

Airbnbs in New York City

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Introduction

The rise of short-term rental platforms, particularly Airbnb, has significantly disrupted the traditional hospitality industry and transformed urban housing markets worldwide. In New York City, one of the world's most popular tourist destinations, the impact of Airbnb has been particularly pronounced, raising questions about its effects on local communities, housing affordability, and the broader urban economy.

Previous research has identified several factors that impact Airbnb pricing. One study found that host attributes, site and property attributes, amenities and services, rental rules, and online review ratings all play significant roles in determining listing prices (Wang and Nicolau 2017). Furthermore, recent studies have provided evidence of Airbnb's influence on housing markets. Another study found that a 1% increase in Airbnb listings leads to a 0.018% increase in rents and a 0.026% increase in house prices (Barron, Kung, and Proserpio 2018). This effect is more pronounced in areas with a lower share of owner-occupiers, suggesting that non-owner-occupiers are more likely to reallocate their properties from long-term to short-term rentals.

Our research question is: "How do various factors, such as bedroom number, room type, review scores, and neighborhood, influence the price of Airbnb listings in New York City?"

Price is the total price per night including fees (quantitative). Bedroom number is the total number of bedrooms in the rental (quantitative). Room type is whether the rental is a hotel room, entire home/apartment, private room, or shared room (categorical). Review score is the average review score of the rental from 1-5 stars (quantitative). Neighborhood is the borough of New York City that the rental is located in (categorical).

The Airbnb dataset that we are utilizing can be found on Inside Airbnb (<https://insideairbnb.com/>). Inside Airbnb has randomly collected data on dozens of countries and cities, but we decided to focus on New York City. The data was sourced from publicly available data on the Airbnb website on March 1, 2025.

Understanding the determinants of Airbnb pricing in New York City is crucial for several reasons. Firstly, it can provide valuable insights for policymakers grappling with the challenges posed by the growth of short-term rentals, including potential impacts on housing affordability and neighborhood character (Toader et al. 2021). Secondly, it can help hosts make more informed pricing decisions, potentially leading to more efficient market outcomes.

Univariate Exploratory Data Analysis

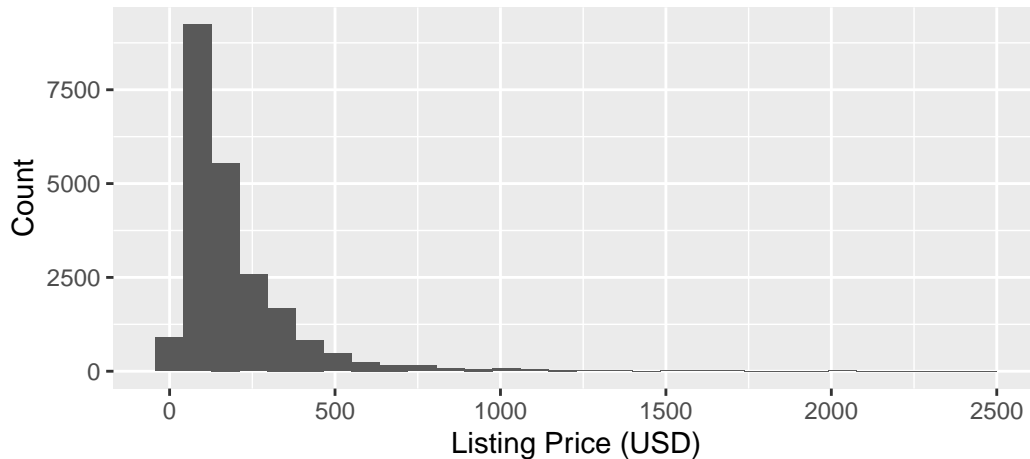
Response Variable - Price

Table 1: Price Distribution Summary

minimum	q1	median	mean	q3	maximum
7	85	140	213.835	240	20000

The distribution is pretty heavily right skewed. There is an outlier at \$20,000 that impacts the mean, since the median of \$140 is quite a bit less than the mean of around \$213.84, and the mean is roughly equal to the 3rd quartile which is also around \$240. The second highest price value is less than \$1,000. We have removed this outlier for our analysis.

