be x/δ. This implies that in the "control" group of non-VS users, only a fraction of $\frac{1-x/\delta}{1-x}$ are true non-VS users. If the true treatment effect of having a VS experience is β, then our DID estimate $\hat{\beta}$ in Table 6 captures the difference between β and $\beta \times (1 - \frac{1-x/\delta}{1-x})$, hence the true effect $\beta = \hat{\beta} \times \frac{1-x}{1-x/\delta}$. In our data, VS listings account for 8% of Airbnb bookings and the average probability of writing any review after a stay is 44.56% , implying $x = 8\%$, $\delta = 0.4456$ and thus $\beta = \hat{\beta} \times 1.1213$. In other words, the DID estimates may underestimate the true effect by roughly 12%.

One may argue that the extent of learning through self experience would depend on a guest's prior about vicinity safety. Unfortunately, we have no data on each guest's home town and therefore cannot approximate their prior with the type of vicinity in which they normally live. Nevertheless, some VS users may have seen some VSR left by a listing's prior guests, and that listing eventually triggered their own VS review, and therefore would not respond as vigorously to their own vicinity safety experience as other VS users. To test this, we create a dummy (First-Is-First) indicating whether a VS user's own VS

[40] This is not the coefficient of the treatment dummy (-0.918) because we use a Poisson model for this regression, i.e., the applicable percentage is $1 - e^{-.918}$.

Table 6: Reduced-form Guest-level Analysis: DID for VS users (treated) and non-VS Users (control)

	(1)	(2)	(3)	(4)	(5)	(6)
Sample	monthly reservation	reserved property	reserved property	reserved property	reserved property	reserved property
Model	Poission	Poission	Logit	OLS	OLS	OLS
Dependent Variable	# reservations in a month	# VSR in booked listing	1 if any VSR in booked listing	Crime in booked zip	% VS listing in booked zip	% VS listing in 0.3m radius
	Panel A: Full sample					
VS_user × post	-0.918***	-0.697***	-0.490***	-0.927***	-0.0250***	-0.0247***
	(0.0601)	(0.135)	(0.113)	(0.112)	(0.00267)	(0.00505)
Observations	254,056	22,265	22,237	22,415	22,415	22,415
	Panel B: Sub-sample = VS user's 1st VSR is the 1st VSR of the listing					
VS_user × post	-0.961***	-0.793***	-0.696***	-0.961***	-0.0280***	-0.0275***
	(0.0667)	(0.146)	(0.129)	(0.127)	(0.00271)	(0.00551)
Observations	202,262	17,743	17,726	17,893	17,893	17,893
	Panel C: Sub-sample = VS user's 1st VSR is not the 1st VSR of the listing					
VS_user × post	-0.726***	-0.372	0.256	-0.710***	-0.00872	-0.00854
	(0.139)	(0.298)	(0.239)	(0.228)	(0.00838)	(0.0129)
Observations	51,794	4,522	4,511	4,522	4,522	4,522

Note: This table presents the DID results of VS users and the non-VS users that are similar to the VS users in user attributes and Airbnb history before the VS user posts her first VSR. Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All regressions control treatment-control pair ID FE and the post dummy. Standard errors are clustered by pair ID.

review was the first VS review on the focal listing. About 79.6% of VS users have First-Is-First = 1. We then rerun the DID analysis for the subsamples of First-Is-First = 1 and First-Is-First = 0, respectively. Each subsample includes the VS users with the specific value of First-Is-First and their matched normal users. Regression results are reported in Panels B and C of Table 6. If the above prediction is correct, the VS users with First-Is-First = 1 should demonstrate greater changes post their own VS experience, as compared to those with First-Is-First = 0.

Indeed, the coefficients reported in Panel B of Table 6 (for First-Is-First = 1) are of a larger magnitude than those in Panel C (for First-Is-First = 0). The estimates in Panel C are noisier and sometimes insignificant, in part because only 20.4% of VS users may have seen prior VSR on the focal listing before posting their own VS review. That being said, even these VS users demonstrate a strong decline of Airbnb bookings post their own VS experience (-51.62% Column 1) as compared to -61.75% for VS users with First-Is-First = 1 and -60.07% for all VS users. These numbers are not statistically different from each other, suggesting that the VSR left on the focal listings before our VS users' own VS experience have a limited influence on their prior of vicinity safety before booking the focal listing and one's own VS experience is a still a salient shock ex post. This points to a significant cross-listing-within-buyer effect of VSR.

We further examine whether VS users subsequently act differently as a function of the area (high-income, low-income, minority or white) in which they posted their first VS review. To do so, we group VS users according to the zip code of the listing for which they posted their first VS review, and proceed to conduct the DID analysis separately for each of the four subsamples.

Table 7: Reduced-form Guest-level Analysis: DID for VS users by the zip code of their VSR bookings

	(1)	(2)	(3)	(4)
Sample	1st_vsr_h_zip	1st_vsr_l_zip	1st_vsr_w_zip	1st_vsr_m_zip
Model	Logit	Logit	Logit	Logit
Dependent Variable	1 if book in any H zip	1 if book in any H zip	1 if book in any W zip	1 if book in any W zip
	Panel A: Full sample			
VS_user × post	-0.351**	0.316***	-0.628***	0.682***
	(0.160)	(0.0990)	(0.135)	(0.105)
Observations	6,205	14,830	8,880	12,815
	Panel B: Subsample = VS user's 1st VSR is the 1st VSR of the listing			
VS_user × post	-0.287*	0.370***	-0.646***	0.729***
	(0.169)	(0.111)	(0.149)	(0.117)
Observations	5,539	11,377	7,181	10,113
	Panel C: Subsample = VS user's 1st VSR is not the 1st VSR of the listing			
VS_user × post	-0.887*	0.143	-0.545*	0.494**
	(0.496)	(0.218)	(0.327)	(0.247)
Observations	666	3,453	1,699	2,702

Note: This table presents the DID results of VS users vs. the non-VS users that are similar to the VS users in user attributes and Airbnb history before the VS user posts her first VSR. Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All regressions control treatment-control pair ID FE and the post dummy, with standard errors clustered by pair ID. Columns 1-4 use the sub-sample corresponding to the VS users whose 1st VSR is posted on a property listing in a H, L, W, or M area, respectively.

From the interaction term in Panel A of Table 7, it is apparent that VS users exhibit a positive effect on subsequent reservations in opposite types of zip codes (Columns 2 and 4) and a negative effect in the same type of zip codes (Columns 1 and 3). One explanation is that VS users expect a certain level of safety in the area of their booking, and when they encounter a negative shock, they prefer to avoid that type of area in subsequent stays.

One may argue that the tendency to avoid the same type of areas is driven by mean reversion rather than active learning. To address this, we repeat the exercise for the subsamples with First-Is-First=1 and First-Is-First=0 separately. Results are reported in Panels B and C of Table 7. Three of the four columns (Columns 2-4) are consistent with the argument that learning through self-experience is stronger when the VS user did not see any other VSR on the focal listing before her own VS review. The only exception is when the self VSR is in a high-income zip code (Column 1). In that case, both VS users of First-Is-First equal to 1 or 0 decrease their likelihood of booking future Airbnb stays in high-income zip codes (which is consistent with learning) but the coefficient on the DID interaction term is of a larger magnitude for those with First-Is-First = 0, though the difference is not statistically significant. Compared with other columns, this column has less statistical power because VSR are rarer in high-income zip codes. Overall, we conclude that the tendency to avoid the type of zip code that triggered VS users' own VS review is partially driven by learning from one's own VS experience.

To push it further, we reorganize our DID sample into another eight subsamples depending on whether a VS user previously had Airbnb stays in the same type of area that triggered her own VS experience. For example, if her own VS experience was in a low-income (L) area, she may or may not have had Airbnb stays in low-income areas before. This gives us the subsamples of HL, LL, LH, and HH, where the second letter indicates the income type of the area that triggered the VS user's own VS review, and the first letter represents the income type area of her prior experience. Similarly, we can create the subsamples of WM, MM, MW, and WW depending on whether the area is primarily white or minority. All matched normal users belong to the same subsample as the VS users with whom they are paired.

Results are reported in Appendix Tables A9 and A10. In the raw data, we know VSR are more likely to occur in low-income and minority areas, but listings in these areas also account for over 60% of all Airbnb bookings; thus, the sample sizes of LH and LL are larger than those of HL and HH and the sample sizes of MW and MM are larger than those of WM and WW. If we focus on Column 1 of Table A9, the VS users in LH are the most 'surprised' (in terms of reducing future reservations on Airbnb) among the four L/H groups and the VS users in MW are the most surprised among the four M/W groups. This is intuitive because the VS users with at least one L or M stay before their own VS experience in H or W may have high vicinity safety expectations in H or W and are consequently most disappointed when vicinity safety issues arise in those areas. In contrast, the VS users in HL or WM are not as surprised (Column 1), likely because they had a lower prior for vicinity safety in the L or M areas. Nevertheless, conditional on booking on Airbnb, they tend to book listings with fewer VSR following their own VS review. These patterns confirm the cross-listing-within-buyer effect of self-experience with vicinity safety.

Guest-level analysis for LS guests. For comparison, we repeat the same DID+matching procedure for guests that ever wrote LSR on Airbnb (LS users) and those that never wrote LSR (non-LS users), and rerun a similar DID regression on the panel data that tracks the Airbnb activities of LS users and their matched non-LS users:

$$y_{it} = \alpha_t + \alpha_p + \beta_1 \cdot LS\_user_i + \beta_2 \cdot post\_1st\_LSR_{pt} + \beta_3 \cdot LS\_user_i \times post\_1st\_LSR_{pt} + \epsilon_{i,t}, \qquad (5)$$

where the subscript p denotes the treatment-control pair identified in the sample construction and the dummy $post\_1st\_LSR$ indicates whether t is after the time of the first LSR of the LS user herself or the LS user with whom the non-LS user is matched. We construct the dependent variables the same way as in Equation 4.

Results in Table 8 suggest that LSR triggers some cross-listing-within-buyer effect as well: having experienced and written about LSR in an Airbnb listing makes the LS user 48.21% less likely to book on Airbnb afterwards,[41] and conditional on having future bookings, the LS user is less likely to book listings

[41] Because the specification is Poisson, the marginal effect is $exp(-0.658) - 1 = 0.4821$.

with any LSR (Columns 2 and 3), listings in a zip code that has a higher percentage of LS listings, or listings that are within 0.3-mile radius of any listings with LSR.

It is worth noting that these effects are stronger for VS users than for LS users, on both the extensive margin of not making any subsequent Airbnb booking after self experience (-60.07% for VS users vs. -48.21% for LS users) and the intensive margin of shying away from the listings that have the same type of safety reviews that the treated user has written about herself (-38.74% for VS users vs. -28.39% for LS users).[42]The extensive margin results are further confirmed in the event study plot (Appendix Figure A14). Combined with the fact that LSR tend to have a greater within-listing-cross-buyer effect than VSR as shown in Table 2, the larger cross-listing-within-buyer effects of VSR relative to LSR imply that guests may receive a bigger surprise from a vicinity safety experience than from a listing safety experience and therefore react more strongly to the negative shock. It is also possible that guests believe LSR can be addressed by hosts and therefore they can find non-LSR listings on Airbnb but VSR describe a problem out of the host's control and harder to avoid on Airbnb.

Table 8: Reduced-form Guest-level Analysis: Compare DID results for VS users and LS users

	(1)	(2)	(3)	(4)	(5)	(6)
Sample	monthly reservation	reserved property	reserved property	reserved property	reserved property	reserved property
Model	Poission	Poission	Logit	OLS	OLS	OLS
	Panel A: Full sample Results for VS-user DID					
Dependent Variable	# reservations in a month	# VSR in booked listing	1 if any VSR in booked listing	Crime in booked zip	% VS listing in booked zip	% VS listing in 0.3m radius
VS user × post	-0.918***	-0.697***	-0.490***	-0.927***	-0.0250***	-0.0247***
	(0.0601)	(0.135)	(0.113)	(0.112)	(0.00267)	(0.00505)
Observations	254,056	22,265	22,237	22,415	22,415	22,415
	Panel B: Full sample Results for LS-user DID					
Dependent Variable	# reservations in a month	# LSR in booked listing	1 if any LSR in booked listing	Crime in booked zip	% LS listing in booked zip	% LS listing in 0.3m radius
LS user × post	-0.658***	-0.269***	-0.334***	-0.671***	-0.0117***	-0.0238***
	(0.0516)	(0.103)	(0.109)	(0.112)	(0.000983)	(0.00277)
Observations	288,072	21,113	25,981	26,915	22,629	22,629

Note: This table compares the DID results for VS users and LS users. Panel A sample consists of VS users and non-VS users that are similar to the VS users in user attributes and Airbnb history before the VS user posts her first VSR. Panel B sample consists of LS users and non-LS users that are similar to the LS users in user attributes and Airbnb history before the LS user posts her first LSR. Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All regressions control treatment-control pair ID FE and the post dummy, with standard errors clustered by pair ID.

[42] $exp(-0.490) - 1 = -0.3874$ and $exp(-0.334) - 1 = 0.2839$.

6 Structural Estimation and Counterfactual Analysis

So far, the reduced-form evidence supports (i) the classical within-listing-cross-buyer effect of VSR and LSR, as listing performance worsens after a listing receives its first VSR or LSR; and (ii) the cross-listing-within-buyer effect of VSR or LSR, as a guest that wrote VSR or LSR tends to avoid other listings/vicinities with any VSR or LSR in their future bookings or avoid booking on Airbnb altogether. Interestingly, the former is stronger for LSR than for VSR but the latter is stronger for VSR than for LSR, suggesting that self experience in VSR generates a greater negative surprise to guests. In comparison, the spillover from a listing's VSR to nearby listings is weak and hard to identify from other local shocks at the zip code level.

It is difficult to use these reduced-form estimates to understand the implications of the externalities for hosts and platforms, because they do not address listing competition. In particular, listings with and without VSR/LSR may compete against each other on Airbnb, and all Airbnb listings compete with the outside options (including listings on competing short-term-rental platforms, hotels, bed and breakfasts, a friend's or relative's couch in the destination city, or no travel at all). To address this shortcoming, we resort to a structural model that describes how guests choose among competing short-term lodging options.

6.1 Demand Model and Estimation

Possible market definitions. We have explored several ways of defining the short-term lodging market: option (a) is limited to Airbnb and VRBO bookings in a zip code-month; option (b) includes all hotels, Airbnb, and VRBO stays in a zip code-month; option (c) includes hotels, Airbnb, and VRBO stays across all zip codes in a city-month; and option (d) includes all incoming air travelers in a city-month.

Among the four options, (a) is the narrowest because it assumes a guest has a specific zip code in mind when she searches for short-term lodging and there is no competition between hotels and STR listings. This can be problematic, not only because hotels compete with STR listings but also because guests that are concerned about vicinity safety with regard to Airbnb listings may have similar concerns for nearby VRBO listings (if they can overcome the information friction across the two platforms to figure out what Airbnb listings and VRBO listings are geographically close). However, adding hotels to the market at the zip code-month level is also problematic, because most zip codes do not have any hotels. Expanding the market from zip code-month to city-month can get around this problem, but it assumes any potential guests would consider all zip codes in a city. This consideration set might be larger than what most guests actually consider, calling for model parameters that address different substitution patterns within and across zip codes in the same city.

As we explore the above four options of market definition, we focus on entire-home listings on STR platforms because only entire-home listings are available on VRBO and the few hotel listings on Airbnb suggest that entire-home listings are much more similar to hotel listings than private-room or shared-space listings (Table A3). Since our VRBO data period is from 2017/6 to 2019/12, our analysis in this subsection is limited to 2017/6 to 2019/12 only.

