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# Assessing the Impact of Tourism on Housing Price Dynamics: Evidence from Hawaii Highlighting Directional Causality and Vacation Rentals

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*While writing this thesis, I have not witnessed any wrongdoing, nor have I personally violated any conditions of the Skidmore College Honor Code.*

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**Abstract**

Tourism has been shown to impact housing prices and residents' ability to afford housing in a host community as well as impacting several other aspects of host community. This study uses Hawaii as a case study to examine how tourism impacts housing price dynamics and whether there is different distribution of effects across the different islands due to tourism levels including an aspect about short-term rentals and housing prices. Compiled datasets spanning from 2000 to 2023 of monthly data and from 2019 to 2023 (short-term rentals) OLS and 2SLS regression methodologies were employed to analyze the relationship between tourism (using two proxies: tourist arrivals and tourism expenditure) and housing prices and short-term rental and housing prices along with some GIS mapping. The results of this study support previous literature regarding the extent of the relationship between tourism and housing prices being endogenous variables and tourism having a positive statistically significant relationship with housing prices. There are many limitations to this study with many opportunities to expand this field of research. This research can help to inform policies geared towards tourism and economic development of Hawaii and can be used to explore the economic well-being of local Hawaii residents.

## Introduction

Popular media is stating that Hawaii residents are being priced out of paradise as tourism is becoming more prevalent, housing costs and cost of necessities are on the rise residents are forced to reevaluate their finances and desire to live at 'home'. How is tourism numbers/development impacting the housing price dynamics using Hawaii as a case study and is the distribution of effects different depending on the level of tourism.

Tourism plays a significant role as an economic driver of the Hawaii economy, comprising the largest portion of GDP at around 24% (DBEDT, 2024). Despite being economically beneficial, the impact of tourism is multifaceted. Tourism can impact several aspects of a host economy including economic, social, cultural, and environmental dimensions. The relationship between tourism and a host community is complex with both negative and positive externalities and the occurrence of tourism affecting residents' ability to afford housing.

The purpose of this paper is to investigate the impact of tourism on housing prices in Hawaii to see if there are uneven distribution effects across the islands and to analyze vacation rentals for distribution and impacts of short-term rentals (STRs) on housing prices. Analysis employed both OLS and 2SLS regressions as techniques to investigate the relationship between tourism, through two proxies: tourist arrivals and tourism expenditure, and housing prices as well as the differences across the four counties of Hawaii. OLS as well as some Geographic information systems (GIS) mapping analysis techniques are also used to explore the relationship between short-term rentals and housing prices and the distribution of short-term rental units supplied. Through analyzing the relationship between tourism and housing prices, I can partially be informed of the economic well-being of residents as the price of housing in the forms of buying a house and renting are large financial burdens for Hawaii residents and incomes of residents may not be able to cover all necessary costs of living. The findings aim to inform tourism planning policies and sustainable tourism development to mitigate the negative impacts on housing affordability for local residents in Hawaii.

## Literature Review

### *Tourism*

Tourism plays a significant role in the global economy, it is a form of trade, an export, where goods and services are bought and sold. This allows it to provide economic opportunities and cultural exchanges to host communities. However, the impact of tourism on these host communities extends beyond economic benefits, encompassing environmental, cultural, historical, and societal dimensions. As tourism is not limited to the accommodation and hospitality sector, transportation, and entertainment sectors with visitor attractions, but it is integrated into the larger economy. A host community in this paper refers to the area in which visitors come to stay and experience where people are directly and indirectly impacted in some way by visitor activities, this includes the people and the physical environment incorporated in a space.

It is acknowledged that tourism can be defined differently by different people and the industry can be composed of a variety of different sectors within an economy depending on where that economy is located. The World Trade Organization (WTO) defines tourism as "the activities of persons traveling to and staying in places outside their usual environment for no more than one consecutive year for leisure, business, and other purposes" (WTO, 1995 as cited by Zaei & Zaei, 2013). Zaei and Zaei defines tourism as a “set of socioeconomic activities carried out either by or for tourists” and this definition will be used as the basis of tourism in this paper. This paper will use tourists and visitors interchangeably and also loosely follow the definition provided by the Hawaiian Tourism Authority (HTA) which defines a visitor as an “out-of-state traveler who stays in Hawaii for at least one night but less than one year”, not including returning residents, intended residents, or in-transit passengers (HTA, 2024). There are many different tourism terms like heritage tourism, medical tourism, volunteer tourism, and so much more that correspond to different activities/reasons a tourist visits a certain area/place (Cunha, 2012). Tourism in Hawaii caters to a variety of these types of tourism with its beautiful environment, culturally rich history, and its location for both domestic and international visitors. Hawaii, especially Oahu, is increasingly experiencing gentrification particularly tourism gentrification becoming a “playground for the rich” (Menina, 2021).

The term tourism gentrification was first used by Gotham (2005, as cited by Wang et al., 2022) and he defined the term as the "process of changing the areas from middle-class neighborhoods to wealthy and exclusive places driven by the development of tourism and entertainment" (Wang et al., 2022). In terms of this research, the definition that will be used is the 'social changes that place undergoes because of tourists or tourist-oriented service pressures leading to the displacement of residents.' This displacement can come in two forms direct and indirect displacement. Direct displacement refers to the outmigration of residents from the neighborhood and indirect displacement describes the longer process of low-income residents finding it increasingly difficult to remain in the area and the feeling of 'loss of place' (Gravari-Barbas, 2020). Past literature has found the drivers of tourism gentrification as: globalization, regional integration, promotion of favorable policies and real estate development, individual tastes and preferences, and capital investment (Wang et al., 2022). Wang et al. (2022) also highlights the findings regarding the impact of tourism gentrification being the transformation of city functions, advancements in tourism development, and changes in social spaces.