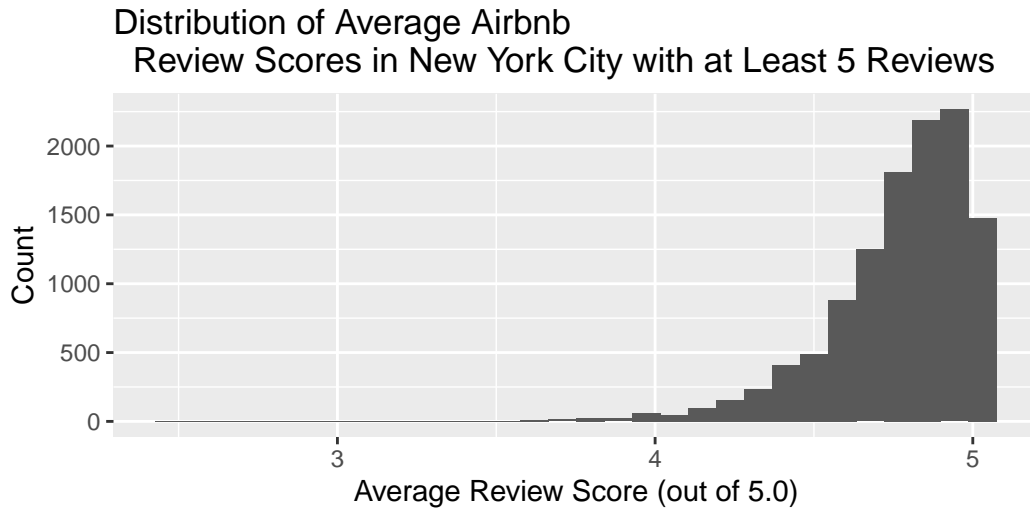
Closer Look at Distribution of Price (Removed Outliers)



We can see that the distribution is still right skewed, and the vast majority of the listings seem to cost between \$50-\$200. Because of this skewedness, we also plan to apply log transformation to this variable to address the skew of the response variable.

Predictor Variable - Review Scores

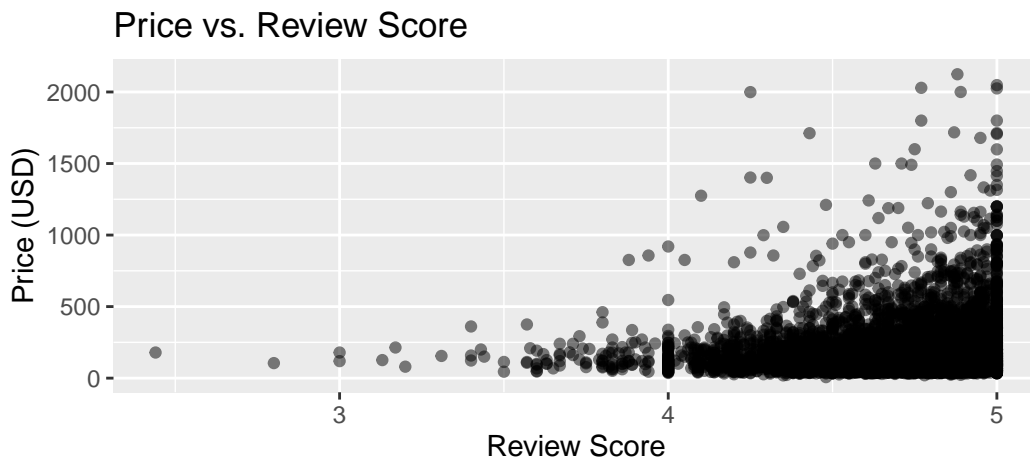
To account for the 6733 NA values for review scores, we will filter the dataset to include only listings with 5 or more reviews, since the median number of reviews for a listing is 5.