Guest utility. Under any of the four market definitions, following Berry (1994) and Mansley et al. (2019), we assume that each prospective guest chooses an Airbnb entire-home listing or the outside good so as to maximize her utility from the listing, where the utility associated with listing j in zip code z of city k and month t can be written as:

$$\begin{aligned} U_{j,t} &= EU_{j,t} + \epsilon_{j,t} \\ &= \alpha_j + \alpha_{k,t} + \delta \cdot X_{j,t} + \beta_0 \cdot log(P_{j,t}) + \beta_1 \cdot Crime_{z,t-1} \\ &+ \beta_2 \cdot LSR_{j,t-1} + \beta_3 \cdot VSR_{j,t-1} + \beta_4 \cdot VSRADIUS_{j,t-1} \\ &+ \zeta_j^{city} + (1-\sigma_{city})\zeta_j^{zip} + (1-\sigma_{zip})(1-\sigma_{city})\epsilon_{j,t}. \end{aligned} \tag{6}$$

where $X_{j,t}$ stands for listing attributes[43], $\alpha_{k,t}$ represents some area-time fixed effects[44], $\epsilon_{j,t}$ conforms to i.i.d. extreme value distribution and $\zeta_j^{city}, \zeta_j^{zip}$ follow the unique distributions such that $[\zeta_j^{city} + (1-\sigma_{city})\zeta_j^{zip} + (1-\sigma_{zip})(1-\sigma_{city})\epsilon_{j,t}]$ describes a two-level nested logit error. As shown in Figure 2, if the market definition is city-month, a guest first chooses between Airbnb and the outside good, and then within Airbnb chooses among different zip codes before selecting an Airbnb listing in a specific zip code.

The nesting parameter $0 < \sigma_{city} < 1$ describes how Airbnb listings in different zip codes are closer substitutes to each other than the substitution between Airbnb and the outside good, and the nesting parameter $0 < \sigma_{zip} < 1$ describes how Airbnb listings in the same zip codes are closer substitutes to each other than the substitution between Airbnb listings across zip codes. When $\sigma_{zip} = \sigma_{city}$, the two level nesting structure collapses to one nest (Airbnb vs. the outside good); when $\sigma_{city} = 0$, it further collapses to a simple logit where the outside good is equivalent to another single listing available in the market. If the market definition is zip code-month rather than city-month, we can only have a one-nest structure.

[43]For VRBO listings in the outside good, we observe their X directly except for VSR and LSR because we observe no reviews on VRBO. We code their VSR and LSR as zero. For hotels in the outside good, we observe their average daily price and occupancy volume directly but not other listing attributes. Given the general difference between regular hotels and STR listings, we assume all hotels have the highest ratings (in the Airbnb definition) and do not have a strict cancellation policy.

[44]Note that the area-time fixed effects ($\alpha_{k,t}$) cannot be as detailed as the market definition, as that way the fixed effects would absorb the outside good market size and make the results independent of market definition. When we define the market as zip code-month, we use city-year-month fixed effects for $\alpha_{k,t}$. When we define the market as city-month, we use city-calendar month (1-12) and year-month fixed effects for $\alpha_{k,t}$ to control for common time effects and city-specific seasonality.

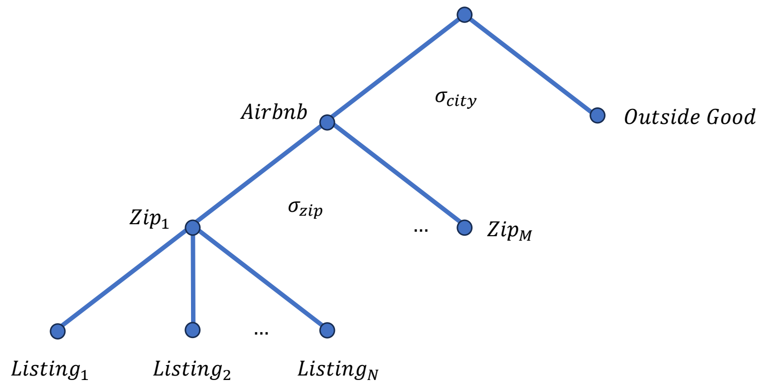


Figure 2: Two-level Nested Demand for Short-term Lodging

Under this nesting structure, we can express the market share of listing j at time t as:[45]

$$s_{j,t} = \bar{s}_{j,t|zip_z} \cdot \bar{s}_{zip_z|Airbnb} \cdot \bar{s}_{Airbnb}$$

Thus:

$$ln(s_{j,t}) - ln(s_{0,t}) = EU_{j,t} + \sigma_{zip} \cdot log(\bar{s}_{j,t|zip_z}) + \sigma_{city} \cdot log(\bar{s}_{zip_z|city}). \tag{7}$$

This is equivalent to regressing the difference of log market shares between listing j and the outside good ($ln(s_{j,t}) - ln(s_{0,t})$) on the attributes of listing j in month t plus its within-zip-code market share and the within-city market share of j's zip code. The right-hand side of Equation 7 is similar to Equation 1, except for three changes. First, we exclude the number of Airbnb listings in the zip code-month because the discrete choice model already accounts for the size of the choice set. Second, we include the log of the listing's daily price. And third, we include a listing's within-zip code market share and the zip code's within Airbnb market share; these two within market shares are endogenous, and we use the number of Airbnb listings within the corresponding zip code-month interacting with average listing attributes in that zip code-month as instrument for $log(\bar{s}_{j,t|zip_z})$ and the number of zip codes in a city interacting with the average Airbnb listing attributes in the city as instruments for $log(\bar{s}_{zip_z|city})$.

As $log(P)$ might be endogenous, we consider three instruments. First, following Berry et al. (1995), the average attributes of entire-home listings within a 0.3-mile radius of the focal listing in the same zip code-month can be instruments as they are correlated with price because of horizontal competition (whereby competitors' attributes affect margins) but are excluded because they do not affect the focal

[45] In particular, the within zip code market share is $\bar{s}_{j,t|zip_z} = \frac{exp\left(\frac{EU_{j,t}}{1-\sigma_{zip}}\right)}{exp\left(\frac{I_{zip_z}}{1-\sigma_{zip}}\right)}$, the zip code's within Airbnb market share is $\bar{s}_{zip_z|Airbnb} = \frac{exp\left(\frac{I_{zip_z}}{1-\sigma_{city}}\right)}{exp\left(\frac{I_{Airbnb}}{1-\sigma_{city}}\right)}$, Airbnb's overall market share in the city is $\bar{s}_{Airbnb} = \frac{exp(I_{Airbnb})}{exp(I)}$, the zip code-specific inclusive value is $I_{zip_z} = (1 - \sigma_{zip}) \cdot log \sum_{j \in zip_z} exp\left(\frac{EU_{j,t}}{1-\sigma_{zip}}\right)$, the Airbnb-specific inclusive value is $I_{Airbnb} = (1 - \sigma_{city}) log \sum_{z \in city} exp\left(\frac{I_{zip_z}}{1-\sigma_{city}}\right)$, and the overall inclusive value is $I = log\,(1 + exp(I_{Airbnb}))$.

listing's utility directly; we refer to them as BLP instruments hereafter. Second, the average price of private-room listings within a 0.3-mile radius of the focal listing in the same zip code-month can be potential instruments, under the assumption that guests of private-room listings are fundamentally different from guests of entire-home listings and hotels, but both types of listings are subject to similar cost shocks in the same location. We refer to them as Private Room instruments. Third, Zillow's home value index (ZHVI) by zip code-month can capture local property taxes, house maintenance costs, and non-rental usage of the property. Usually, short-term rental units only account for a tiny fraction of the housing stock in a city[46], so the potential impact of short-term rental activities on ZHVI shall be minimal. Because ZHVI is zip code but not property specific, we interact it with a listing's basic attributes (# of bedrooms and star ratings) to construct property specific instruments. We refer to them as $ZHVI \cdot x$ instruments.

Table 9 reports the results for 12 combinations of different market definitions and different instruments for listing price. In Panel A, we adopt a narrow market definition of zip code-month and use BLP instruments for listing price, but explore whether or not to include hotels in the market and whether or not to allow one-level nesting (Airbnb vs. the outside good). When VRBO is the only outside good, the nesting parameter is found to be 1.15, out of the regular range of 0 to 1. But when the outside good consists of hotels and VRBO listings, we find a more reasonable nesting parameter (0.25), which suggests that substitution within Airbnb listings is closer than the substitution between Airbnb and Hotel+VRBO in the same zip code-month. This is not surprising because the volume of hotel stays is much larger than Airbnb and VRBO listings if they are available in the zip code.

However, most zip codes do not have hotels; thus, in Panel B, we expand the market to city-month. We try two market size definitions (hotel+Airbnb+VRBO and the total count of incoming air travelers), while still using BLP instruments for listing price. The two market size definitions are highly correlated but the count of incoming air travelers is 5-9 times larger than the total count of hotel, Airbnb and VRBO stays in a city-month. For each of them, we try one-level and two-level nesting models for comparison. Results between these two market size definitions are mostly similar, except that we have difficulty identifying significant nesting parameters if we require the model to have two nesting parameters when the market is defined as all incoming air travelers. When the market is defined as hotel+Airbnb+VRBO, the zip code nesting parameter (σ_{zip}) is slightly smaller (0.219) than the city nest parameter (σ_{city}, 0.238). These estimates suggest that Airbnb listings are closer substitutes to each other than hotels and other short-term lodging options, and listings within the same zip codes are closer substitutes than across zip codes. Note that, although both Panels A and B use BLP instruments for listing price, the coefficient on price drops dramatically from somewhere between -5 to -9 in Panel A where the market is defined as zip code-month to between -1 and -2 in Panel B where the market is defined as city-month. This suggests

[46]For example, Chicago has 1.26 million housing units in total but only 5,499 Airbnb listings in an average month of our data (of which 3,420 are entire-home listings).

Table 9: Specification Test for the Structural Model

	(1)	(2)	(3)	(4)
	Panel A: Market = zip code-month, BLP IV for listing price			
Market size	Airbnb+VRBO		Hotel+Airbnb+VRBO	
Model	Logit	Nlogit	Logit	Nlogit
log(price)	-7.762***	-5.744***	-9.163***	-8.724***
	(1.185)	(1.174)	(1.315)	(1.316)
nesting parameter (zip)		1.150***		0.250***
		(0.0354)		(0.0389)
Any VSR	-0.142***	-0.0705***	-0.152***	-0.137***
	(0.0159)	(0.0159)	(0.0186)	(0.0187)
Any LSR	-0.210***	-0.0913***	-0.230***	-0.204***
	(0.0226)	(0.0226)	(0.0256)	(0.0259)
% Any nearby VSR	-0.190***	-0.229***	-0.306***	-0.315***
w/in 0.3m radius	(0.0601)	(0.0598)	(0.0812)	(0.0812)
1st stage F-stat for P	293.8	293.8	293.9	293.9
1st stage F-stat for nesting par. (zip)		131.8		131.8
Property ID FE	yes	yes	yes	yes
City-year-month FE	yes	yes	yes	yes
Observations	921,092	921,092	921,092	921,092
R-squared	0.755	0.756	0.937	0.937
	Panel B: Market = city-month, BLP IV for listing price			
Market size	Hotel+Airbnb+VRBO		Incoming Air Travelers	
Model	N1Logit	N2logit	N1Logit	N2logit
IV for price	BLP	BLP	BLP	BLP
log(price)	-1.833***	-1.492***	-1.538**	-1.378**
	(0.550)	(0.551)	(0.549)	(0.548)
nesting parameter (city)	0.371***	0.238***	0.146***	-0.0527
	(0.0194)	(0.0613)	(0.0193)	(0.0611)
nesting parameter (zip)		0.219***		0.0310
		(0.0230)		(0.0229)
Any VSR	-0.0457***	-0.0506***	-0.0464***	-0.0497***
	(0.00908)	(0.00915)	(0.00907)	(0.00912)
Any LSR	-0.0831***	-0.0894***	-0.0931***	-0.0995***
	(0.0120)	(0.0121)	(0.0120)	(0.0121)
% Any nearby VSR	-0.0122	-0.00225	0.0426	0.0489
w/in 0.3m radius	(0.0363)	(0.0363)	(0.0361)	(0.0361)
1st stage F-stat for p	490.8	490.8	490.8	490.8
1st stage F-stat for nesting par. (city)	250.5	164.3	250.5	164.3
1st stage F-stat for nesting par. (zip)		216.5		216.5
Property ID FE	yes	yes	yes	yes
City-month(1-12) FE + year-month FE	yes	yes	yes	yes
Observations	921,092	921,092	921,092	921,092
R-squared	0.681	0.680	0.646	0.646
	Panel C: Market = city-month, other IV for listing price			
Market size	Hotel+Airbnb+VRBO		Hotel+Airbnb+VRBO	
Model	N1Logit	N2Logit	N1Logit	N2Logit
IV for price	$ZHVI \cdot x$	$ZHVI \cdot x$	PrivRoom P	PrivRoom P
log(price)	-8.911***	-2.582***	-1.439***	-1.429***
	(0.933)	(0.894)	(0.221)	(0.224)
nesting parameter (city)	0.444***	0.231***	0.360***	0.197***
	(0.0202)	(0.0614)	(0.0194)	(0.0615)
nesting parameter (zip)		0.225***		0.194***
		(0.0231)		(0.0233)
Any VSR	-0.106***	-0.0599***	-0.0427***	-0.0511***
	(0.0111)	(0.0110)	(0.00784)	(0.00791)
Any LSR	-0.199***	-0.108***	-0.0772***	-0.0903***
	(0.0172)	(0.0170)	(0.00828)	(0.00843)
% Any nearby VSR	-0.124***	-0.0193	-0.00530	-0.00014
w/in 0.3m radius	(0.0381)	(0.0378)	(0.0356)	(0.0356)
1st stage F-stat for p	502	502	516.2	516.2
1st stage F-stat for nesting par. (city)	250.5	164.3	250.5	164.3
1st state F-stat for nesting par. (zip)		216.5		216.5
Property ID FE	yes	yes	yes	yes
City-month(1-12) FE + year-month FE	yes	yes	yes	yes
Observations	921,092	921,092	920,815	920.815
R-squared	0.681	0.680	0.681	0.681

Note: This table reports the structural estimates following Equation 7. Standard errors in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1. All regressions control for property ID fixed effects, listing attributes, and log of cumulative crime reports since 2015/7 to last month in the zip code of the listing. Within-city and with-zip market shares (for the nesting parameters) are instrumented by # of listings within inside goods or # of zip codes in a city × average listing attributes.

that BLP instruments may be good at capturing guest sensitivity to price within a zip code but not good at capturing it citywide.

In Panel C, we keep the market definition at the city-month level with market size defined as hotel+Airbnb+VRBO[47], but try ZHVI and Private Room instruments for listing price. As in Panel B, we report results for one-level and two-level nesting for comparison. The nesting parameters are similar to

[47]In an unreported table, we also tried a version that excludes VRBO from the outside good and use $ZHVI \cdot x$ as instruments for listing price. We find almost identical results as Table 9 Panel C Columns 1-2. This is reasonable because VRBO listings accounts for less than 1% market share in a city-month.

what we find in Panel B, but the price coefficient differs. When we use ZHVI instruments, the price coefficient (-2.582) is more negative than using the BLP instruments in Panel B, suggesting that the ZHVI instruments can capture more price sensitivity. When we use Private Room instruments, the price coefficient is much smaller (around -1.4) and similar to that of Panel B.

In all 12 specifications, we find a consistent pattern for the coefficients of VSR, LSR, and $VSRADIUS$. Similar to our reduced-form results in Table 2, coefficients of VSR and LSR are negative and significant with 99% confidence and the coefficient of LSR is consistently larger in magnitude than that of VSR, suggesting that guests perceive worse utility from a listing after it receives a safety review, especially if the safety review is about the property itself. At the same time, we continue to observe an insignificant coefficient of $VSRADIUS$, echoing the mixed effect of VSR on nearby listings in the reduced-form analysis at the listing level.

Given the robustness, from now on, we will use Table 9 Panel C Column 2 — where market definition is city-month, market size is hotel+Airbnb+VRBO, and we use $ZHIV \cdot x$ are instruments for listing price — as our preferred structural model estimation for counterfactual analysis.

Note that the coefficient of VSR captures how an *average* prospective guest in our sample *perceives* the vicinity safety of listing i at the time of choice. Because VSR only account for 0.25% of all guest reviews, the vast majority of the guests may have not experienced any vicinity safety issues on Airbnb (or have experienced but never reported it in a user review) before t. Indeed, if we rerun Equation 7 excluding the VS users identified in our reduced-form analysis, the estimated coefficients barely change. This means that Equation 7 can yield reliable estimates for the within-listing-cross-buyer effects, but not the cross-listing-within-buyer effect driven by VS users learning from their own VS experience.