***Tourism impact on a host community***

The impact of tourism on host communities is a complex topic that has been increasingly studied in recent years. One recent study by Brooks et al. (2023) provides a systematic review assessing the impact of heritage tourism on sustainable community development, as well as the health and wellbeing of local communities. Heritage tourism is the type of cultural tourism where the person is traveling to experience the places, artifacts, and activities that authentically represent the stories and (past) people of that place (de la Calle Vaquero & García-Hernandez, 2024). Brooks et al. find that heritage tourism has both positive and negative impacts on social determinants of the health/well-being of a host community. The positive impacts include economic gains, improved services, preservation of cultural values and traditions, employment opportunities, greater financial security, and environmental conservation. All the impact categories (social, cultural, economic, and ecological) depend on community participation because as Brooks et al. highlight if there are high levels of community participation the impacts are perceived more positively while low levels can lead to the opposite being true making the impacts negative. Examples of the negative impacts that tourism can bring include are

displacement, increased crime, overcrowding, cultural dilution or commodification, increased cost of living, reliance on tourism income, pollution, and environmental damage (Brooks et al., 2023). The review provided a conclusion that tourism can be used as a poverty-reducing strategy, however the studies that were analyzed are mostly using the assumption that uses economic benefits as a proxy for other determinants in society like cultural, social, and environmental. Because of this there needs to be more studies exploring cultural well-being over time incorporating qualitative data. Despite some of the missing aspects in the literature, Brooks et al. does state that "more than half of the negative consequences" could be mitigated with policy guidance, protocols, and the inclusion of the local community (Brooks et al. 2023).

As Brooks et al. (2023) shows there is a wide range of studies that document the positive and negative effects of tourism on the economic, social, cultural, and environmental well-being, Kim et al. (2013) also observed this at an earlier time but attempted to test a theoretical model linking community perceptions and satisfaction of their lives in each category. They did this through surveys sent out, which found that tourism has a perceived positive relationship with social, material, and emotional well-being impacts but a negative relationship is seen with the perception of tourism impact on environmental impact in association with community health and safety. Answers to the questions posed by Kim et al. (2013) are important because they can help guide successful planning policies in tourism development. Zaei and Zaei (2013) also reviewed the impacts of the tourism sector on a host communities' economy, environment, politics, and socio-cultural being. They conclude the level of development of a community can contribute the uneven distribution of benefits/effects which threatens the sustainability of tourism in developing countries. Despite the benefits and gains that have be realized to be associated with the tourism sector, there has been increasing studies that focus attention on the negative impacts associated with tourism development. Thullah and Jalloh (2021) feature that tourism development has led to socio-cultural problems, including congestion, soaring crime rates, resentment, and conflicts in host communities. On the environmental front, tourism has created problems for production and consumption resource availability, as well as increasing carbon emissions, ecological disturbances, and waste management problems. The environmental problems depend on the type and scale of tourism and the level of environmental awareness of inbound tourists. These studies provide an overview of the effects of tourism on communities and the economy of the host

countries studied but only state observable facts and do not investigate this impact further, empirically which this paper strives to do.

Hawaii serves as an insightful case study to examine the impact of tourism on host communities due to its heavy reliance on the tourism industry. There have been a handful of studies that concentrate on Hawaii as a case study. These studies in Hawaii support the findings of those abroad, one study by Darowski et al. (2007) acknowledges that tourism is a large part of the economy in Hawaii but highlights that the economic growth it provides cannot be sustained if it remains the way it is, as the tourism industry places tremendous pressure on the local environment and culture (Mak, 2003; Ghali, 1976). Hawaii is home to a rich cultural history and those of Native Hawaiian descent have a special connection with their ancestral land, meaning that particular tourism activities can have negative socio-cultural impacts (Kanaʻiaupuni & Malone, 2006; Cohen, 1978). The damaging effects found by Brooks et al. (2023) ring true for Hawaii as locals face immense challenges with limited access to culturally significant lands, high cost of living, and increased outmigration (Matsuoka & Kelly, 1988). Due to the limited number of quantitative studies examining tourism and tourism development impact on the well-being of Hawaii residents and community over time housing and rental prices will be used as a proxy to analyze these effects. This study will be different from these previous studies about Hawaii in a couple of ways, (1) this is an empirical paper analyzing the relationship between tourism development and housing prices which can be used to assume well-being of residents and (2) this study also includes how the new development of short-term rentals (like Airbnb) can have on this relationship.

### *Tourism and housing prices*

Housing prices are a helpful agent to provide an idea of the economic well-being of the community because the United States is currently experiencing a housing affordability crisis nationally with over half of renter households spending more than 30 percent of their incomes on rent and utilities (Airgood-Obrycki et al., 2023). There have been multiple studies critiquing how housing prices have increased while working-class incomes have not (Shamsuddin & Campbell, 2022), and traditional measures underestimate the hardships renter households face as other non-housing expenses are not considered. With the US housing affordability crisis there are serious

implications for the stability and well-being of households with almost half of renters facing a material hardship at some point in the last 12 months of when the study was conducted. The standard method for assessing housing affordability of using a maximum of 30 percent of an individual's income towards rent fails to account for the non-housing needs and differences among income groups and with housing being the biggest expenditure for most households often leaves there being little money left to cover basic needs. Airgood-Obrycki et al. (2023) used a residual income approach and found that there are aggregate affordability gaps, and the most cost-burdened households also have a residual-income tax burden. It is also found that on average a renter household needs more than $40,000 to cover their non-housing necessary expenses alone and the race and nativity of the householder are significantly associated with greater burdens (Blacks are 1.2 times more likely to have cost burdens and Hispanics having 1.1 times more compared to whites). This is particularly crucial to note as the per capita income in Hawaii is $42,683 and the median household income is $94,814 with an average of nearly three people per a household (see U.S. Census Bureau, 2022).

There has been a recent shift in the literature from studies about tourism and its impacts on host communities towards an increasing interest in observing the relationship between tourism and housing prices/affordability. This shift is prevalent after the 2010s with many being published in the last couple years. Biagi et al. (2012, as cited by Cró & Martins, 2023) suggest that there are two main strands of literature surrounding the topic of tourism that analyze the impact of tourist activities on the housing market due to studies being limited in number. These two main strands being hedonic prices and holiday homes. Literature surrounding hedonic prices is often microeconomic in nature focusing on the impact of tourist activities on the housing market by running regressions between individual property prices and series of explanatory variables. There are few past studies exploring an in-depth relationship between local housing markets and holiday homes, as one of the tough challenges for researchers in this area is the lack of consistent data collection across countries and cities.