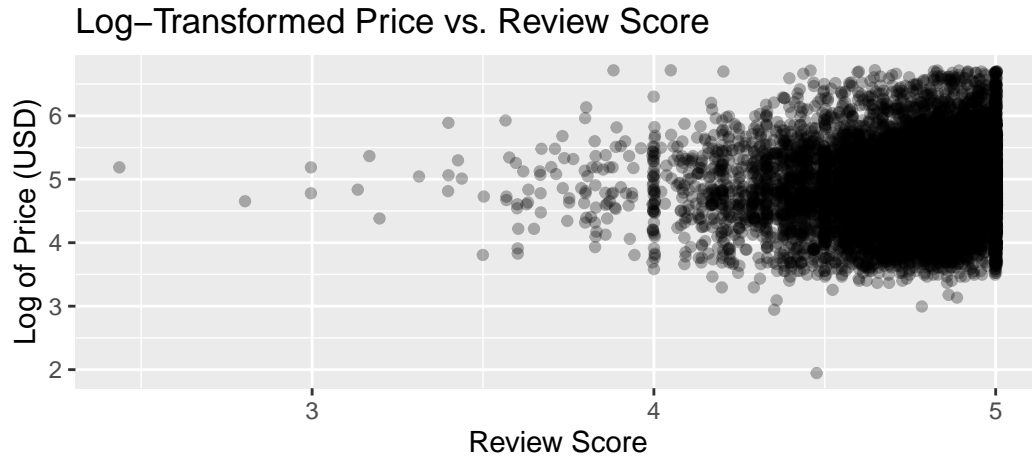
The distribution of review scores is skewed left after the transformation, with a median of 4.82 and a mean of 4.765. The minimum review score has increased from 1 to 2.44, and the third quartile review score has decreased from 5 to 4.93.

Bivariate Exploratory Data Analysis

Response (Price) vs Predictor Variable (review scores)



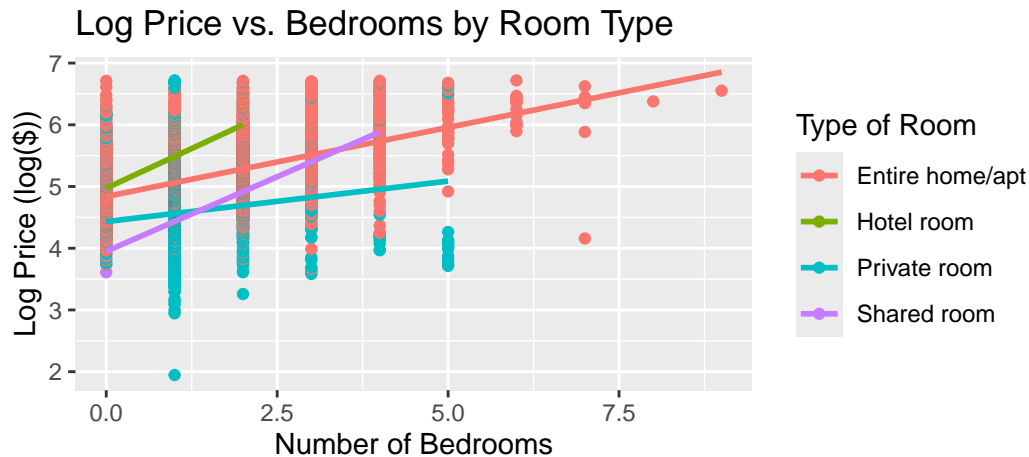
This scatter plot shows the relationship between price and review scores. However, it looks a little problematic and hard to interpret because high data density at certain score levels, especially between 4 and 5. Since the price variable is highly skewed, we applied a log transformation to try to help spread out values and make trends more visible.



The majority of listings have review scores between 4 and 5, this shows that most listings have scores within this range. Higher-rated listings tend to have slightly higher prices, but the effect is weak.

Interaction Effects

Bedrooms and Room Type



Based on the graph, it appears that the rate at which price increases per number of bedrooms varies across room types. The slope of the shared room especially seems to differ from the others. Thus, there may be an interaction effect here.

Methodology

We chose to build a multiple linear regression model, as we wanted to use multiple explanatory variables to predict our continuous response variable: Airbnb price.