We have also considered including an interaction of the dummy of VS users with VSR. Aside from the aforementioned sample size issue, this interaction would add endogeneity to the specification because we do not observe whether a listing is booked by a VS user until the user has booked and left reviews for that listing on Airbnb. Because we cannot observe the situations where a VS user considers Airbnb listings but decides to not book on Airbnb, including this interaction will not tell us how self experience of VSR has changed the VS user's expected utility from Airbnb listings.

Fortunately, such learning from self experience has already been captured in our reduced-form guest-level analysis; thus, a key question is how to incorporate the DID estimate into the structural framework. This is important not only because this extra cross-listing-within-buyer effect is in addition to the within-listing-cross-buyer effect that we can identify directly from the vast majority of Airbnb guests but also because self experience sheds light on the guest's *realized* utility when she stays in a listing with vicinity safety issues. Although such realized utility, as indicated by guest reviews, only occurred in a tiny fraction of Airbnb stays, a fully-informed guest should expect the realized utility when she subsequently chooses where to stay. As documented by Jin and Sorensen (2006); Allcott (2011); Train (2015); Reimers and Waldfogel (2021), the difference between realized and perceived utility is essential for evaluating how consumer surplus changes under different information regimes.

In particular, Figure 3 illustrates the role of perceived and realized utility in consumer surplus. Consider two demand curves: the inner one represents demand for Airbnb listings under a high-alert regime of VSR while the outer one represents demand under a regime with less information about VSR. When prospective guests perceive the listings to be safer than they actually are, the market clears at a higher price and with more bookings than under high alert (i.e. $P_{\text{less info}} > P_{\text{full info}}$ and $Q_{\text{less info}} > Q_{\text{full info}}$). Those who book under less information comprise two guest types: some have a high willingness to pay and would have booked on Airbnb even if they knew the high alert ex ante, with their realized consumer surplus being area A; others have a relatively low willingness to pay and would not book on Airbnb had they known the listings are actually less safe than they appear, with their realized consumer surplus being negative (area B). Hence, the total realized consumer surplus is A-B under the less information regime. In comparison, under the high alert regime, the realized consumer surplus is A+C, where C represents the extra consumer surplus that fully-informed guests could obtain via a lower equilibrium price.

There is another way to arrive at the same conclusion. Let us denote the white trapezoid between the two demand curves as area D. Under the less information regime, the perceived consumer surplus is A+D while the realized consumer surplus is A-B; under a full information regime, both the perceived and realized consumer surplus are A+C. Thus, the difference between the realized consumer surplus under full and less information regimes, (A+C)-(A-B)=C+B, can also be written as the difference between their perceived consumer surplus plus an adjustment that reflects the shift of the demand curve for all consumers that would purchase under less information, namely (A+C)-(A+D)+(D+B)=C+B. We will use this alternative expression to compute consumer surplus changes in the counterfactual analysis.

As shown below, our counterfactual analysis assumes the listing choices made by VS users *after* they wrote VSR on Airbnb reflects their updated, subsequent interpretation of VSR on all potential listings. Since this updated interpretation incorporates their true experience in the stay that triggered their VSR, we assume it captures the realized utility from VSR. This means that VS users would have a new β_3 in the utility function upon their own VS experience. Changes in their β_3 would capture the difference between perceived and realized utility driven by VSR.

We calibrate a new β_3 that would explain why the number of Airbnb bookings of VS users dropped 60.07% after their own VS experiences as compared to similar non-VS users, according to our guest-level DID analysis (Table 6 Column 1). Following the procedure described in Appendix B, our calibration suggests that the VS users must have changed their β_3 by -2.195, which is more than 35 times of the estimated β_3 of the whole sample (-0.0599). If we consider the possibility that non-VS users in the control group of the DID analysis may include some true VS users that chose not to write any VSR, the DID estimate (60.07%) would be under-estimated. According to our calculation on page 33, the degree of under-estimation depends on the degree of under reporting. Since the probability of leaving a review after any Airbnb stay is 44.56% in our sample, the calculation suggests the true effect is $60.07\% \cdot 1.1213 =$

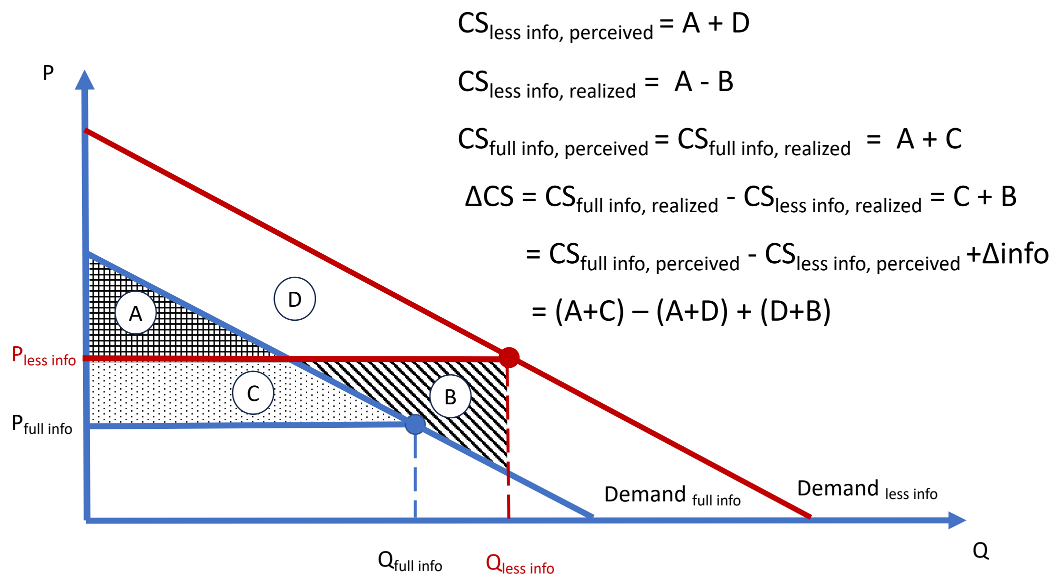


Figure 3: Consumer Surplus Under high alert of VSR (Realized) Or Less Information of VSR (Perceived)

67.36% and the calibrated $\Delta\beta_3$ would be even bigger (-2.274). Overall, the calibration suggests that the cross-listing-within-buyer effect of VSR – based on a guest's own VS experience – is strong and would have an impact on booking decisions should all non-VS users interpret VSR the same way as VS users.

Arguably, the same process may apply to the self-experience of LSR as well. Since the reduce-form evidence suggests that the self-experience of VSR is a greater negative shock to the guest than self-experience of LSR, the counterfactual analysis below focuses on VSR only for the ease of illustration.

6.2 Counterfactual Analysis

We consider four counterfactual regimes as compared to the status quo. The first is "no disclosure no belief update," where all VSR are removed from the data and no guests update their belief of VSR risk despite the removals. Conceptually, this is equivalent to an extreme interpretation and implementation of Airbnb's December 2019 policy on VSR, where all VSRs are removed and all guests view all listings as if they have never received any VSR.

One may argue that guests may change their belief about a listing's VSR risk if they know that no VSR would ever be disclosed. To accommodate this possibility, we explore a second no-disclosure regime where Airbnb removes all VSR but all guests form a rational expectation of a listing's VSR risk conditional on the listing's observable attributes. This regime of "no disclosure but with rational belief" can occur if the announcement of the no-disclosure policy is salient, and all prospective guests fully understand the statistical correlation between VSR risk and other observable listing attributes in the raw data.

The two no-disclosure regimes differ in information treatment. Under "no disclosure no belief update," VSR information on VS listings changes from some VSR to zero VSR, while non-VS listings remain clean of VSR. Under "no disclosure but with belief update," VS listings look less risky than in the status quo but all normal listings now look as risky as VS listings with similar attributes (rather than of zero VSR risk). This amounts to a positive information shock to VS listings *and* a negative information shock to non-VS listings. The positive information shock to VS listings is less in "no disclosure but with rational belief" than in "no disclosure no belief update" because by definition rational guests should have predicted some probability of having VSR for VS listings.

A priori, it is unclear which of the two no-disclosure regimes is closer to reality. "No disclosure no belief update" could occur if the platform quietly removes all VSR without the notice of most customers (even if the platform makes a public announcement of the policy change). In that case, most guests may interpret that the list did not receive any VSR in the past rather than the platform did not report any VSR. By contrast, "no disclosure but with rational belief" could occur if the platform's public announcement of the no-disclosure policy is widely disseminated and guests are fully aware of the statistical relationship between historical VSR occurrences and listing attributes. Given the facts that the platform does not have full incentives to broadcast a no-disclosure policy, not all potential guests pay close attention to every platform announcement, and it is rare for an average guest to have the same access to the comprehensive listing-month data as in this paper, we believe the reality is likely somewhere between the two no-disclosure regimes. We report both to help readers understand their differences.

An extreme regime in contrast to no-disclosure is "high alert," where we assume all users react to VSR as much as VS users react to their own reported VSR. Comparing to the above three regimes, the fourth counterfactual regime keeps the information policy as is but removes listings with 1+ or 2+ VSR. This is different from no-disclosure, because it removes VS listings from guests' choice set, while VS listings are kept alive and appear similar to non-VS listings (on the lack of VSR) in the no-disclosure regimes. This "listing removal" counterfactual aims to mimic a change in the platform's listing screening policy rather than information policy.

We now elaborate on how we calculate consumer welfare under each counterfactual regime. For the status quo, we use the results in Column 2 of Table 9 Panel C to calculate $EU_{j,t}$ for each Airbnb listing-month, and then use the price coefficient to normalize it to US dollars. By definition, this is the guest's perceived utility. Following Small and Rosen (1981) and McFadden (2001), in a nested logit model as ours, a consumer's expected utility from her utility-maximizing choice depends on the inclusive value of the choice set, namely $I = log\left(1 + exp(I_{Airbnb})\right)$, where $I_{Airbnb} = (1 - \sigma_{city}) log \sum_{z \in city} exp\left(\frac{I_{zip_z}}{1-\sigma_{city}}\right)$ is the Airbnb-specific inclusive value, and $I_{zip_z} = (1 - \sigma_{zip}) \cdot log \sum_{j \in zip_z} exp\left(\frac{EU_{j,t}}{1-\sigma_{zip}}\right)$ is the zip code-specific inclusive value. As depicted in Figure 3, a consumer's perceived utility may guide her choice of listing ex ante, but her realized utility may deviate from her perceived utility. To measure the realized utility, we use the calibrated change of β_3 (-2.274 as described above) to update β_3 in the utility function (while taking everything else unchanged) and recompute the utility.

For the counterfactual of "no disclosure no belief update," we set all VSR as zero in the (perceived) utility function, recompute $EU_{i,t}$ for each Airbnb entire-home listing, and simulate its market share. This assumes everything else remains the same when the platform removes all VSR, which could be violated if listings adjust prices after the regime shift. Since the vast majority of our data precede Airbnb's new review policy and Airbnb seems far from fully implementing the policy, we cannot observe such price adjustments directly. The reduced-form regressions in Table 2 associate the presence of VSR in VS listings with a 1.47% difference in price. Hence in an alternative calculation, we assume the no-disclosure regime may enable a 1% price increase in VS listings while the price of normal listings remains unchanged. This gives us a comparison between no disclosure with price changes versus no disclosure without price changes.

To implement the "no disclosure but with rational belief" counterfactual, we use a logit specification to regress the dummy of any VSR observed in our data (at the listing-month level) on observable listing attributes up to the month before, including whether the listing has any LSR, local crime statistics (cumulative by zip code), the listing's total number of reviews on Airbnb, the listing's average star ratings, whether the listing has a super host status, whether the listing is cross-listed on VRBO, whether the listing has a strict cancellation policy, year-month fixed effects, and city-month fixed effects. We then use the estimated coefficients to predict the likelihood of having any VSR per listing-month. Replacing the VSR dummy in the utility equation with this predicted VSR probability, we compute the subsequent market shares, consumer surplus, and Airbnb GBV.

As in the first no-disclosure regime, we run the second no-disclosure counterfactual with and without price changes. In particular, we assume the price may be adjusted down for normal listings by predicted probability of VSR x 1% because they look riskier in this counterfactual than in the status quo, and the price will be adjusted up for VS listings by (1-predicted probability of VSR) x 1% because they look less risky in this counterfactual than in the status quo.

The high alert counterfactual is equivalent to assuming that guests have full information and therefore their perceived utility is the same as the realized utility calculated above. In other words, all guests use the calibrated β_3 (based on the DID results from VS users) in the utility of each listing, for both perceived and realized utility. As for the listing removal regime, we use each listing's utility as in the status quo, but remove listings with 1+ or 2+ VSR from the guest's choice set. As in the no-disclosure regimes, in "high-alert" and "listing-removal" regimes, we first simulate market shares without price changes and then introduce an ad-hoc price change (-1% for VS listings) to illustrate how price changes may alleviate the impact of the counterfactual regime.

After we compute the perceived and realized utility under each regime, we can quantify changes in consumer surplus from the status quo to any counterfactual. Defining each city-month (k, t) as a unique market, our analysis includes 145 markets in total. We further define market size $M_{k,t}$ as the total reserved days in the market (hotel+Airbnb+VRBO). Following Reimers and Waldfogel (2021) and Figure 3, the consumer surplus changes in a single market from the status quo to the high alert regime can be computed as:

$$\Delta CS_{k,t} = \frac{M_{k,t}}{\beta_0} \cdot \left[ln(I|highalert) - ln(I|perceived) + \sum_j ((U_{jt,perceived} - U_{jt,highalert}) \cdot s_j) \right]. \quad (8)$$

Similar calculations are performed for other counterfactual regimes.

Table 10 reports the consumer surplus results under different counterfactuals, for an average user with an average reservation day across all city-months. The first two rows refer to "no disclosure no belief update" with and without price changes; Rows 3-4 refer to "no disclosure but with rational belief" with and without price changes; Rows 5-8 refer to high alert with and without price changes and with and without a "radius effect," where the radius effect allows for the same updated distaste for VSR to apply to the VSR in nearby listings as well. To quantify the radius effect, we assume that the estimated coefficient of $VSRADIUS$ (β_4) would increase in the same proportion as the calibrated coefficient of VSR (β_3), should guests extrapolate the high alert of vicinity safety concerns to nearby VSR in the same way as a listing's own VSR. This extreme regime is designed to illustrate the potential consequences in case prospective guests become sensitive to *any* VSR under high alert. The last two rows refer to removing listings with 1+ or 2+ VSR.

Table 10 indicates that, under high alert without price changes and without a radius effect, overall consumer surplus under high alert (without a radius effect) increases by roughly 9.756%, which is slightly less if we incorporate the hypothetical 1% price drop of VS listings (9.599%) and slightly higher if we allow a radius effect in high alert (10.340% and 10.183%), because high alert helps guests reduce their stays in relatively unsafe listings.

Consumer surplus under no-disclosure regimes declines in comparison to the status quo. Under "no disclosure no belief update," consumer surplus may decline by 1.183% without price change (and 0.676% with price changes) because consumers cannot use VSR to sort among Airbnb listings. Under "no disclosure but with rational belief," consumer surplus is still less than the status quo but the decline is smaller (by 0.993% without price change and 0.571% with price changes). This is as expected because rational belief would associate all Airbnb listings with an average belief of VSR risk conditional on observable listing attributes. Consequently, the positive information shock on VS listings is less than in the regime without belief update and the negative information shock on non-VS listings further alerts consumers of average VSR risk. In both no-disclosure regimes, the ad hoc 1% price adjustment can mitigate the loss in consumer surplus but is not enough to eliminate it. Interestingly, removing listings with 1+ or 2+ VSR would generate a bigger decline of consumer surplus (-1.187% to -5.008%) than no-disclosure regimes, because they narrow consumer's choice set. The second column of Table 10 reports bootstrapped standard errors for the consumer surplus changes. To compute standard errors, we redraw 99% of the data at the zip code-year-month level for 100 times, rerun the counterfactual analysis for each redrawn sample, and report the standard deviation of counterfactual estimates.