Many of the earlier studies related to the hedonic price (homes with more access to tourism activities may come at a premium) strand of literature are authored by Biagi and others (2012; 2015; 2016). Biagi et al. (2012) uses the hedonic pricing method (HMP) and ordinary least squares (OLS) methodology to estimate the total impact of the tourism sector on the housing market and examine how demand for holiday homes can affect the functioning of local

housing markets. Studies in this topic employ a wide variety of economic models to analyze the data available, the available data is often inconsistent across study sites making it difficult to analyze multiple locations within the same study and compare across locations at once. Biagi et al. (2015; 2016) also employed the generalized method of moments (GMM) approach and the laten class approach, all of which concluded that tourism has a positive and statistically significant effect on housing prices to some degree but suggest that the relationship may not be the same for all cities with evidence from Italy.

Other previous studies exploring this topic concur with the findings of Biagi et al. (2012; 2015; 2016) while utilizing different methodologies. A study Mikulić et al. (2021) on the effect of tourism activity on housing affordability resulted in the findings that tourism has negative effects on housing affordability by employing a two-step system GMM model on data from Croatia. This study suggests that tourism has a significant impact on local residents' ability to purchase real estate, due to the relation between population income levels and housing prices, and has strong seasonal impact indicating negative externalities. This means that Mikulić et al. (2021) found that with an increase of tourism resident's ability to afford housing decreases which coincides with other studies that find tourism increases housing prices. Zhang and Yang (2021) and Peric (2022) both found that higher inbound tourism demand raises both house prices and rental prices. Churchill et al. (2022) explores the time-varying effect of tourism flows on housing prices and finds that overall, there is a time-varying effect, with mixed impacts but after 2000 is when they saw a consistent significant positive relationship between the two.

Among the literature looking at tourism activities and housing prices there is a limited number of those studying the causal relationship between the two, this aspect of which should be explored further. Yildirim and Karul (2022) found that international tourism has a substantial role in the increase in house prices in Turkey with causality tests. Building off this previous literature Cró and Martins (2023) controlled for determinants outlined by Wu (2019) and Yildirim and Karul (2022) for the direction of causality between the two variables (tourism and housing prices) in eight countries heavily dependent on tourism. They employed several econometric models in their study: vector error-correction model (VECM), granger causality model, vector autoregression model (VAR), and ordinary least squares (OLS) methodology. Through cointegration tests they find that the series is cointegrated. They conclude that tourists' activities have a positive impact on housing prices in the long-run and short-run and find bi-directional

causality in three countries and tourism-leading causality in the remaining five countries examined. Their findings highlight that a 10% increase in tourism receipts would increase house prices between 3.75% and 1.97% in long run and 3.23% and 1.31% in short run, on average (Cró & Martins, 2023). Wu (2019) supports these findings of a bi-directional causal relationship between some of their explanatory variables. Studies suggest that impact varies at different levels of tourism specialization as it varies from tourist to non-tourist cities (Cong Abdul Samad, 2023; and Zhang, 2023).

In addition to the literature examining the impact of tourist activities on housing prices there are some newer studies doing more in-depth examinations looking at the effect of tourism development on housing prices. A study by Song et al. (2023) findings indicate that tourism development also increases urban housing prices, with the effect coming more from domestic tourism rather than international tourism. Zhang (2023) also examined the interplay between tourism development and housing prices using a panel smooth transition regression approach and found there to be a nonlinear tourism-housing price nexus using evidence from China. A nonlinear tourism housing price nexus means that there is a positive correlation between the two which is consistent with other studies, all of which demonstrated that the growth of tourism industry contributes to the escalation of housing prices. As Song et al. (2023) highlights there are few studies on the mechanism and heterogeneity of tourism affecting housing prices and existing literature has some differencing conclusions with many finding that tourism does have a positive statistically significant impact on housing prices and one study by Pashardes and Savva (2009, as cited by Song et al. 2023) found that tourism had basically no effect at all while studying the factors affecting housing prices in Cyprus. Song et al. (2023) proposes two main reasons for these different conclusions in the existing research (1) “there are differences in the mechanisms of tourism’s effect on housing prices” but all result in tourism having a negative impact on housing prices (increased tourism = higher housing prices) and (2) “tourism’s effect on housing prices is heterogeneous” as there are various factors that influence tourism’s effect on housing prices including the development stage and type, and intensity of tourism in the area. It can be concluded that much of the previous literature primarily corresponds to each other with that there is a relationship present between tourism activities and housing prices/affordability.

The few past studies looking into holiday homes demonstrate that an increase in demand for holiday homes places pressure on local housing markets. This causes a conflict between

residents and tourists to arise because residents are unable to live in places where there is high tourist attractiveness due to rising housing prices and property taxes (Cró & Martins, 2023). Literature that focuses on this specific topic of the relationship between tourism and the housing market in Hawaii are either survey based or anthropologically focused through observations. There are few studies done specifically in Hawaii, none of which are empirical economic papers. In recent year there have been reports done by the government of Hawaii and the University of Hawaii Economic Research Organization (UHERO), but these reports fail to examine the variability over time as they focus mainly on changes in a singular year. With the nature of these reports the analysis included in them overlooks the compounding effects and the time-varying impacts.

One of these previous studies is conducted by Park and Agrusa (2020) who surveyed 20 respondents across the island of Oahu (Honolulu County) to gain an understanding of influence of short-term rentals (STRs) or vacation rentals on residents of the community in which the STR is located. They found that the negative impacts of STRs that are seen worldwide are also seen in Hawaii and that the costs that STRs bring outweigh the benefits of the profits and tourism revenue seen, and if there are profits there are no guarantees that that inflow of money is going to local residents as many owners are corporations or out-of-state individuals. This is due to the lack of housing and rising rental rates worsened by the increase of STRs, furthering the housing crisis in Hawaii. Some of the impact that respondents mention are undesirable changes to community, unruly tourist behavior increased traffic, crowding, and others. There are policies in place to manage STRs but many 'hosts' evade this issue by having illegal rentals as permits are needed (0.03% of rentals are legal in Maui). The impacts are also not dispersed among island residents as STRs are densely concentrated in specific communities. According to the Hawaii Tourism Authority (HTA)'s Resident Sentiment Survey the sentiment towards the growth of Hawaii's tourism is eroding in present years compared to past years, and there has been outmigration of the population due to the increased tourism (Park & Agrusa, 2020). The main problems attributed with the negative impacts of STRs in Hawaii highlighted by Park and Agrusa (2020) are the lack of management, insufficient infrastructure, lack of enforcement, and advertisement strategies employed by STR and tourism companies. The impacts are realized with the decreased sense of security/safety for a community, the behavior of visitors, ecological

damage, and the price of rentals increasing causing outmigration of residents which then allow more accommodation to replace those community members lost.