To build the model, we kept used the log transformed price as the response variable due to our findings from the EDA above. The predictor variables we included in the model were the number of bedrooms, room type, review score ratings, and neighborhood. We decided to wanted to build a model that did not include the interaction between room type and number of bedrooms (this was the most obvious potential interaction effect from our EDA compared to the other ones we looked at), and then build a second model that included the interaction and see which one performed better before selecting our final model.

Evaluating the Models

To evaluate both models' performance, we decided to take a look at their R^2 and adjusted R^2 values to see which model had higher values.

Table 2: R Squared Values for Model Without Interaction

r.squared	adj.r.squared
0.393	0.393

Table 3: R Squared Values for Model With Interaction

r.squared	adj.r.squared
0.396	0.395

The model that includes the interaction effect between bedrooms and room type seems to perform slightly better, with higher R^2 and adjusted R^2 values of 0.396 and 0.395, respectively. To further validate this, we wanted to conducted a drop in deviance test to see if there was a difference between the two models' performance.

Table 4: Drop in Deviance Test

Res.Df	RSS	Df	Sum of Sq	Pr(>Chi)
9045	2038.054	NA	NA	NA
9042	2028.250	3	9.804	0

The results from the drop in deviance test also support this, as the p-value is less than the threshold, indicating that including the interaction effect is able to significantly improve the model's ability to explain variation in log price. As a result, we decided to select the model with the interaction effect as our final model.

We then fit our final model on the testing data to see how it performed and calculated the RMSE and R^2 values.

Table 5: Testing Data R Squared Values

r.squared	adj.r.squared
0.373	0.37

Table 6: Testing Data RMSE Value

.metric	.estimator	.estimate
rmse	standard	173.219

The model returns a final R^2 value of 0.373 and an RMSE value of 173.219, which show that the model has relatively low predictive power.

Table 7: VIF Values for Model With Interaction

Predictor	VIF
bedrooms	1.253
room_typeHotel room	6.497
room_typePrivate room	4.810
room_typeShared room	3.918
review_scores_rating	1.043
neighbourhood_group_cleansedBrooklyn	5.717
neighbourhood_group_cleansedManhattan	5.622
neighbourhood_group_cleansedQueens	4.089
neighbourhood_group_cleansedStaten Island	1.346

Predictor	VIF
bedrooms:room_typeHotel room	6.489
bedrooms:room_typePrivate room	4.566
bedrooms:room_typeShared room	3.909

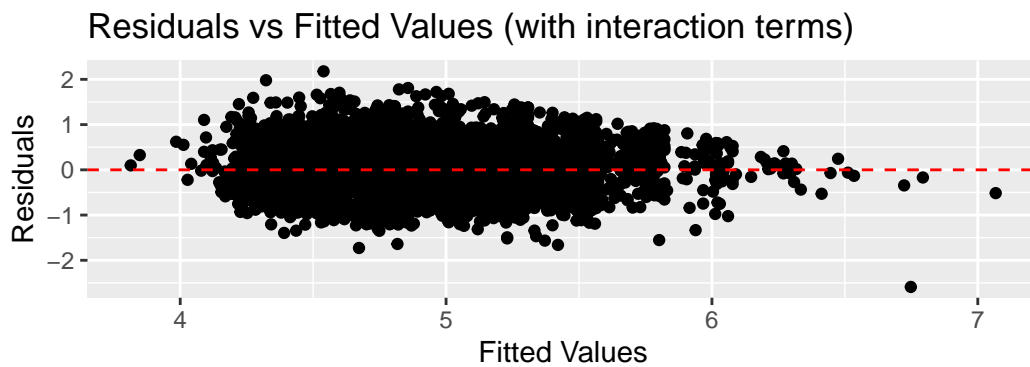
To assess multicollinearity, we calculated Variance Inflation Factors (VIFs) for both the two models. In the model without interaction terms, all predictors had VIF values below 6. The highest values were observed for the neighborhood dummy variables `neighbourhood_group_cleansedBrooklyn` ($VIF = 5.659$) and `neighbourhood_group_cleansedManhattan` ($VIF = 5.573$), indicating moderate multicollinearity, but still within acceptable limits. All other predictors had VIFs close to 1, suggesting low collinearity.