These changes in consumer surplus are driven by changes in consumer beliefs, which in turn shift market shares. Under "no disclosure no belief update," the lack of VSR information moves market share from hotels, VRBO and normal Airbnb listings to VS listings. In comparison, "no disclosure but with rational belief" also introduces a negative information shock to non-VS listings, thus, moving market share toward VS listings and away from non-VS listings. In comparison, the dramatic high alert counterfactual would move almost all market shares away from VS listings. By definition, removing listings with one or more VSR would eliminate VS listings' market share, while removing listings with two or more VSR only reduces the market share of VS listings modestly because most VSR listings have only one VSR.

Table 10: Counterfactual Analysis: Simulated Changes in Consumer Surplus in the market

Δ Consumer Surplus (versus Status quo)	All Listings estimate	All Listings std. err.
No Disclosure No Belief Change w/o P change	-1.183%	(0.043%)
No Disclosure No Belief Change w/ P change	-0.676%	(0.012%)
No Disclosure w/ Rational Belief w/o P Change	-0.993%	(0.037%)
No Disclosure w/ Rational Belief w/ P Change	-0.571%	(0.010%)
High Alert w/o P change & w/o radius effect	9.756%	(0.019%)
High Alert w/ P change & w/o radius effect	9.599%	(0.023%)
High Alert w/o P change & w/ radius effect	10.340%	(0.157%)
High Alert w/ P change & w/ radius effect	10.183%	(0.148%)
Remove listings with any VSR	-5.008%	(0.033%)
Remove listings with 2+ VSR	-1.187%	(0.008%)

Note: Counterfactual simulations are based on (i) structural estimates from Table 9 panel C column 2 where market is city-year-month, market size is hotels+Airbnb+VRBO, and IV for price is $ZHVI \cdot x$ and (ii) calibrated VSR coefficient based on the DID+matching of VS users (Table 6 panel A column 1). Bootstrapped standard errors in parentheses. To compute standard errors, we redraw 99% of the data at the zip code-year-month level for 100 times, rerun the counterfactual analysis for each redrawn sample, and report the standard deviation of counterfactual estimates.

Table 11 reports GBV changes based on simulated market shares in each regime. "No disclosure no belief update" generates 0.327% more GBV for entire-home listings on Airbnb in our sample if no price changes, or 0.285% more GBV if assuming the price for VS listings increases by 1%. This suggests that the platform could have strategic incentives to hide VSR if the no-disclosure regime can be implemented quietly without much consumer notice. However, "no disclosure but with rational belief" would *decrease* Airbnb's GBV by 0.047% if no price changes, or increase the GBV by 0.013% if VS and non-VS listings may adjust their prices up to 1% according to changes in consumer belief. This suggests that consumers' rational belief based on observable listing attributes could mitigate the platform's incentive to hide VSR. Price changes in response to the information changes can soften the effects on platform GBV, or even overturn the direction of the GBV effects. We caution that the assumed 1% price adjustment is not necessarily the equilibrium change, as we do not observe hosts' costs and do not model how hosts set their prices in reality. Rather, it points to the possibility that price changes can play an important role determining the platform's overall incentives in disclosing VSR.

Compared with the no-disclosure regimes, high alert generates substantial GBV loss for the platform, ranging from -2.726% to -6.026%, depending on whether we incorporate 1% price change and the radius effect. In short, under high alert and no disclosure no belief update, the interests of Airbnb and consumers are misaligned: consumers would prefer more transparency but a GBV-centric Airbnb would prefer no disclosure without consumer belief update.

Interestingly, the interests of guests and the platform are aligned on listing removal: both would suffer from the removal of (all or some) listings with VSR because it narrows consumers' choice set. The interests of guests and the platform are also partially aligned in the regime of "no disclosure but with rational belief," especially when price adjustment is small or non-existing.

One caveat of all above counterfactual calculation is that we focus on consumers' static choice of short-term lodging, but do not account for the fact that the status quo may decay over time without any change of platform policy because consumers burned by self experience in VSR would become high-alert organically even if everyone else with no such self experience continues to hold her perception of VSR as observed in our data. Since 0.8% of consumers would choose VS listings on Airbnb in the status quo, this means every month 0.8% of the not-yet-alerted consumers may become alerted by self experience in VSR, and thus the market at any time would reflect a mixture of the static status quo and the high alert as simulated in Tables 10 and 11.

The solid lines in the left graph of Figure 4 show this organic decay process in 25 years (300 months on the horizontal axis) under the status quo, assuming consumers can only update their understanding of the real impact of VSR based on self experience. By the end of the 3rd year, 25.7% of consumers would have booked any VS listings and get a self experience of VSR, this percentage increases to 38.2% by the 5th year, and 61.9% by the 10th year. In the meantime, consumer surplus grows slowly for by $< 6\%$ and Airbnb GBV drops slowly for about 1.7% by the end of the 10th year. This is less and slower than the high-alert counterfactual (which generates $> 9\%$ increase in consumer surplus and $> 5\%$ drop in GBV). This contrast highlights the importance of platform information policy when negative self experience is rare but strong as we have seen in the case of VSR.

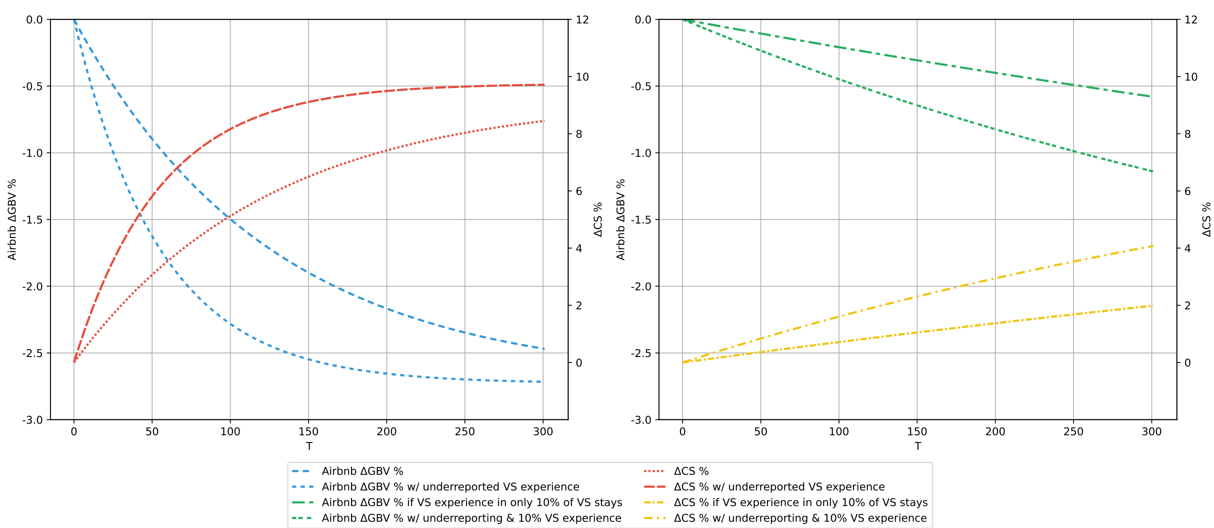
To further illustrate how the organic evolution of the status quo depends on the extent of VSR experience, we add three alternative decay processes in Figure 4.

The first alternative—depicted by the dashed lines in the left graph of Figure 4—incorporates the fact that only 44.56% of Airbnb guests write any review after a stay in our data. This implies that there may be more listings with VS experience than the number of VS listings we can find in the data. Assuming the actual number of VS listings shall be increased from x to $x/44.56\%$, the market share of actual VS listings would be $0.8\%/44.56\% = 1.8\%$ rather than 0.8%. As shown by the dashed lines in the left graph of Figure 4, this change would make more consumers aware of VS and speed up the convergence.

The second alternative relaxes the assumption that every guest staying in a VS listing must encounter a VS experience. In our data, VS listings account for 8% of stays within Airbnb, but VSR only account for 0.25% of all reviews. If review rate does not depend on the nature of experience, this implies that only $0.25\%/8\% = 3.1\%$ of stays in VS listings have resulted in a VS experience worth reporting in VSR. From the literature, we know negative experience may suffer from more under-reporting than positive experience, but it is difficult to pin down the extent of this difference. Hence, for illustration purpose, we simulate an alternative process in the right graph of Figure 4, assuming 10% of stays in VS listings generate a negative VS experience and only such experience would motivate the guest to update her coefficient of VSR in the utility function. This amounts to only $0.8\% \times 10\% = 0.08\%$ of all not-yet-burnt short-term-rental consumers would get an update in each month. Consequently, the market evolution is much slower, with only 4.7% of consumers ever burnt by a VS experience by the end of the fifth year. As shown by the real lines in the right graph of Figure 4, the changes in consumer surplus and platform GBV are much slower in this alternative process than what happens if we assume VSR experience always occurs in any stays of VS listings (the left graph of Figure 4).

The third alternative includes the assumptions in both the first and second alternatives, namely VS experience is under-reported by 44.56% but only 10% of VS stays trigger a VS experience. The results of this alternative process are displayed in the dashed lines in the right graph of Figure 4. Again, incorporating underreporting in our organic evolution would speed up the information update from self experience and subsequent changes in consumer surplus and platform GBV, everything else being equal.

Figure 4: Potential Evolution of the Status Quo due to self experience of VSR only



Note: This graph simulates how consumer surplus and Airbnb GBV change over time as guests learn about VSR via self experiences over time. The simulation is based on results in Tables 10 and 11.

To explore the distributional effects of our counterfactual regimes, Table 12 breaks down the counterfactual GBV changes in Airbnb listings by the four types of zip codes. Since VS listings are more likely to locate in low-income and minority zip codes, both no-disclosure regimes benefit Airbnb listings in these zip codes. However, the regime of "no disclosure but with rational belief" can hurt listings in high-income and white zip codes, especially if price adjustment is not deep enough to counter the negative information shock to them. In both high-alert and listing removal regimes, low-income and minority areas would suffer from a bigger drop in GBV, either by consumer's informed choice or by removing some VS listings from consumer's choice set.

Table 11: Counterfactual Analysis: Simulated Market Shares and Changes in GBV

ΔGBV (versus Status quo)	Airbnb VS Listings %	Airbnb non-VS Listings %	Airbnb Listings %	Hotel+VRBO Listings %	All Listings %
No Disclosure No Belief Update w/o P change	8.052%	-0.129%	0.327%	-0.058%	-0.026%
	(0.296%)	(0.016%)	(0.028%)	(0.004%)	(0.001%)
No Disclosure No Belief Update w/ P change	5.689%	-0.034%	0.285%	-0.038%	-0.011%
	(0.081%)	(0.021%)	(0.022%)	(0.002%)	(0.001%)
No Disclosure w/ Rational Belief w/o P change	6.637%	-0.442%	-0.047%	-0.014%	-0.016%
	(0.250%)	(0.014%)	(0.019%)	(0.003%)	(0.001%)
No Disclosure w/ Rational Belief w/ P Change	4.715%	-0.265%	0.013%	-0.012%	-0.010%
	(0.071%)	(0.023%)	(0.023%)	(0.003%)	(0.001%)
High Alert w/o P change w/o radius effect	-94.520%	2.699%	-2.728%	0.563%	0.291%
	(0.091%)	(0.037%)	(0.030%)	(0.003%)	(0.001%)
High Alert w/ P change w/o radius effect	-94.390%	2.693%	-2.726%	0.562%	0.290%
	(0.093%)	(0.037%)	(0.029%)	(0.003%)	(0.001%)
High Alert w/o P change w/ radius effect	-95.029%	-0.764%	-6.026%	0.923%	0.350%
	(0.132%)	(0.676%)	(0.645%)	(0.070%)	(0.012%)
High Alert w/ P change w/ radius effect	-94.911%	-0.769%	-6.024%	0.922%	0.349%
	(0.127%)	(0.676%)	(0.645%)	(0.070%)	(0.012%)
Remove listings with any VSR	-100%	2.859%	-2.883%	0.595%	0.308%
	(0.000%)	(0.036%)	(0.034%)	(0.003%)	(0.001%)
Remove listings with 2+ VSR	-39.523%	0.723%	-1.523%	0.150%	0.012%
	(0.066%)	(0.010%)	(0.010%)	(0.001%)	(0.000%)

Note: Counterfactual simulations are based on (i) structural estimates from Table 9 panel C column 2 where market is city-year-month, market size is hotels+Airbnb+VRBO, and IV for price is $ZHVI \cdot x$ and (ii) calibrated VSR coefficient based on the DID+matching of VS users (Table 6 panel A column 1). Bootstrapped standard errors in parentheses. To compute standard errors, we redraw 99% of the data at the zip code-year-month level for 100 times, rerun the counterfactual analysis for each redrawn sample, and report the standard deviation of counterfactual estimates.

7 Conclusion

Taking safety reviews as an example of critical feedback on Airbnb, we show that vicinity safety reviews (VSR) and listing safety reviews (LSR) not only have the classical within-listing-cross-buyer effect of guiding future buyers toward listings without VSR/LSR, but they also motivate guests that have written VSR/LSR themselves to learn and update their understanding of the VSR/LSR of other listings. As a result, these guests are less likely to book future stays on Airbnb, and when they do book, they tend to book listings without VSR/LSR and in areas with fewer official crime reports and fewer VSR/LSR. More interestingly, such cross-listing-within-buyer effect is stronger for VSR than for LSR, although the

Table 12: Counterfactual Analysis: Changes in GBV By Four Area Types

	Airbnb Listings			
ΔGBV (versus Status quo)	H	L	W	M
No Disclosure w/o P change	0.158%	0.593%	0.241%	0.535%
	(0.023%)	(0.037%)	(0.025%)	(0.035%)
No Disclosure w/ P change	0.167%	0.471%	0.225%	0.431%
	(0.021%)	(0.022%)	(0.021%)	(0.022%)
No Disclosure w/ Rational Belief w/o P change	-0.193%	0.183%	-0.122%	0.133%
	(0.016%)	(0.026%)	(0.018%)	(0.024%)
No Disclosure w/ Rational Belief w/ P change	-0.086%	0.167%	-0.041%	0.142%
	(0.023%)	(0.023%)	(0.023%)	(0.023%)
High Alert w/o P change w/o radius effect	-0.715%	-5.881%	-1.697%	-5.195%
	(0.032%)	(0.033%)	(0.032%)	(0.028%)
High Alert w/ P change w/o radius effect	-0.715%	-5.875%	-1.696%	-5.189%
	(0.032%)	(0.032%)	(0.032%)	(0.028%)
High Alert w/o P change w/ radius effect	-4.074%	-9.083%	-5.026%	-8.418%
	(0.655%)	(0.627%)	(0.650%)	(0.631%)
High Alert w/ P change w/ radius effect	-4.074%	-9.077%	-5.025%	-8.413%
	(0.655%)	(0.627%)	(0.650%)	(0.630%)
Remove listings with any VSR	-0.753%	-6.219%	-1.792%	-5.493%
	(0.035%)	(0.040%)	(0.035%)	(0.034%)
Remove listings with 2+ VSR	-0.492%	-3.138%	-1.061%	-2.628%
	(0.009%)	(0.015%)	(0.011%)	(0.011%)

Note: Counterfactual simulations are based on (i) structural estimates from Table 9 panel C column 2 where market is city-year-month, market size is hotels+Airbnb+VRBO, and IV for price is $ZHVI \cdot x$ and (ii) calibrated VSR coefficient based on the DID+matching of VS users (Table 6 panel A column 1). Bootstrapped standard errors in parentheses. To compute standard errors, we redraw 99% of the data at the zip code-year-month level for 100 times, rerun the counterfactual analysis for each redrawn sample, and report the standard deviation of counterfactual estimates.

classical within-listing-cross-buyer effect is greater for LSR than for VSR, suggesting that self experience of VSR is a greater negative shock for guests.

Using a structural approach to account for listing competition on and off Airbnb, we show that a revenue-centric platform may prefer to limit the disclosure of VSR altogether, even though the aggregate surplus of guests appears to increase when the VSR are instead emphasized to alert prospective guests. However, this strategic incentive to hide VSR can be mitigated or even overturned if consumers can form rational beliefs about VSR risks (conditional on observable listing attributes) after the platform announces a no-disclosure policy. In that case, although no-disclosure prevents consumers from distinguishing seemingly identical VS and non-VS listings, it generates a negative information shock on non-VS listings, which discourages consumers from booking non-VS listings and thus could reduce the overall GBV of the platform. Put another way, consumers' rational beliefs under a no-disclosure regime helps to align the interests of consumers and the platform. In comparison, removing listings with VSR may hurt both consumer surplus and platform GBV because it narrows consumers' choice set.