Building off of what has been done in previous literature this paper will observe the impact of tourism/visitors on housing prices in Hawaii which will be broken down and analysis will be run on these separated counties to see if there are uneven distribution of effects across the islands. Causality tests, specifically the granger causality test will be employed to look at the direction of the causal relationship of the two variables. This is because the past literature examining causality, use this method (Cró & Martins, 2023; Wu, 2019; Yıldırım & Karul, 2021). The granger causality test is a popular tool for analyzing time series data that is based on prediction and is used as a method to infer causal relationships from data to see if one time series can be useful in forecasting another (Seth, 2007; Shojaie & Fox, 2022). In addition to basic causality analysis will also include aspects about short-term rentals (STRs) or holiday homes to combine the two strands of literature highlighted by Biagi et al. (2012). With this aspect of STRs it allows this paper to look more in-depth at the uneven distribution of effects that comes with tourism and tourism development due to the differences in concentration of listings.

## Empirical Strategy

### *Methodology and theory*

This paper strived to analyze the impact of tourism and tourism development on housing prices. Housing prices can help us to indicate the economic well-being of residents as we can see how much income is remaining to afford the cost of living in the relative location. The study by Mikulić et al. (2021) highlighted the need for studies to include housing affordability in relation to the population's income levels. Housing price dynamics can reflect the changing economic state of the area and the resident's economic capability when it comes to being able to live a particular area. In order, to observe the causality of the two main variables of tourism and housing prices ordinary least squares (OLS) regression methodology will be employed. It was expected that the relationship between housing prices and tourism is positive and non-linear and log functions were needed in the regression model to provide a better fit of distribution. The

granger causality test will also be employed following similar methods to those utilized by Cró and Martins (2023), to determine the direction of causality in Hawaii's tourism and housing market relationship Based on results found by Cró and Martins (2023), it is hypothesized there will be a positive tourism-leading causality for Hawaii. In addition to this, following methodology similar to Yang et al. (2021), a non-linear fixed effects regression model will be applied to illustrate the association with the monthly sample of panel data of Hawaii from 2000 to 2023. This study reported that the impact of tourism on house prices becomes positive and significant once a threshold point of economic growth is passed, illustrating that tourism increases house prices.

This paper also strived to analyze vacation rental data for the distribution and change of unit supply to reflect the conversion of residential housing into rental housing for tourism. Theory from Mikulić et al. (2021) suggests that by converting residential housing into tourist rental housing would impact the overall housing supply in the market for residents therefore leading to an increase in overall housing prices overall. This is additionally supported by the rent gap theory first developed by geographer Neil Smith in 1979 but more specifically tourism-led rent gap theory developed by Cheung and Yiu (2022) can help to explain this phenomenon. Cheung and Yiu (2022) hypothesized that given all other conditions remaining the same, tourism can: (1) create new potential base rents (positive externalities) due to new amenities provided with tourism, or (2) can lead to a negative rent gap (negative externalities), which can help to imply residents revealed preferences of tourism. To examine this geographic information system (GIS) methodology was employed, to illustrate the density Airbnb listings across Hawaii.

***Data***

To study the relationship between house prices and tourism, data was collected for the city and counties of Hawaii. Monthly data was collected for the main dependent and independent variables. The sample period has been decided based on data availability for the measures of visitor/tourism arrivals, housing prices, and control variables, with the exclusion of some months sue to missing values. Tourism is measured with two proxies to represent tourism development: total tourism arrivals and total tourism expenditures or receipts measured in millions of dollars following Yang et al. (2022).

Counties for Hawaii consist of either individual islands or a group of islands nearby each other depending on governmental classifications. In Hawaii there are four individual counties. These are the Hawaii County, Maui County, Honolulu County and Kauai County. Hawaii is most prominently known for having eight main islands: Hawai‘i, Maui, O‘ahu, Kaua‘i, Lana‘i, Kaho‘olawe, Molokai, and Ni‘ihau which are broken up amongst the four counties (refer to Figure 1). Hawai‘i and Honolulu County are made up of individual islands Hawai‘i and O‘ahu respectively. Maui county consists of the majority of the islands Maui, Lana‘i, Molokai, and Kaho‘olawe the latter being uninhabited. Kaua‘i county includes Kaua‘i and Ni‘ihau. Ni‘ihau and Kaho‘olawe are both not included in this paper as the purpose of this study is to examine tourism and housing prices and tourists and outside visitors are not allowed due to cultural and safety reasons unless approved by governing bodies.