In the interaction-effects model, VIF values slightly increased, particularly for `room_typeHotel room` (6.497) and its interaction with `bedrooms` ($VIF = 6.489$). This is expected due to the inclusion of interaction terms, which can introduce redundancy and inflate variance when the interacting variables are correlated or when one category has relatively fewer observations. None of the predictors exceeded the common VIF threshold of 10, indicating that severe multicollinearity is not present in either model.

Results

After selecting the interaction effect model to be our final model, we checked model assumptions, diagnostics, and model fit statistics.

Assumption Check



According to the residual plot, the residuals are centered around 0, which suggests that linearity is satisfied. However, there is a mild violation of equal variance because there's a slight funnel

shape – residuals seem more spread out at lower fitted values and slightly tighter at higher fitted values.

We do not need to be concerned about data normality because our dataset has more than 10,000 data points, which is large enough ($n > 30$) to satisfy the normality assumption.

The independence is reasonably satisfied because each row in the dataset represents a distinct Airbnb listing, and the data is randomly collected. There is no indication of temporal or spatial autocorrelation, and there are no repeated measurements from the same listing.

Model Diagnostics

Table 8: Count of Observations by Cook’s Distance Threshold

Over 0.5	At or Below 0.5
0	9055

We used Cook’s Distance to assess whether any individual observations had an undue influence on the overall model fit. As shown in the table, none of the observations exceed the commonly used threshold of 0.5 for moderately influential points. This affirms that there are no overly influential data points in our dataset that disproportionately impact the model.

Model Fit Statistics

To evaluate how well our model explains variation in Airbnb listing prices, we compared two multiple linear regression models: one without and one with interaction terms between room type and number of bedrooms. The final model we chose is the model includes the interaction effects, which shows slightly better performance based on both the r-squared ($R^2 = 0.373$, $AdjR^2 = 0.370$). These values indicate that approximately 37.3% of the variability in log-transformed Airbnb prices is explained by our model, which includes predictors such as room type, number of bedrooms, neighborhood, review scores, and their interactions.

Table 9: Model With Interaction Term

term	estimate	std.error	statistic	p.value
(Intercept)	3.133	0.110	28.366	0.000
bedrooms	0.257	0.007	39.370	0.000
room_typeHotel room	0.288	0.211	1.367	0.172
room_typePrivate room	-0.331	0.022	-15.000	0.000
room_typeShared room	-0.783	0.143	-5.462	0.000

term	estimate	std.error	statistic	p.value
review_scores_rating	0.284	0.023	12.541	0.000
neighbourhood_group_cleansedBrooklyn	0.244	0.024	10.005	0.000
neighbourhood_group_cleansedManhattan	0.484	0.025	19.632	0.000
neighbourhood_group_cleansedQueens	0.080	0.026	3.113	0.002
neighbourhood_group_cleansedStaten Island	0.009	0.044	0.203	0.839
bedrooms:room_typeHotel room	0.076	0.193	0.392	0.695
bedrooms:room_typePrivate room	-0.104	0.017	-6.028	0.000
bedrooms:room_typeShared room	0.281	0.111	2.543	0.011

In our multiple linear regression model, we found that the number of bedrooms has a significant positive effect on price, with each additional bedroom multiplying the expected price by a factor of approximately $\exp(0.257)$ or around 1.29 on average for entire home listings. This effect varies depending on room type: in private rooms, the added value of an extra bedroom is reduced, with the factor becoming $\exp(0.257 - 0.104)$ or around 1.17, while in shared rooms, the effect is stronger, with the factor multiplying by $\exp(0.257 + 0.281)$ or around 1.71. Room type also independently influences price — private rooms and shared rooms multiply expected price by factors of $\exp(-0.331)$ or around 0.72 and 0.46 or $\exp(-0.783)$, respectively, compared to entire homes. Hotel rooms do not differ significantly in price. Review scores show a strong positive relationship with price, where a one point increase in rating multiplies the expected price by $\exp(0.288)$ or 1.33. Location effects are also evident: compared to the Bronx, listings in Manhattan, Brooklyn, and Queens multiply expected price by factors of $\exp(0.484)$ or 1.62, $\exp(0.244)$ or 1.28, and $\exp(0.080)$ or 1.08, respectively. Staten Island does not show a statistically significant difference from the Bronx.