Combined, our findings highlight the economic incentives and tensions behind a platform's information policy regarding critical feedback. For a rare but strong negative experience like VSR, allowing VSR but not highlighting them on the platform may slowly decay guest trust via the organic within-buyer-cross-listing effect, resulting in a slow decline of the platform's general booking value (GBV) and a slow increase of consumer surplus as guests learn from self experience. The platform can hasten this process by adopting a more transparent information policy to warn consumers of the risks. Although doing so may lead to a significant GBV loss for the platform according to our calculations, it may be worthwhile for the platform if more transparency can boost user trust and attract sufficiently many new users to join the platform over the long run.

Another managerial implication from our work is the distributional effects of information policy. Under the high-alert regime, we show that listings in low-income and minority zip codes may stand to lose a disproportionate share of revenues relative to their counterparts in high-income and white zip codes, but consumer surplus under the high-alert regime is higher than under the status quo and the no-disclosure regimes. The platform thus faces a tradeoff as far as generating greater revenues and attracting hosts in low-income and minority areas on the one hand, and providing additional value to its buyers on the other.

To the extent that being inclusive is one motivation behind Airbnb's new review policy, which may affect reviews that mention vicinity safety, our findings suggest that the policy, if fully implemented without rational belief updates on the consumer side, can have some unintended consequences for consumers and listings without VSR. How to balance the economic interests of all users is a challenge for platforms, as well as for policymakers that strive to maximize social welfare. One potential solution is that the platform may import external information about vicinity safety and present it as an alternative to VSR for each listing. Unfortunately, crime statistics (when available) may not fully capture all of the safety concerns a guest may have in mind at the time of booking. Another alternative is to incorporate VSR into the overall ratings of a listing, and how to adjust ratings in line with the platform's or a social planner's objectives certainly merits future research.

There are a number of limitations to our analyses. First, guest reviews in our data do not include potential responses from hosts. Second, in the guest-level analysis, we only observe a guest's reservation provided that they have made any Airbnb reservations in the five major US cities we consider and posted a review on Airbnb. If VS users are more vocal and thus more likely to post subsequent reviews after their first VS review, then our findings underestimate the negative effects on their subsequent booking activities; if, however, VS users are less likely to post subsequent reviews, then our findings overestimate the effects. In our analysis, we attempt to adjust the potential underestimation by relying on the overall review rate observed in our data (44.56%), but this adjustment does not incorporate the possibility that under-reporting might differ by the nature of guest experience. Third, our main analysis ends in December 2019, the same month when Airbnb announced its new review policy. Because we do not know exactly how Airbnb implements its new policy, our counterfactual simulations are hypothetical.

These limitations suggest additional directions for future work. In particular, VRBO does not have a policy of discouraging reviews about the vicinity of listings, as Airbnb introduced in December 2019. This may facilitate an interesting comparison between VRBO and Airbnb listings in the same locales, given a sample period that encompasses Airbnb's introduction of its new review policy. In addition, one welfare aspect that is difficult to quantify but may be relevant for Airbnb is the long-run entry and exit of users. As shown in our counterfactual analysis, a policy that encourages and highlights VSR could disproportionately hurt Airbnb hosts in relatively unsafe neighborhoods. In the long run, this could lead to a smaller choice set for guests, drive away some types of hosts and guests, and affect economic parity across different neighborhoods.

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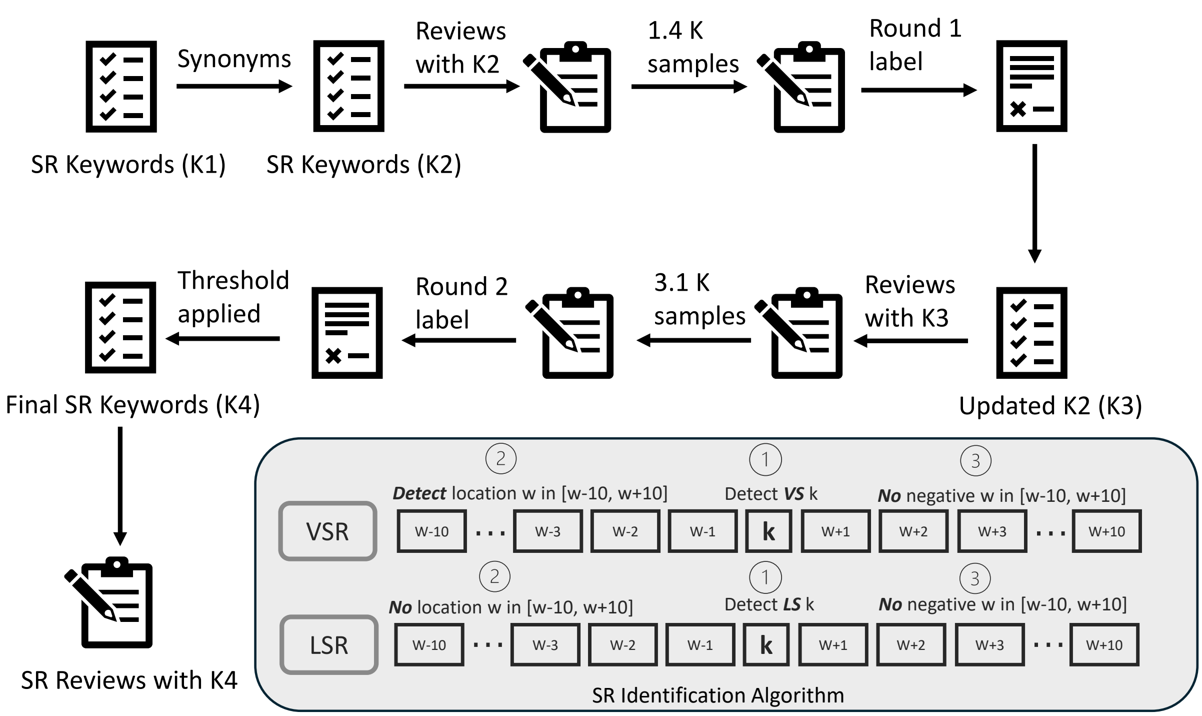
Online Appendix A: Supplemental Figures and Tables

Figure A1: Lexicon Approach



Note: This figure illustrates the steps in the lexicon-based approach. We begin with an initial set of terms such as "unsafe," "dangerous," and "scary" (K1) and retrieve their synonyms to form an initial safety review (SR) keyword set, K2. Using K2, we apply the SR Identification Algorithm to detect an initial group of safety reviews. Next, we select 1.4K samples for Round 1 labeling, where reviewers assess whether each review pertains to neighborhood and/or listing safety, whether it expresses negative sentiment, and identify three supporting keywords. Based on these human-labeled keywords, we refine the list into SR keyword set K3, ensuring that the percentage of critical reviews regarding vicinity safety (listing safety) in the 1.3K sample with such a human-selected keyword is greater than 0% (10%). We then reapply the SR Identification Algorithm with K3, identify a new set of reviews, and manually inspect 3.1K samples, selecting five reviews per keyword for a second labeling iteration, where reviewers confirm negative sentiment related to vicinity and/or listing safety. The final keyword set (K4) is determined by ensuring each vicinity (listing) safety keyword has a negative sentiment review percentage of at least 60% across both reviewers' assessments. After two iterations, we expand the list to 41 vicinity safety keywords and 50 listing safety keywords, forming the final SR keyword set (K4). Finally, we apply the SR Identification Algorithm with K4 to comprehensively identify safety reviews. The SR Identification Algorithm first identifies the SR keyword k and examines its context within a 20-word window. To ensure relevance, we verify that no negative keyword appears within this window. Additionally, for VSR (Vicinity Safety Reviews), a location keyword must be present within the 20-word window, whereas for LSR (Listing Safety Reviews), no location keyword should appear.

Figure A2: Distribution for keywords of vicinity safety review: Main definition

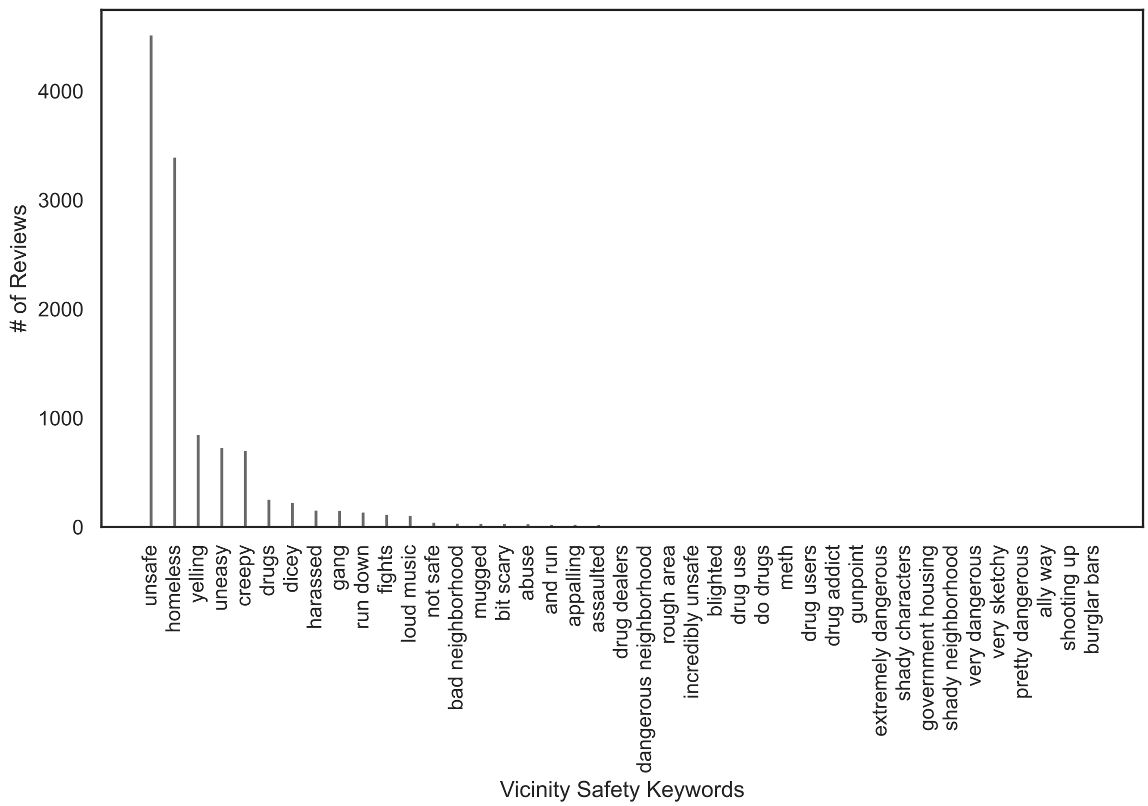


Figure A3: Distribution for keywords of listing safety review: Main definition

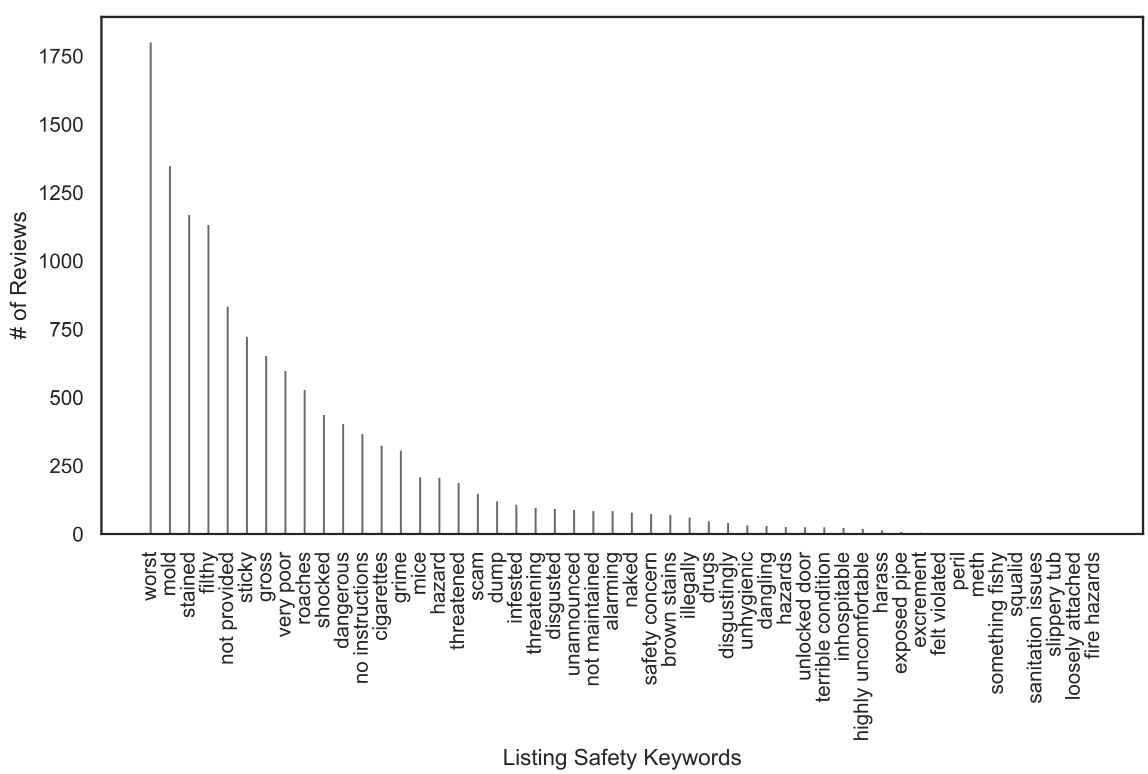
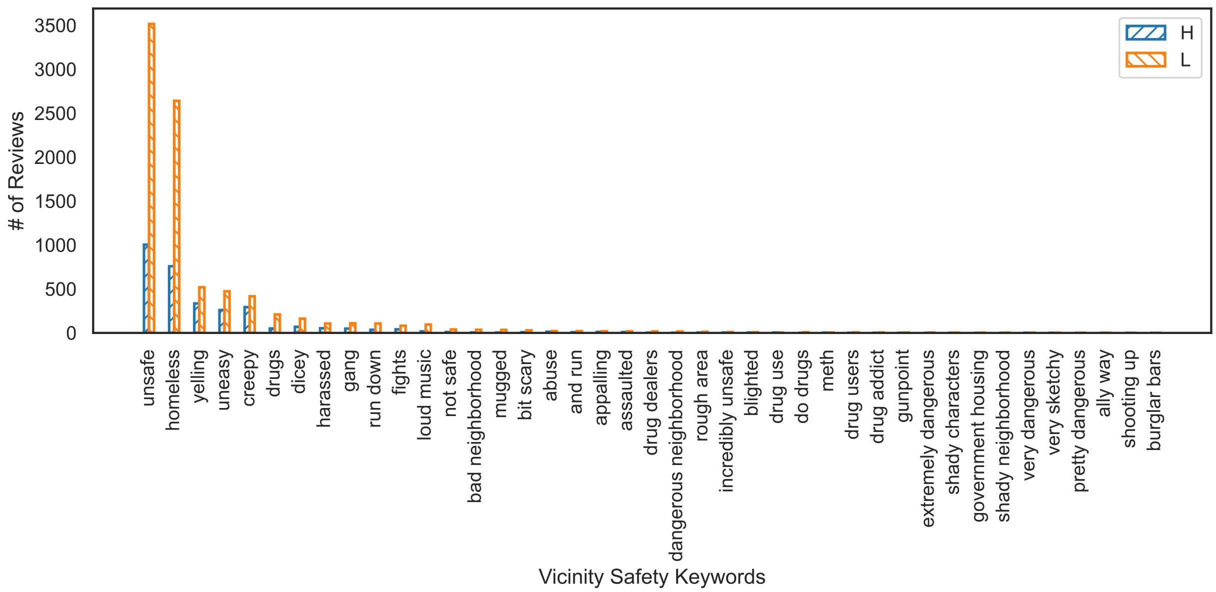
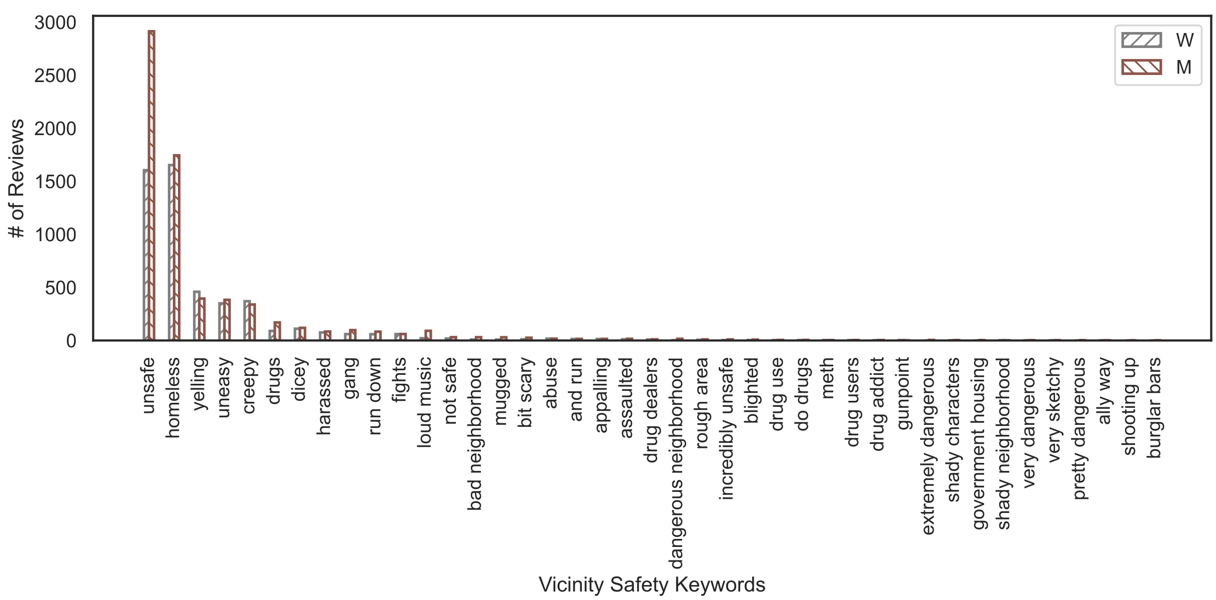