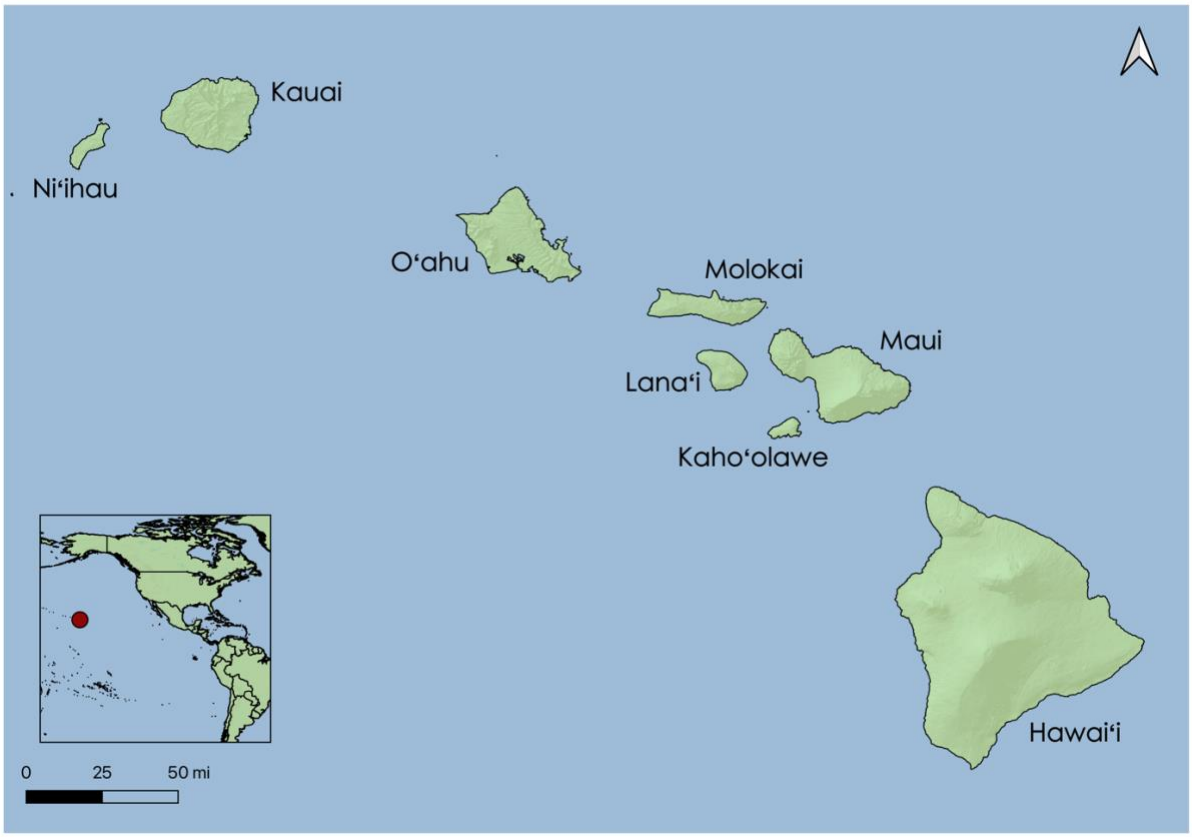


**Figure 1:** Map of main Hawaiian Islands labeled respectively.

*Dependent variable*

Housing prices (HP) for cities and counties in Hawaii is the dependent variable in this study. The data for the typical home value for the region/area was obtained from Zillow (2024). Data is called the Zillow Home Value index (ZHVI) and provides monthly representation of the middle tier ($35^{th}$ to $65^{th}$ percentile range) of the housing market for all homes in the area and is smoothed and seasonally adjusted. Zillow has designed the ZHVI to "capture the value of a typical property across the nation or neighborhood, not just the homes that are sold" but drawing information from the full distribution of homes in the area. This monthly data it shows the level and appreciation of home values across time, geographies, and housing type.

*Independent variable(s)*

Tourism/visitor arrivals and tourist expenditure (TOURARR and TOUREXP) are used as the two proxies for tourism development (Yang et al., 2021), each included in separate equation models from each other, as the independent and explanatory variables, in order to compare the results with each other. Data for these variables was collected for each island by months from visitor statistics by the Department of Business, Economic Development & Tourism run by the Hawaii state government (DBEDT, 2024). Data was reorganized to match the format of Zillow's ZHVI data and as data was only per island, so data was matched with their respective city and counties in the ZHVI data and repeated as necessary for the requirements of the model. Data for visitor arrivals will only include air arrivals and exclude cruise ship arrivals to the islands. Tourism expenditure/receipts data is measure in millions of U.S. dollars ($).

*Vacation (STR) Rentals*

Data on vacation rental listings was collected from Inside Airbnb (2024). Inside Airbnb scrapes publicly available information about listings from Airbnb directly. The dataset is comprised of 34,040 individual listings dispersed across Hawaii. It also includes data about where a host is from, the neighborhood (location) of the listing, number of listings of individual hosts, property type, average length of stay, price, etc. The exact location information for listings is anonymized by Airbnb, this means that in practice the location (the given coordinates) on a map of a listing will be within 0-450 feet (150 meters) of the actual address; due to this the listings available in the data may appear "scattered" in the area surrounding the actual address.

Airbnb and vacation rentals did not become a prominent tourist lodging until the later 2010s, with additional monthly data about the unit supply, unit demand, and occupancy rates available after 2018. This data was obtained from the Hawaii tourism authority (HTA), organized by monthly frequency and by island and major tourism areas per island. Data by month was collected for 2019 to 2023. This data will be used in conjunction with data from UHERO (2024) on available housing units and average housing prices by county obtained from the Zillow dataset.

*Additional (control) variables*

Unemployment rate will be included as a variable to represent the local labor market, as used by Mikulić et al. (2021). It is measured as share of unemployed persons per city and county represented as a percentage (%). Per capital personal income is to be used in place of per capita GDP in this study as there was not enough observations available for the time periods this study observes. Per capita GDP is used by Cró and Martins (2023) as a control variable as they found this used as a control variable in nine previous studies looking at the relationship between housing prices and tourism. Per capita income is used by Biagi et al. (2012) to help to control for populations' ability to afford housing. They recognized the fact that increasing housing demand by tourists (as rental housing) puts pressure on the local housing market leaving residents having problems affording the limited housing supply left in the market for them, which is also accentuated when there is a low per capita income. Inflation rate and population are included as variable in this model, following Yang et al. (2021) as these variables were considered two of the "potential variables that affect the tourism and house prices association" (Wong et al., 2019; Tu et al., 2018; as cited by Yang et al., 2021) and resulted in both variables showing to have a positive and significant effect on house prices.

Data for unemployment rate (EMPLOYR) and per capital personal income (INCOME) variables obtained from the Economic Data Warehouse also by the Department of Business, Economic Development & Tourism run by the Hawaii state government (2024). Data for inflation rate (INFLATION) and population density (PopD) was obtained from the Economic Research Organization at the University of Hawaii (UHERO) database (2024) where it has been compiled from the U.S. census, the U.S. Dept. of Labor, Bureau of Labor Statistics and other

various sources. Inflation rate is measured for the State of Hawaii in this dataset and any missing variables were interpolated by UHERO.