Additionally, we conducted a drop-in-deviance test to validate the improvement from including the interaction terms. According to the results we got, the full model provides a statistically significant improvement in explaining the variability in the price because it has a p-value smaller than 0.001.

While the R^2 is moderately low, this is expected given the complexity and variability in Airbnb pricing. Other unobserved factors (such as amenities, host reputation, seasonal demand, or listing descriptions) likely contribute to price fluctuations and are not captured in this dataset.

Discussion + Conclusion

Overall, our analysis finds that Airbnb prices in NYC are significantly influenced by the number of bedrooms, room type, review scores, and neighborhood. The interaction between the number of bedrooms and room type improves the model fit and shows how the price increase per

bedroom is not constant across room types. Furthermore, the neighborhood in which an Airbnb is listed matters. Listings in Manhattan have the highest prices, followed by Brooklyn with other boroughs having lower prices on average. Review scores were also statistically significant in their positive effect on price.

The final regression model (with interaction) explains 37.3% of the variation in log-transformed prices ($R^2 = 0.373$), which is reasonable given the complexity of real-world pricing. All neighborhoods except Staten Island were statistically significant predictors ($p < 0.05$). Room type and bedroom count were both significant, including their interaction terms ($p < 0.05$). Review scores show a statistically significant but modest positive effect on price, multiplying prices by 1.33 on average for every 1-star increase, holding all else constant ($p < 0.05$). In terms of model diagnostics, the residuals showed mild heteroscedasticity but were generally centered around 0, and there were no serious issues with multicollinearity (VIFs all < 10). Furthermore, there were no overly influential observations once the outlier at \$20,000 was removed or points with problematic leverage.

Our analysis has several limitations. First, the model does not include other possibly influential variables, like availability of amenities, proximities to landmarks like the Empire State Building, and the number of bathrooms. Including these variables could help yield a higher R^2 value. Furthermore, the analysis excludes listings with fewer than 5 reviews and excludes one price outlier, which can bias estimates.

Our analysis also had some validity concerns. First, our results may not generalize to Airbnb listings in other cities, to long-term rentals, or to future time periods if market dynamic change. Furthermore, Inside Airbnb data is scraped from Airbnb's website and not directly from Airbnb, so there could be inconsistencies or missing listings. For example, many listings had no prices, but inputting a price is necessary to put up a listing on Airbnb.

Future work should include additional predictors like amenities (Wi-Fi, kitchen, pool, etc.), cancellation policies, host tenure, and photo quality of listings. Furthermore, a time series analysis of listing prices over different seasons and years can generate better insight into pricing dynamics. Finally, future work can examine whether price differences by neighborhood correlate with gentrification, displacement, or housing shortages.

- Barron, Kyle, Edward Kung, and Davide Proserpio. 2018. "The Sharing Economy and Housing Affordability: Evidence from Airbnb." *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.3006832>.
- Toader, Valentin, Adina Letiția Negrușă, Oana Ruxandra Bode, and Rozalia Veronica Rus. 2021. "Analysis of Price Determinants in the Case of Airbnb Listings." *Economic Research-Ekonomska Istraživanja* 35 (1): 2493–2509. <https://doi.org/10.1080/1331677x.2021.1962380>.
- Wang, Dan, and Juan L. Nicolau. 2017. "Price Determinants of Sharing Economy Based Accommodation Rental: A Study of Listings from 33 Cities on Airbnb.com." *International Journal of Hospitality Management* 62 (April): 120–31. <https://doi.org/10.1016/j.ijhm.2016.12.007>.