Figure A4: Distribution for keywords of vicinity safety review in H & L zip codes: Main definition



Note: High-income (H) and low-income (L) zip codes are classified based on the median household income within each city.

Figure A5: Distribution for keywords of vicinity safety review in W & M zip codes: Main definition



Note: White-dominant (W) and minority-dominant (M) zip codes are determined by the median percentage of white residents in the corresponding city.

Figure A6: Distribution for keywords of vicinity safety review: Alternative definition for sensitivity check

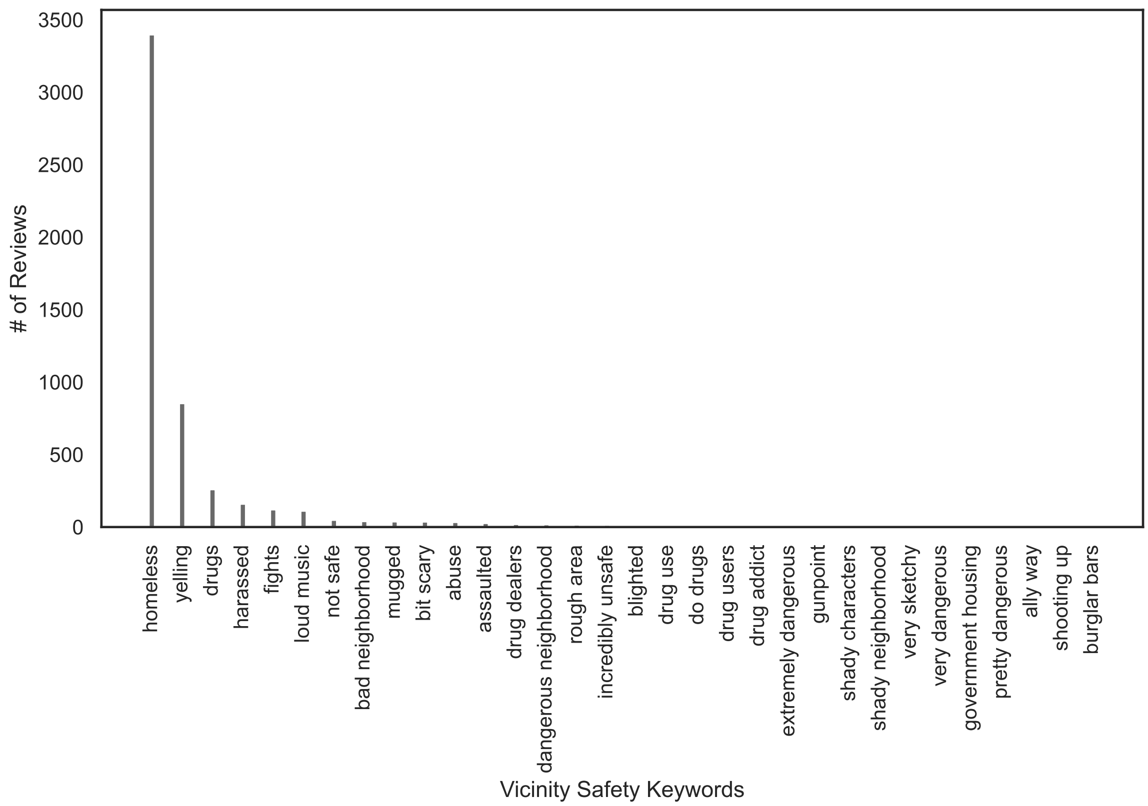


Figure A7: Distribution for keywords of listing safety review: Alternative definition for sensitivity check

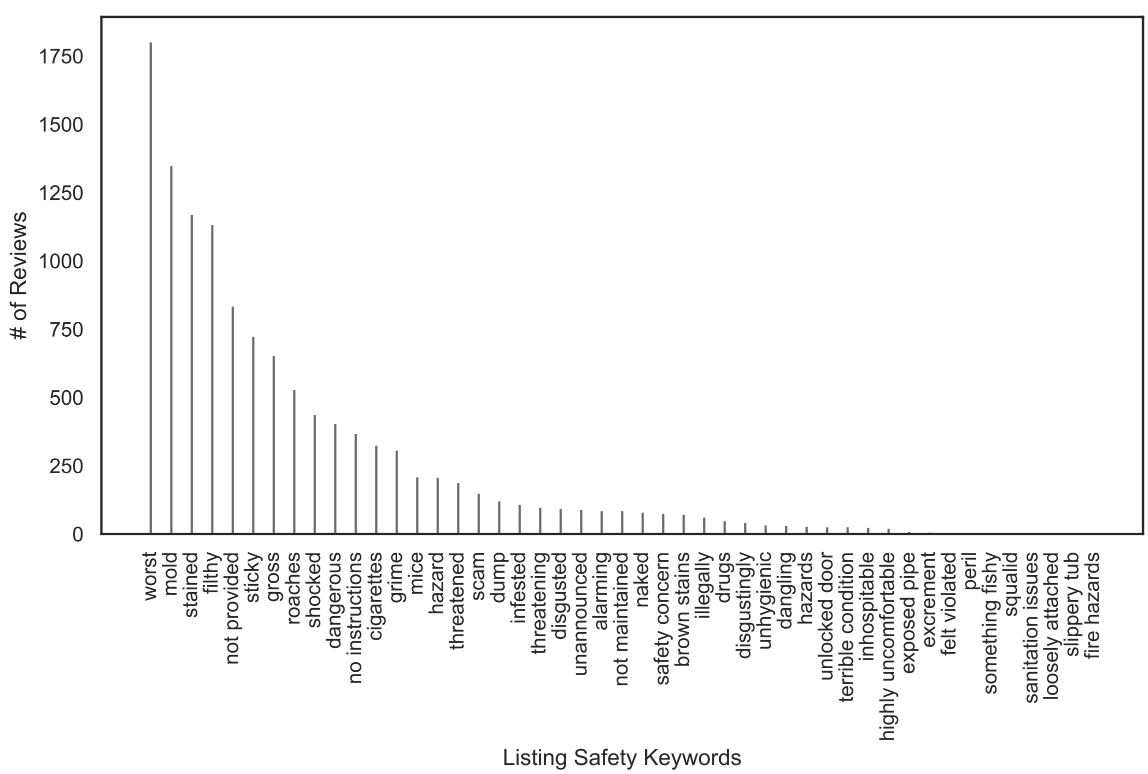


Table A1: Vicinity and listing safety review keywords

Vicinity safety keywords:	‘abuse’, ‘ally way’, ‘and run’, ‘appalling’, ‘assaulted’, ‘bad neighborhood’, ‘bit scary’, ‘blighted’, ‘burglar bars’, ‘creepy’, ‘dangerous neighborhood’, ‘not safe’, ‘dicey’, ‘do drugs’, ‘drug addict’, ‘drug dealers’, ‘drug use’, ‘drug users’, ‘drugs’, ‘extremely dangerous’, ‘fights’, ‘gang’, ‘government housing’, ‘gunpoint’, ‘harassed’, ‘homeless’, ‘incredibly unsafe’, ‘loud music’, ‘meth’, ‘mugged’, ‘pretty dangerous’, ‘rough area’, ‘run down’, ‘shady characters’, ‘shady neighborhood’, ‘shooting up’, ‘tenement area’, ‘uneasy’, ‘unsafe’, ‘very sketchy’, ‘yelling’
Listing safety keywords:	‘alarming’, ‘threatening’, ‘brown stains’, ‘cigarettes’, ‘dangerous’, ‘dangling’, ‘peril’, ‘disgusted’, ‘disgustingly’, ‘drugs’, ‘dump’, ‘excrement’, ‘exposed pipe’, ‘felt violated’, ‘filthy’, ‘fire hazards’, ‘something fishy’, ‘very poor’, ‘mold’, ‘grime’, ‘not maintained’, ‘gross’, ‘harass’ ‘hazard’, ‘hazards’, ‘highly uncomfortable’, ‘safety concern’, ‘illegally’, ‘infested’, ‘inhospitable’, ‘loosely attached’, ‘meth’, ‘mice’, ‘naked’, ‘no instructions’, ‘not provided’, ‘scam’, ‘unhygienic’, ‘roaches’, ‘sanitation issues’, ‘shocked’, ‘slippery tub’, ‘squalid’, ‘stained’, ‘sticky’, ‘terrible condition’, ‘threatened’, ‘unannounced’, ‘unlocked door’, ‘worst’,
Vicinity location keywords:	‘neighborhood’, ‘area’, ‘feel’, ‘felt’, ‘night’, ‘location’, ‘walking’, ‘people’, ‘seemed’, ‘outside’, ‘looked’, ‘looks’, ‘late’, ‘surrounding’, ‘located’, ‘neighbourhood’, ‘walked’, ‘areas’, ‘feeling’, ‘streets’, ‘street’, ‘outside’, ‘parking’, ‘neighbors’
Negative keywords:	‘hardly’, ‘never’, ‘scarcely’, ‘seldom’, ‘barely’, ‘no’, ‘not’, ‘without’, ‘nothing’, ‘nobody’, ‘neither’, ‘nor’, ‘none’

Table A2: Variable Definition

VARIABLES	Explanation
occupancy rate	Occupancy Rate = Count of Reservation Days / (Count of Reservation Days + Count of Available Days).
occupancy rate dummy	1 if occupancy rate is greater than 0.
ADR	Price per night in USD. ADR = Total Revenue / Booked Nights. Includes cleaning fees.
# of reservations	# of reservations in a listing in a reporting month.
# of reservation-days	# of days reserved in a listing in a reporting month.
any VSR	1 if a listing ever has any VSR before a reporting month.
any LSR	1 if a listing ever has any LSR before a reporting month.
# of VSR	Total number of VSR for a listing before a reporting month.
# of LSR	Total number of LSR for a listing before a reporting month.
% of any VSR within 0.3-mile radius	% of listings that ever have any VSR in a 0.3 mile radius area before a reporting month.
overall ratings	The overall rating score shown to the users. Normalized on a range from 0 to 10 with a uniform distribution.
# of reviews	# of reviews in a listing until a reporting month.
# of listings within zip code	# of listings in a zip code.
cross-listing	1 if the listing is also listed on VRBO in a reporting month.
super host	1 if the listing is hosted by a super host in a reporting month.
strict cancellation policy	1 if the listing has a strict cancellation policy in a reporting month.
avg word count in a review	Average word counts for all reviews before a reporting month.
Median income in zip code	Median income in USD for households in a zip code (using 2014 census data).
Population in zip code	# of population in a zip code (using 2014 census data).
% white in zip code	% of white population in a zip code (using 2014 census data).
high income zip code	1 if the median income in USD of a zip code exceeds the city's median income level.
white zip code	1 if the % of white population in a zip code surpasses the city's median % of white population.
Normalized crime reports	Normalized # of cumulative crime until a reporting month in a zip code by the population in the same zip code.

Table A3: Summary Statistics of Airbnb Listings by Four Area Types

	Panel A: H			Panel B: L			Panel C: W			Panel D: M		
VARIABLES	mean	p50	N	mean	p50	N	mean	p50	N	mean	p50	N
occupancy_rate	0.56	0.64	1,484,474	0.57	0.65	1,381,764	0.56	0.64	1,716,774	0.57	0.65	1,149,464
occupancy_rate_dummy	0.84	1.00	1,484,474	0.86	1.00	1,381,764	0.85	1.00	1,716,774	0.85	1.00	1,149,464
adr	190.38	149.00	1,484,474	137.08	103.62	1,381,764	188.33	147.48	1,716,774	129.37	98.07	1,149,464
No._of_reservations	3.65	3.00	1,484,474	3.91	3.00	1,381,764	3.71	3.00	1,716,774	3.87	3.00	1,149,464
No._of_reservationdays	13.86	14.00	1,484,474	14.48	15.00	1,381,764	13.99	14.00	1,716,774	14.41	15.00	1,149,464
lag_VSR_cumu_dummy	0.02	0.00	1,484,474	0.07	0.00	1,381,764	0.03	0.00	1,716,774	0.06	0.00	1,149,464
lag_LSR_cumu_dummy	0.05	0.00	1,484,474	0.05	0.00	1,381,764	0.05	0.00	1,716,774	0.05	0.00	1,149,464
lag_VSR_cumu	0.03	0.00	1,484,474	0.09	0.00	1,381,764	0.04	0.00	1,716,774	0.08	0.00	1,149,464
lag_LSR_cumu	0.05	0.00	1,484,474	0.06	0.00	1,381,764	0.06	0.00	1,716,774	0.06	0.00	1,149,464
lag_VS_listing_radius_pct	0.05	0.03	1,484,474	0.09	0.05	1,381,764	0.05	0.03	1,716,774	0.09	0.05	1,149,464
ratingoverall	9.23	9.60	1,484,474	9.13	9.50	1,381,764	9.23	9.60	1,716,774	9.11	9.50	1,149,464
review_utd	33.07	14.00	1,484,474	34.40	15.00	1,381,764	33.65	15.00	1,716,774	33.80	15.00	1,149,464
No._of_listing_zip	502.69	463.00	1,484,474	581.47	428.00	1,381,764	609.92	512.00	1,716,774	437.24	372.00	1,149,464
cross_listing	0.02	0.00	1,484,474	0.02	0.00	1,381,764	0.03	0.00	1,716,774	0.02	0.00	1,149,464
superhost	0.25	0.00	1,484,474	0.22	0.00	1,381,764	0.24	0.00	1,716,774	0.22	0.00	1,149,464
strict_cp	0.50	0.00	1,484,474	0.49	0.00	1,381,764	0.51	1.00	1,716,774	0.48	0.00	1,149,464
ave_wordcount_cumu_review	53.93	50.67	1,484,474	53.72	50.15	1,381,764	54.40	51.18	1,716,774	52.98	49.25	1,149,464
median_income_zip	75,865	71,278	1,484,474	37,121	35,112	1,381,764	69,745	68,346	1,716,774	38,432	37,116	1,149,464
population_zip	43,535	41,453	1,484,474	53,124	51,791	1,381,764	44,706	38,752	1,716,774	53,313	54,440	1,149,464
white_pct_zip	0.68	0.72	1,484,474	0.37	0.32	1,381,764	0.69	0.72	1,716,774	0.28	0.30	1,149,464
h_zip	1.00	1.00	1,484,474	0.00	0.00	1,381,764	0.78	1.00	1,716,774	0.13	0.00	1,149,464
w_zip	0.90	1.00	1,484,474	0.27	0.00	1,381,764	1.00	1.00	1,716,774	0.00	0.00	1,149,464
normalized_crime_cumu	0.56	0.19	1,484,474	1.19	0.24	1,381,764	1.10	0.19	1,716,774	0.51	0.23	1,149,464

Note: This table summarizes Airbnb listings from July 2015 to December 2019 across five sample cities, categorized by four vicinity types. The crime report variable is recorded at the zip code-year-month level and normalized by the zip code's population. High-income (H) and low-income (L) zip codes are classified based on the median household income within each city, while white-dominant (W) and minority-dominant (M) zip codes are determined by the median percentage of white residents in the corresponding city.