***Analytical Framework***

For the relationship between housing prices and tourism the basic OLS regression models used are outlined below:

**Model 1:**

$$HP_{it} = \beta_0 + \beta_1 TOUR_{it} + \beta_2 INCOME_{it} + \beta_3 INFLATION_{it} + \beta_4 EMPLOYR_{it} + \beta_5 PopD_{it} + \varepsilon_{it}$$

where $i = 1,2,\ldots,N$ denotes the number of number of cross-sections (city and county) and $t = 1,2,\ldots,N$ denotes the time dimentions of the study, in this case monthly data (2000 to 2023). $HP_{it}$ is the housing prices measure in dollars ($); $TOUR_{it}$ represents the variable for tourism which will be measured through the two proxies mentioned earlier $TOURARR_{it}$ being the tourist arrivals by air only and $TOUREX_{it}$is tourism expenditure/receipts in millions of dollars ($) these two proxies will be interchanged respectively in the equations to see if both could be used with similar results. $INCOME_{it}$ is the per capita personal income of residents ($); $INFLATION_{it}$ is the inflation rate (%); $EMPLOYR_{it}$ is the unemployment rate (%); $PopD_{it}$ is the population density; and $\varepsilon_{it}$ is the error term.

Multiple steps were taken to analyze this data, first the linearity of this model was checked to see if additional models and regressions were needed. Nonlinear panel regressions we run next with log functions placed in the code to help with a better fit of distribution as there are different measures of dollars used between housing prices and tourism expenditure. Relationships were found to be non-linear. Multicollinearity and endogeneity checks were both employed. STATA software was used for this study with the collected data. Since the data collected was panel data, the Hausman's test was used and fixed effects were chosen.

It was hypothesized that there will be an endogeneity issue between the tourism proxies and housing prices as found with previous literature (Song et al. 2023). With employed

endogeneity test it was found that variables housing prices and tourism are endogenous, to correct for this two time lagged variables ($t-1$ and $t-2$) of tourism are used as instruments, illustrated below in the corrected model. Due to endogeneity a 2sls model will be used for the continuation of this study and results following the corrected model with both tourism proxies.

**Corrected model 1:**

$$HP_{it} = \beta_0 + \beta_1 TOUR_{it-1} + \beta_2 TOUR_{it-2} + \beta_3 INCOME_{it} + \beta_4 INFLATION_{it} + \beta_5 EMPLOYR_{it} + \beta_6 PopD_{it} + \varepsilon_{it}$$

$TOUR_{it-1}$ represents the variable for tourism lagged by one year, and $TOUR_{it-2}$ is the tourism variable lagged by two years as the instruments to correct for endogeneity.

***Short-term rentals***

**Model 2:**

$$HP_{it} = \beta_0 + \beta_1 Rsup_{it} + \beta_2 Occup_{it} + \beta_3 HU_{it} + \varepsilon_{it}$$

where $i = 1,2,\ldots,N$ denotes the number of number of countes there are (4 different counties as outlined before) and $t = 1,2,\ldots,N$ denotes the time dimentions of the study, in this case monthly data (2019 to 2023). $HP_{it}$ is the housing prices measure in dollars ($); $Rsup_{it}$ represents the variable for short-term rental supply. $Occup_{it}$ is the occupancy rate of supplied units (%); $HU_{it}$ is the total available housing units in the respective county; and $\varepsilon_{it}$ is the error term.

The linearity of this model was checked to see if additional models and regressions were needed. Nonlinear panel regressions we run next with log functions placed in the code to help with a better fit of distribution as there are different measures of variables used between housing prices, rental supply, and control variables. Multicollinearity and endogeneity checks were both employed. Variables were found to be exogenous, and relationship was non-linear. The data collected was panel data, the Hausman's test was run and random effects were chosen for short-term rentals due to the smaller observation size.

The mapping component of this study utilized the longitude and latitude provided by the Inside Airbnb dataset which was input into a GIS software QGIS. Data was used to map the

relative location and density of the vacation rental listings, specifically Airbnb provided rentals, in neighborhoods using the create points using table tool.-This mapped data was used in accompaniment with the OLS regression output to observe and describe the relationship between these listed vacation (STR) rentals and change in housing prices overtime to inform discussion of the relationship between the two (housing prices and short-term/holiday homes).

## Data analysis and discussion of results

### *Descriptive Statistics*

The first codes that were applied to these datasets were descriptive statistics, to explain the basic features of the data collected and compiled. The results of descriptive statistics of tourism development and housing prices can be seen in Table 1 of the appendix. For majority of the variables there are 22,464 observations with housing prices being the limiting variable of this study at 16,272. There was a mean cost of $529,225.04 for the price of a housing unit with a range from $97,354.72 to $2,414,121.31 across the state of Hawaii. Tourists' arrivals had a mean of 212,022.95 people with a range of 21.28 to 598,985.88 people per month. Tourism expenditure had a mean of $308.05 measured in millions of dollars with a range between $0.62 and $885.14. The results of descriptive statistics of short-term rentals (STR) and housing prices can be seen in Table 9 of the appendix. In this dataset there was a total of 240 observations for all variables. The values for housing prices were taken as averages per county from the previous dataset resulting in slightly different values with the mean being $733,993.51 (±193931.28). The short-term rentals supplied per county has a mean of 163,860.06 units with a range of 26,395 units to 323,332 units supplied and a mean occupancy rate of 58% meaning the number of units supplied that were actually occupied in each month.

### *Regression Models*

#### *1. Tourism and housing prices*

OLS linear and non-linear regressions were run following the regression model 1 and output of results are shown in Table 2 of the appendix. OLS regressions (1-3) are the results using tourist arrivals as the proxy of tourism whereas regressions (4-6) are the results using tourism expenditure as the proxy of tourism. Both linear and non-linear OLS regressions were run to capture the nature of the relationship between tourism and housing prices. Regressions (2) and (5) in table 2, are linear with log functions of housing prices and the respective tourism variable to show a better fit of distribution Regressions (1) and (4) are nonlinear OLS regressions were modified by adding the squared value of the respective tourism variable into the model. Regressions (2) and (5) in table 2, are linear with log functions of housing prices and the respective tourism variable to show a better fit of distribution. Regressions (3) and (6) in table 2, follow the two regression models stated above but with log functions of housing prices and the respective tourism variable to show a better fit of distribution. It can be seen in table 2, that tourism when measured with both tourism proxies tourist arrivals and tourism expenditure/receipts, tourism has a positive and significant relationship with housing prices. The majority of the variable output are displayed at a level of 99% confidence meaning that there is a significant p-value of less than 0.01, with the exception of unemployment rate in both the tourism expenditure regressions. Regression output of the regression models (2) and (5) from table 2 are found to not have any significant linear relationship between independent variables included the models as VIF values are less than 5 for all variables in both models (Table 3 and 4).

Due to tourism and housing prices being endogenous 2SLS regressions were run following the corrected regression model 1 and output of results are shown in Tables 6 to 8 of the appendix. Table 6 displays the results of linear 2SLS regressions; Table 7 displays the linear log 2SLS regressions; and Table 8 displays non-linear and non-linear log 2SLS results which will be focused on in this discussion. All variables but one (population density in regression 4) of the variable output are displayed at a level of 99% confidence meaning that there is a significant p-value of less than 0.01, this means that all important variables analyzed are significant and worth noting. For tourist arrivals when not using a log function in the equation there is a positive significant relationship with housing prices (3.87) whereas when there is a log function in the equation there is a negative significant relationship with housing prices (-1.29). For tourism expenditure there is a positive significant relationship with housing prices (1697.39 and 0.83) in

both non-linear regressions. These results are further shown in figures 3 through 6 in the appendix, figures 3 and 4 show tourist arrivals and figures 5 and 6 show tourism expenditure. Focusing on the two non-linear predictions of the relationship between tourism and housing prices (Figures 4 and 6), we can see opposite trends. In figure 4 we can see that there is a minima meaning that as there are more tourists coming there is an increase in housing prices initially but there reaches a point where the trend reverses and an increase leads to a decrease in housing prices. This could imply that there is a balance that can be made where there is a limit to tourist arrivals in order to balance out resident's ability to afford housing. In contrast, figure 5 has a maxima for tourist expenditure, analyzing this while keeping in mind the tourist arrivals data one could infer that although there are increased tourist arrivals these tourists may be spending less on average. Overall tourism as a whole has a significant positive impact on housing prices in all counties of Hawaii which supports previous literature that found similar results (tourism increasing housing prices, with a positive statistically significant relationship) in other areas of the world (Cró and Martins, 2023; Mikulić et al., 2021; Peric, 2022; Song et al, 2023; Wu, 2019; Yildirim and Karul, 2022; Zhang and Yang, 2021; Zhang, 2023).

### *2.1 Short-term rentals (STR) and housing prices*

OLS linear and non-linear regressions were run following the regression model 2 and output of results are shown in Table 10 of the appendix. Linear and non-linear OLS regressions were run to capture the nature of the relationship between STRs and housing prices. It can be seen in table 10, that STRs and housing prices have a slightly negative significant relationship, there are no significant linear relationships between independent variables included the models as VIF values are less than 5 for all variables in both models (Tables 11 and 12), and variables are exogenous. These results are further shown in figures 7 and 8 in the appendix, the linear prediction of STRs supplied with housing prices differs by county with Hawaii, Honolulu, and Kauai having a slightly positive relationship meaning that with increased STRs supplied housing prices increase. For Maui County this relationship is negative, but this could be due to extenuating circumstances as there were three months in 2023 where there were zero STR units supplied due to them being reserved for families who were displaced due to the Lahaina wildfires. Figure 8 shows similar trends to tourism expenditure and housing prices with a maxima for all counties except Honolulu county where the trend remains a positive linear

relationship. This relationship is hypothesized to be positive meaning with an increase of STRs available there is an increase of housing prices, but these results contradict this. These results may be misleading as this regression is simple and more variables may be needed to get an accurate picture of the relationship.

### *2.2 STR GIS Mapping*

Shown in Figure 2 below it can be seen that the majority of Airbnb rental listings are concentrated along the coasts of each of the islands with higher concentrations seen in certain areas over others. The islands of O‘ahu and Hawai‘i having the greatest number of listings and Molokai having the smallest number of lisings compared to the other islands.