Table A3: Summary Statistics of Airbnb Listings By Four Listing Types

	Panel E: Entire Home			Panel F: Private Room			Panel G: Shared Room			Panel H: Hotel Room		
VARIABLES	mean	p50	N	mean	p50	N	mean	p50	N	mean	p50	N
occupancy_rate	0.58	0.67	1,745,432	0.55	0.63	1,016,553	0.44	0.41	94,722	0.46	0.43	9,531
occupancy_rate_dummy	0.87	1.00	1,745,432	0.83	1.00	1,016,553	0.77	1.00	94,722	0.87	1.00	9,531
adr	212.81	170.46	1,745,432	91.67	76.25	1,016,553	58.23	39.36	94,722	197.16	153.87	9,531
No._of_reservations	3.86	3.00	1,745,432	3.65	3.00	1,016,553	3.31	2.00	94,722	5.79	5.00	9,531
No._of_reservationdays	14.45	15.00	1,745,432	13.93	14.00	1,016,553	11.44	9.00	94,722	12.53	11.00	9,531
lag_VSR_cumu_dummy	0.05	0.00	1,745,432	0.04	0.00	1,016,553	0.04	0.00	94,722	0.06	0.00	9,531
lag_LSR_cumu_dummy	0.06	0.00	1,745,432	0.04	0.00	1,016,553	0.03	0.00	94,722	0.03	0.00	9,531
lag_VSR_cumu	0.06	0.00	1,745,432	0.06	0.00	1,016,553	0.06	0.00	94,722	0.11	0.00	9,531
lag_LSR_cumu	0.07	0.00	1,745,432	0.05	0.00	1,016,553	0.03	0.00	94,722	0.04	0.00	9,531
lag_VS_listing_radius_pct	0.06	0.03	1,745,432	0.07	0.04	1,016,553	0.08	0.05	94,722	0.06	0.04	9,531
ratingoverall	9.26	9.60	1,745,432	9.09	9.50	1,016,553	8.74	9.30	94,722	9.03	9.40	9,531
review_utd	34.28	16.00	1,745,432	34.20	14.00	1,016,553	19.24	8.00	94,722	21.77	7.00	9,531
No._of_listing_zip	562.51	481.00	1,745,432	513.44	401.00	1,016,553	433.98	339.00	94,722	504.51	449.00	9,531
cross_listing	0.04	0.00	1,745,432	0.00	0.00	1,016,553	0.00	0.00	94,722	0.00	0.00	9,531
superhost	0.25	0.00	1,745,432	0.22	0.00	1,016,553	0.11	0.00	94,722	0.13	0.00	9,531
strict_cp	0.53	1.00	1,745,432	0.43	0.00	1,016,553	0.52	1.00	94,722	0.41	0.00	9,531
ave_wordcount_cumu_review	55.03	51.60	1,745,432	52.94	49.48	1,016,553	42.84	38.70	94,722	37.27	33.14	9,531
median_income_zip	59,726	54,023	1,745,432	53,568	47,050	1,016,553	48,929	40,873	94,722	60,291	56,337	9,531
population_zip	44,465	38,752	1,745,432	54,260	54,440	1,016,553	52,003	48,852	94,722	35,315	30,648	9,531
white_pct_zip	0.56	0.61	1,745,432	0.48	0.46	1,016,553	0.45	0.44	94,722	0.55	0.60	9,531
h_zip	0.59	1.00	1,745,432	0.41	0.00	1,016,553	0.37	0.00	94,722	0.59	1.00	9,531
w_zip	0.68	1.00	1,745,432	0.48	0.00	1,016,553	0.43	0.00	94,722	0.74	1.00	9,531
normalized_crime_cumu	1.13	0.22	1,745,432	0.44	0.19	1,016,553	0.36	0.19	94,722	2.99	0.38	9,531

Note: This table This table summarizes Airbnb listings from July 2015 to December 2019 across five sample cities, categorized into four listing types: entire home, private room, shared space, and a small subset of hotel rooms listed on Airbnb. The crime report variable is recorded at the zip code-year-month level and normalized by the zip code's population.

Figure A8: Distribution of Propensity Scores for VS listings (treated) and non-VS listings (control)

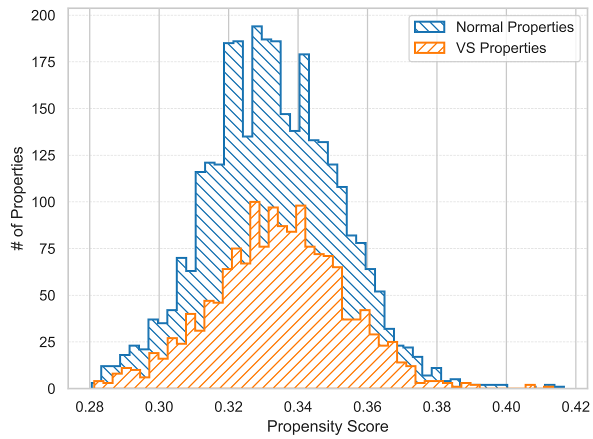


Table A4: Summary Statistics by VS and Non-VS Listings in the DID Sample

	Panel A: VS listings				Panel B: Non-VS (Normal) listings			
VARIABLES	mean	p50	sd	N	mean	p50	sd	N
listing_type_code_pre	1.45	1.00	0.52	1,566	1.45	1.00	0.52	3,132
bedrooms_pre	1.19	1.00	0.62	1,566	1.19	1.00	0.62	3,132
log_ave_review_utd_pre	3.14	3.18	0.77	1,566	3.11	3.14	0.76	3,132
log_ave_rating_overall_pre	2.34	2.35	0.05	1,566	2.34	2.35	0.05	3,132
ave_superhost_pre	0.18	0.00	0.32	1,566	0.19	0.00	0.31	3,132
ave_strict_cp_pre	0.58	0.93	0.48	1,566	0.57	0.86	0.46	3,132
ave_cross_listing_pre	0.00	0.00	0.02	1,566	0.00	0.00	0.02	3,132
ave_h_pre	0.40	0.00	0.49	1,566	0.40	0.00	0.49	3,132
ave_w_pre	0.49	0.00	0.50	1,566	0.49	0.00	0.50	3,132
log_ave_listing_size_zip_pre	6.04	6.20	0.80	1,566	6.04	6.15	0.78	3,132
propensity_score_match	0.33	0.33	0.02	1,566	0.33	0.33	0.02	3,132

Note: This table presents the results of balanced matching on covariates and propensity scores. The covariates include the average attributes of listings prior to treatment, such as listing type (EH, PR, SR, HR), number of bedrooms, average number of reviews, star rating, Superhost status, cancellation policy, cross-listing on VRBO, zip code characteristics (high-income vicinity, white-dominant vicinity), average number of listings in the zip code, and the propensity score.

Figure A9: Distribution of Propensity Scores for LS listings (treated) and Non-LS listings (control)

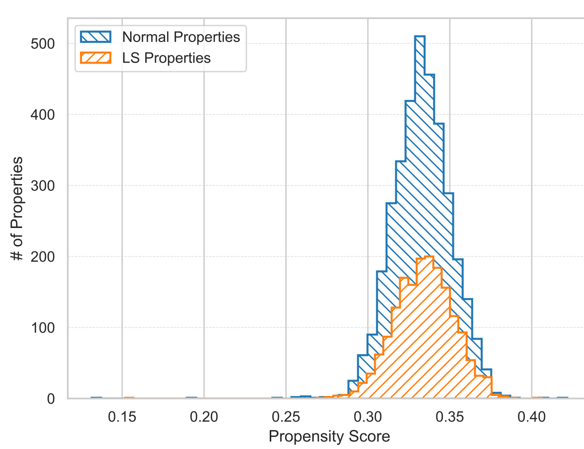
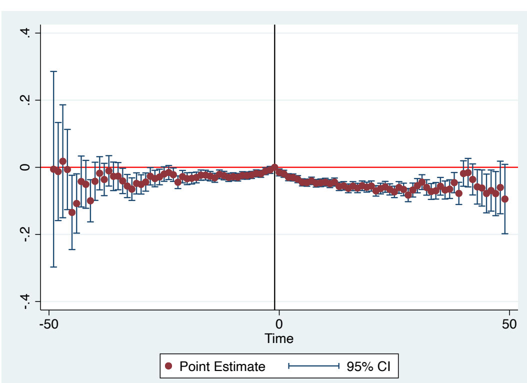


Table A5: Summary Statistics by LS and Non-LS Listings in the DID Sample

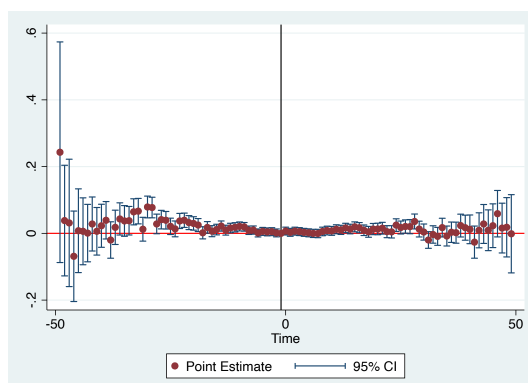
	Panel A: LS listings				Panel B: Non-LS (Normal) listings			
VARIABLES	mean	p50	sd	N	mean	p50	sd	N
listing_type_code_pre	1.37	1.00	0.50	1,759	1.37	1.00	0.50	3,518
bedrooms_pre	1.25	1.00	0.64	1,759	1.25	1.00	0.64	3,518
log_ave_review_utd_pre	2.94	2.97	0.77	1,759	2.92	2.97	0.77	3,518
log_ave_rating_overall_pre	2.34	2.35	0.05	1,759	2.34	2.35	0.05	3,518
ave_superhost_pre	0.20	0.00	0.33	1,759	0.21	0.00	0.31	3,518
ave_strict_cp_pre	0.58	0.89	0.46	1,759	0.59	0.82	0.43	3,518
ave_cross_listing_pre	0.00	0.00	0.02	1,759	0.00	0.00	0.03	3,518
ave_h_pre	0.58	1.00	0.49	1,759	0.58	1.00	0.49	3,518
ave_w_pre	0.64	1.00	0.48	1,759	0.64	1.00	0.48	3,518
log_ave_listing_size_zip_pre	6.07	6.23	0.77	1,759	6.06	6.16	0.73	3,518
propensity_score_match	0.33	0.33	0.02	1,759	0.33	0.33	0.02	3,518

Note: This table presents the results of balanced matching on covariates and propensity scores. The covariates include the average attributes of listings prior to treatment, such as listing type (EH, PR, SR, HR), number of bedrooms, average number of reviews, star rating, Superhost status, cancellation policy, cross-listing on VRBO, zip code characteristics (high-income vicinity, white-dominant vicinity), average number of listings in the zip code, and the propensity score.

Figure A10: Event study plot for the DID analysis of VS listings and non-VS listings



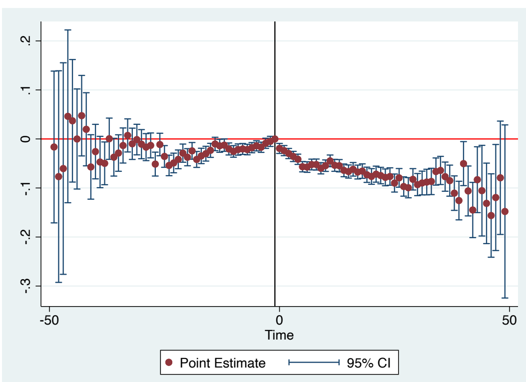
log(occupancy rate)



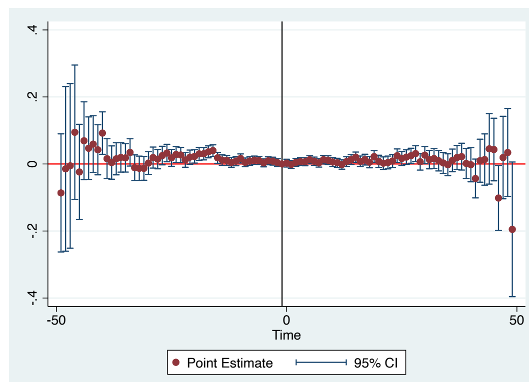
log(price)

Note: The x-axis represents time relative to the treatment, measured in months before and after the treatment. The y-axis represents the estimated effect of the treatment on occupancy rate and price, respectively.

Figure A11: Event study plot for the DID analysis of LS listings and non-LS listings



log(occupancy rate)



log(price)

Note: The x-axis represents time relative to the treatment, measured in months before and after the treatment. The y-axis represents the estimated effect of the treatment on occupancy rate and price, respectively.

Figure A12: Distribution of Propensity Scores for VS users (treated) and Non-VS users (control)

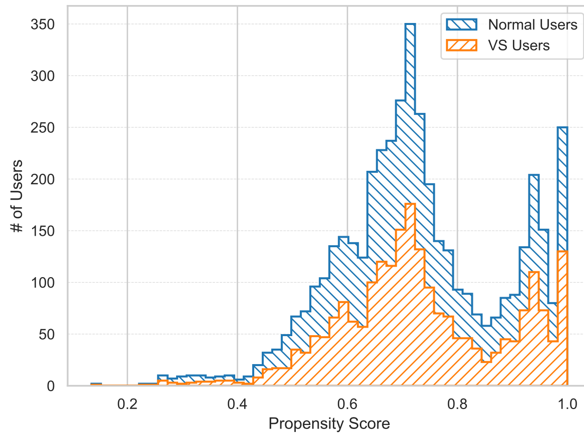


Table A6: Summary Statistics by VS and non-VS Users in the DID Sample

	Panel A: VS users				Panel B: Non-VS (Normal) users			
VARIABLES	mean	p50	sd	N	mean	p50	sd	N
reservation_pre	2.76	2.00	1.51	2,252	2.72	2.00	1.43	4,504
log_ave_crime_cumu_norm_pre	0.45	0.25	0.52	2,252	0.44	0.24	0.48	4,504
ave_vsr_cumu_pre	0.63	0.50	0.44	2,252	0.64	0.50	0.43	4,504
ave_vs_listing_zip_pct_pre	0.06	0.05	0.04	2,252	0.06	0.05	0.04	4,504
ave_vs_listing_radius_pct_pre	0.09	0.07	0.07	2,252	0.08	0.07	0.06	4,504
log_ave_wordcount_cumu_review_pre	4.37	4.39	0.64	2,252	4.36	4.39	0.63	4,504
propensity_score	0.74	0.72	0.15	2,252	0.73	0.71	0.15	4,504

Note: This table presents the results of balanced matching on covariates and propensity scores. The covariates include the average attributes of users' booked properties prior to treatment, including the number of reservations, average normalized crime records, average cumulative vicinity safety reviews, average percentage of vicinity safety listings within the same zip code, average percentage of vicinity safety listings within a 0.3-mile radius area, average number of words in the reviews they have written, and the propensity score.

Figure A13: Distribution of Propensity Scores for LS users (treated) and Non-LS users (control)

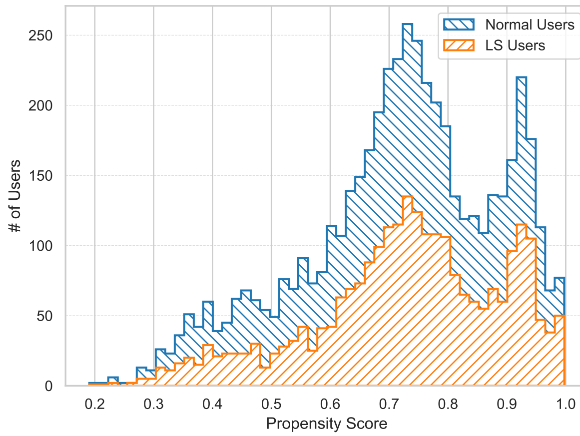
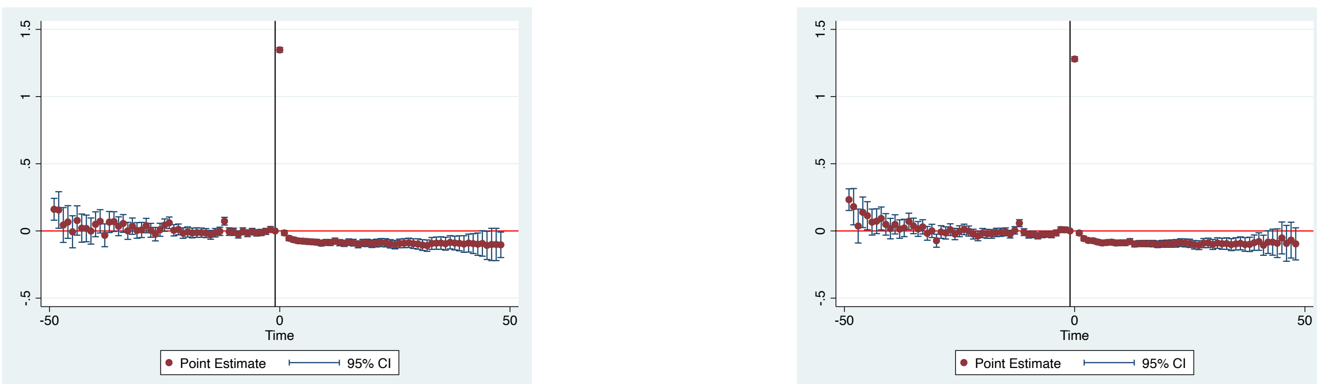


Figure A14: Event study plot for the DID analysis by VS users and LS users



Monthly Reservations
(VS vs. non-VS users)

Monthly Reservations
(LS vs. non-LS users)

Note: The x-axis represents time relative to the treatment, measured in months before and after the treatment. The y-axis represents the estimated effect of the treatment on monthly reservations.

Table A7: Summary Statistics by LS and non-LS Users in the DID Sample

	Panel A: LS users				Panel B: Non-LS (Normal) users			
VARIABLES	mean	p50	sd	N	mean	p50	sd	N
reservation_pre	2.93	2.00	1.77	2,526	2.89	2.00	1.72	5,052
ave_lsr_cumu_pre	0.53	0.50	0.37	2,526	0.52	0.50	0.39	5,052
ave_ls_listing_zip_pct_pre	0.05	0.05	0.02	2,526	0.05	0.04	0.02	5,052
ave_ls_listing_radius_pct_pre	0.08	0.07	0.05	2,526	0.08	0.07	0.05	5,052
log_ave_wordcount_cumu_review_pre	4.57	4.59	0.55	2,526	4.57	4.58	0.55	5,052
propensity_score	0.73	0.74	0.16	2,526	0.72	0.73	0.16	5,052

Note: This table presents the results of balanced matching on covariates and propensity scores. The covariates include the average attributes of users' booked properties prior to treatment, including the number of reservations, average cumulative listing safety reviews, average percentage of listing safety listings within the same zip code, average percentage of listing safety listings within a 0.3-mile radius area, average number of words in the reviews they have written, and the propensity score.

Table A8: Reduced-form Listing-level Analysis of Airbnb Listings By Four Listing Types

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sample	EH	PR	SR	HR	EH	PR	SR	HR
Model	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
VARIABLES	log occupancy rate	log occupancy rate	log occupancy rate	log occupancy rate	log (price)	log (price)	log (price)	log (price)
lag_VSR_cumu_dummy	-0.0134***	-0.0158***	-0.0228**	-0.0184	-0.0137***	-0.0165***	-0.0100	-0.0247
	(0.00167)	(0.00240)	(0.00937)	(0.0174)	(0.00265)	(0.00348)	(0.0129)	(0.0395)
lag_LSR_cumu_dummy	-0.0219***	-0.0283***	-0.0235**	-0.0616***	-0.0189***	-0.00842**	-0.00459	0.0187
	(0.00152)	(0.00256)	(0.00926)	(0.0215)	(0.00237)	(0.00381)	(0.0129)	(0.0227)
lag_VS_listing_radius_pct	-0.00237	-0.00268	-0.0307*	0.997***	-0.00276	-0.00894	-0.0221	0.281
	(0.00318)	(0.00379)	(0.0182)	(0.482)	(0.00520)	(0.00550)	(0.0285)	(0.710)
Observations	1,745,432	1,016,553	94,722	9,531	1,745,432	1,016,553	94,722	9,531
R-squared	0.549	0.594	0.685	0.757	0.890	0.864	0.925	0.946

Note: This table reports the baseline results following Equation 1 by four listing types. The sample consists of all Airbnb listings from 2015/7 to 2019/12 in the five sample cities. All regressions control for Property ID fixed effects, zip code-year-month fixed effects, and listing attributes including # of reviews, star ratings, whether the listing is a super host, whether the listing is cross-listed on Airbnb and VRBO, whether the listing offers a strict cancellation policy, and the number of Airbnb listings in the same zip code. Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A9: Reduced-form Guest-level Analysis: DID for VS Users whose 1st VSR booking and bookings before 1st VSR are in H or L.

	(1)	(2)	(3)	(4)	(5)	(6)
Model	Poission	Poission	Logit	OLS	OLS	OLS
VARIABLES	reservation monthly	VSR_cumu	VSR_cumu dummy	crime_cumu norm	VS_listing pct zip	VS_listing pct radius
Sample	Monthly Reservation	Reserved Property	Reserved Property	Reserved Property	Reserved Property	Reserved Property
Subsample	1st VSR booking in H, at least 1 booking before 1st VSR in L					
VS_user × post	-1.215***	-0.796***	-0.598***	-0.945***	-0.0292***	-0.0378***
	(0.0990)	(0.247)	(0.227)	(0.200)	(0.00394)	(0.00604)
Observations	69,417	6,101	6,101	6,155	6,155	6,155
Subsample	1st VSR booking in L, at least 1 booking before 1st VSR in L					
VS_user × post	-0.806***	-0.618***	-0.421***	-0.926***	-0.0224***	-0.0175***
	(0.0740)	(0.162)	(0.135)	(0.134)	(0.00340)	(0.00675)
Observations	175,770	15,556	15,533	15,648	15,648	15,648
Subsample	1st VSR booking in L, all booking before 1st VSR in H					
VS_user × post	-0.730**	-1.445**	-1.105	-0.190	-0.00572	-0.0326
	(0.342)	(0.642)	(0.711)	(1.055)	(0.0216)	(0.0239)
Observations	6,612	462	462	462	462	462
Subsample	1st VSR booking in H, all booking before 1st VSR in H					
VS_user × post	-0.730	-1.474	-0.720	-1.949**	-0.0567***	-0.0717***
	(0.445)	(1.312)	(0.941)	(0.759)	(0.0164)	(0.0185)
Observations	2,135	146	141	146	146	146

Note: This table presents the DID results of VS users and the non-VS users that are similar to the VS users in user attributes and Airbnb history before the VS user posts her first VSR. The subsamples are defined by whether the VS users' 1st VSR post is in the L area and whether VS users have bookings in the L area before their 1st VSR post. Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All regressions control treatment-control pair ID FE and the post dummy. Standard errors are clustered by pair ID.

Table A10: Reduced-form Guest-level Analysis: DID for VS Users whose 1st VSR booking and bookings before 1st VSR are in W or M.

	(1)	(2)	(3)	(4)	(5)	(6)
Model	Poission	Poission	Logit	OLS	OLS	OLS
VARIABLES	reservation monthly	VSR_cumu	VSR_cumu dummy	crime_cumu norm	VS_listing pct zip	VS_listing pct radius
Sample	Monthly Reservation	Reserved Property	Reserved Property	Reserved Property	Reserved Property	Reserved Property
Subsample	1st VSR booking in W, at least 1 booking before 1st VSR in M					
VS_user × post	-1.012***	-0.877***	-0.727***	-1.502***	-0.0261***	-0.0337***
	(0.0911)	(0.211)	(0.191)	(0.185)	(0.00398)	(0.00596)
Observations	104,313	8,959	8,959	9,031	9,031	9,031
Subsample	1st VSR booking in M, at least 1 booking before 1st VSR in M					
VS_user × post	-0.869***	-0.546***	-0.306**	-0.550***	-0.0247***	-0.0176**
	(0.0814)	(0.175)	(0.146)	(0.135)	(0.00360)	(0.00759)
Observations	140,874	12,698	12,675	12,772	12,772	12,772
Subsample	1st VSR booking in M, all booking before 1st VSR in W					
VS_user × post	-0.595*	-1.774**	-1.298*	-0.664	-0.00956	-0.0406**
	(0.331)	(0.757)	(0.740)	(1.153)	(0.0212)	(0.0193)
Observations	5,656	383	383	383	383	383
Subsample	1st VSR booking in W, all booking before 1st VSR in W					
VS_user × post	-0.994**	-0.848	-0.454	-1.039**	-0.0353	-0.0433
	(0.433)	(1.110)	(0.829)	(0.430)	(0.0240)	(0.0373)
Observations	3,091	225	220	225	225	225

Note: This table presents the DID results of VS users and the non-VS users that are similar to the VS users in user attributes and Airbnb history before the VS user posts her first VSR. The subsamples are defined by whether the VS users' 1st VSR post is in the M area and whether VS users have bookings in the M area before their 1st VSR post. Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All regressions control treatment-control pair ID FE and the post dummy. Standard errors are clustered by pair ID.

Online Appendix B: Calibrating the cross-listing-with-buyer effect of VSR for the structural model

This appendix explains how we use the reduced-form DID results of VS users to calibrate the coefficient of having any VSR in the structural demand model.

According to Table 6 Column 1, the DID coefficient on treated × post is -0.918 in a Poisson regression of the number of Airbnb reservations, which is a 60.07% decrease for VS users relative to normal users. Given the average number of reservations per month for a single VS user in our sample is 0.1092 and review rate is 44.56%, a VS user's Airbnb reservations are $(0.1092 \times 60.07\%/0.4456 = 0.147$ fewer than a normal user after she has reported a VS issue in her first VS review. This can be expressed by:

$$\begin{aligned}&[\#Airbnbbooking_{VS\ user,aft} - \#Airbnbbooking_{VS\ user,bef}]\\&-[\#Airbnbbooking_{NM\ user,aft} - \#Airbnbbooking_{NM\ user,bef}] = -0.147\end{aligned} \tag{9}$$

Recall that we define an average guest's utility from listing j as:

$$\begin{aligned}U_{j,t} &= EU_{j,t} + \epsilon_{j,t}\\&= \alpha_j + \alpha_{k,t} + \delta \cdot X_{j,t} + \beta_0 \cdot log(ADR_{j,t}) + \beta_1 \cdot Crime_{z,t-1}\\&+ \beta_2 \cdot LSR_{j,t-1} + \beta_3 \cdot VSR_{j,t-1} + \beta_4 \cdot VSRADIUS_{j,t-1} + \epsilon_{j,t}.\end{aligned}$$

If we assume self experience of vicinity safety issues only changes β_3, we can write:

$$\beta_3 = \beta_{3,NM} + \Delta\beta_3 \cdot [i = \text{VS User}]$$

where $\beta_{3,NM}$ indicates normal users' sensitivity to observing any VSR in a listing, $[i = \text{VS User}]$ is a dummy equal to one for VS users, and thus $\beta_{3,NM} + \Delta\beta_3$ indicates VS users' updated sensitivity to VSR.

Assuming VS and normal users have the same tendency to book short-term rentals, the DID results can be rewritten as user i's market share for all Airbnb choices $\sum_{j\in Airbnb} s_{ij}$:

$$\left(\frac{\partial \sum_{j\in Airbnb} s_{ij}}{\partial VSR}\right)_{i=VS\ user} - \left(\frac{\partial \sum_{j\in Airbnb} s_{ij}}{\partial VSR}\right)_{i=NM\ user} = -0.147 \tag{10}$$

The market share of all Airbnb reservations is:

$$\sum_{j\in Airbnb} s_{ij} = \bar{s}_{Airbnb} = 1 - s_{outside} = 1 - \frac{1}{1 + exp(I_{Airbnb})} \tag{11}$$

where $I_{Airbnb} = (1 - \sigma_{city})log\sum_{z\in city} exp\left(\frac{I_{zip_z}}{1-\sigma_{city}}\right)$ is the Airbnb-specific inclusive value, and inside it $I_{zip_z} = (1 - \sigma_{zip}) \cdot log\sum_{j\in zip_z} exp\left(\frac{EU_{j,t}}{1-\sigma_{zip}}\right)$ is the zipcode-specific inclusive value conditional on choosing Airbnb. Recall that listing j's market share is $s_{j,t} = \bar{s}_{j,t|zip_z} \cdot \bar{s}_{zip_z|Airbnb} \cdot \bar{s}_{Airbnb}$, where the within zip code market share is $\bar{s}_{j,t|zip_z} = \frac{exp\left(\frac{EU_{j,t}}{1-\sigma_{zip}}\right)}{exp\left(\frac{I_{zip_z}}{1-\sigma_{zip}}\right)}$, the zip code's within Airbnb market share is $\bar{s}_{zip_z|Airbnb} = \frac{exp\left(\frac{I_{zip_z}}{1-\sigma_{city}}\right)}{exp\left(\frac{I_{Airbnb}}{1-\sigma_{city}}\right)}$.

It is not difficult to derive that:

$$\left(\frac{\partial \sum_{j \in Airbnb} s_{ij}}{\partial VSR}\right)_{i=NM\ user} = \beta_{3,NM} \cdot s_{NM\ user,outside} \cdot \sum_{j \in Airbnb\ \&\ VSR} s_{NM\ user,j} \tag{12}$$

$$\left(\frac{\partial \sum_{j \in Airbnb} s_{ij}}{\partial VSR}\right)_{i=VS\ user} = (\beta_{3,NM} + \Delta\beta_3) \cdot s_{VS\ user,outside} \cdot \sum_{j \in Airbnb\ \&\ VSR} s_{VS\ user,j} \tag{13}$$

Denote a user's total probability of choosing any Airbnb listings with any VSR as:

$$s_{NM\ user,Airbnb\ \&\ VSR} = \sum_{j \in Airbnb\ \&\ VSR} s_{NM\ user,j} \tag{14}$$

$$s_{VS\ user,Airbnb\ \&\ VSR} = \sum_{j \in Airbnb\ \&\ VSR} s_{VS\ user,j} \tag{15}$$

The DID results can be written as:

$$\begin{aligned}&(\beta_{3,NM} + \Delta\beta_3) \cdot s_{VS\ user,outside} \cdot s_{VS\ user,Airbnb\ \&\ VSR} \\ &-\beta_{3,NM} \cdot s_{NM\ user,outside} \cdot s_{NM\ user,Airbnb\ \&\ VSR} = -0.147\end{aligned} \tag{16}$$

All the four market share terms in this equation are a function of the estimates from our structural model and $\Delta\beta_3$. Using grid search for $\Delta\beta_3$, we solve Equation 16 and find $\Delta\beta_3 = -2.195$.

If we incorporate the possibility that our DID estimate might understate the true effect of VS experience because the control group may include some guests that had VS experience but chose not to report it in consumer review, Section 5.2 shows that the DID estimate should be adjusted by a factor of 1.1213. Including this adjustment in the calibration would lead to $\Delta\beta_3 = -2.274$.