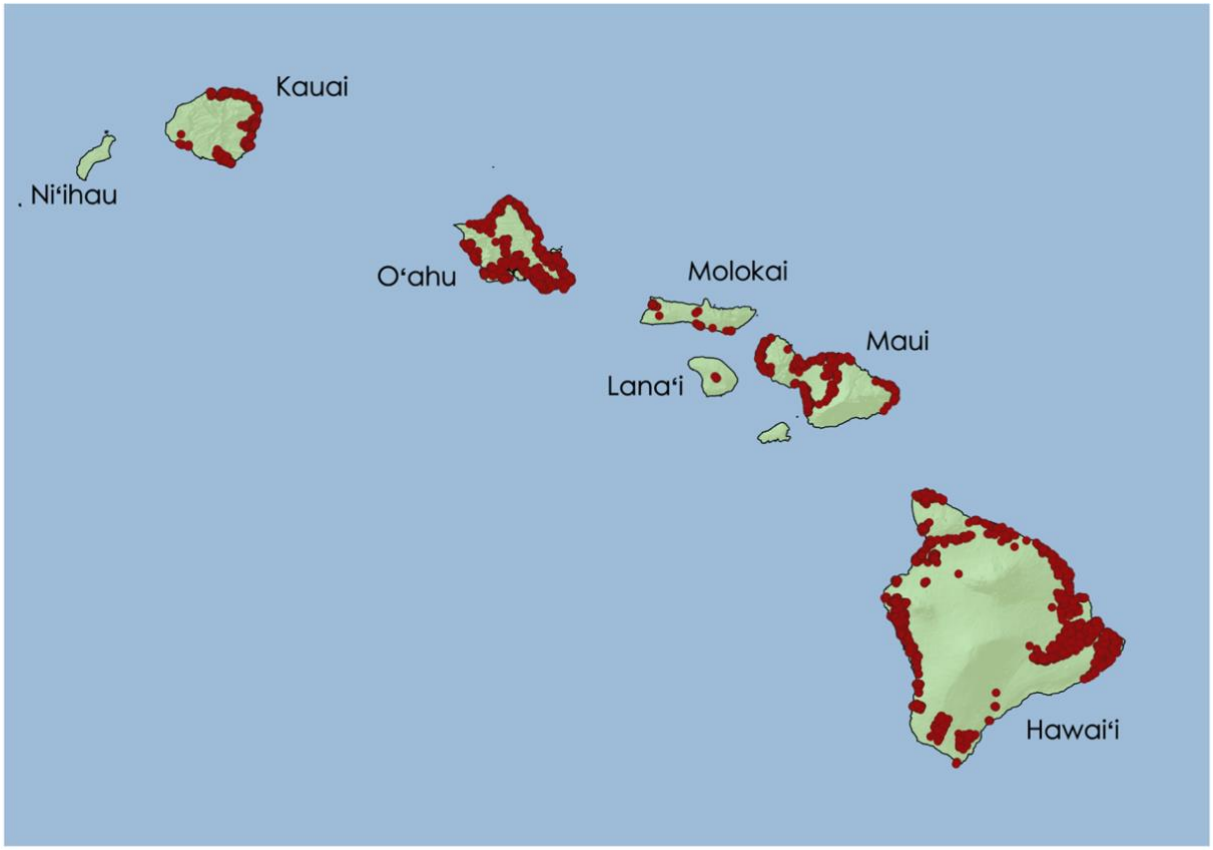


**Figure 2:** Available Airbnb listing data, each red dot depicting the relative location of one listing by a host.

## Conclusion

The primary objectives of this study were to investigate the impact of tourism on housing prices in Hawaii to see if there are uneven distribution effects across the islands and to analyze vacation rentals for distribution and impacts of STRs on housing prices. It was found that tourism has a positive significant impact on housing prices with islands being impacted to different degrees supporting past literature findings as discussed in the literature review. The findings aim to inform tourism planning policies and sustainable tourism development to mitigate the negative impacts on housing affordability for local residents in Hawaii.

### *Study Limitations*

There were several study limitations to consider, some of which could be addressed in future studies. First, due to limitations of the datasets compiled, there are likely outside factors that are unaccounted for in the model that can influence these relationships between housing prices and tourism and housing prices and short-term rentals. Additionally, due to the availability of certain variables they had to be either excluded from this study or interpolated across months as some values were yearly. Another data limitation was short-term rental data was used to address the holiday homes aspect of this study as many hosts are assumed to be out-of-state residents, as seen from the inside Airbnb data set, which was assumed that all STRs are holiday homes to a degree, but this may skew the results as there are some in-state residents who own second homes as a revenue source. Secondly, this study was unable to take into account the other externalities and effects that tourism has on the community, as a goal for this paper was to use housing prices as a proxy to explore the economic well-being of residents residing in Hawaii results may be misleading and not explain positive impacts that tourism brings. Thirdly, the time constraints of this study limited the robustness of these models and analysis. Ideally, this study would break down results into city areas instead of just county data as this could illustrate that the cities which are more tourist-oriented are impacted to a greater degree than those which are not. This would have also allowed more correlations to be made with tourism, short-term rentals, and housing prices as a whole for a more complete picture. This study would also have gone into the direction of the relationship between the dependent and independent variables to find causality.

### *Future Recommendations*

There are several directions that future studies can build off of this research. Firstly, future studies could include additional control variables in the regression models or using different instrumental variables to address the endogeneity issue. It can also be expanded that causality tests will be run on the data as in this study the causality is assumed with the data. This research could also be bolstered with the inclusion of the cost of living to explore more of how tourism affects the economic well-being of residents. Another interesting aspect that could be explore in more depth would be how the Covid-19 pandemic impacted tourism and housing prices and how this relationship was halted for this period of time and possibly rebounded to a greater extent than it was before. Additional studies could also be conducted in Hawaii to see how Airbnb and other forms of short-term rentals (STRs) or holiday homes have impacted the housing prices. While also including aspects of if this money is being input into the local economy (are hosts located in Hawaii or somewhere else). Studies could look more into the economic well-being of residents and whether there are certain groups of people who are adversely affected compared to others (are Native Hawaiians worse off than white people or other people of other ethnicities). A further study could look into the connection of out-migration of local residents to other places and if there is a trend of out-migration concurrent with the increase in housing prices and the cost of living to include the impact that tourism is having on residents which could support the sentiment that residents have of being priced out of Hawaii (paradise). Lastly, to combine hedonic prices, causality, and holiday homes elements as outlined by Biagi et al. (2012) studies could explore the intersection of these as they could correlate and impact each other.

## Appendix: Empirical Results

**Table 1:** Summary statistics of variables used for regression models.

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Time | 22,464 | 144.50 | 83.14 | 1 | 288 |
| County | 22,464 | 2.21 | 1.07 | 1 | 4 |
| City | 22,464 | 28.68 | 17.16 | 1 | 62 |
| Tourists Arrivals | 22,464 | 212,022.95 | 150,999.38 | 21.28 | 598,985.88 |
| Housing Prices | 16,272 | 529,225.04 | 274,657.61 | 97,354.72 | 2,414,121.31 |
| Tourism Expenditure | 18,140 | 308.05 | 223.38 | 0.62 | 885.14 |
| Per Capita Personal Income | 21,528 | 40,111.93 | 10,459.25 | 22,003.00 | 64,936 |
| Inflation Rate | 22,464 | 2.68 | 1.62 | 0 | 7.5 |
| Unemployment Rate | 22,464 | 4.73 | 2.60 | 2.10 | 17.7 |
| Population Density | 22,464 | 435,161.67 | 388,201.16 | 58,568.00 | 1,015,167 |

**Table 2:** OLS Regression results

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Non-linear Arrivals | Linear ln Arrivals | Non-linear ln Arrivals | Non-linear Expenditure | Linear ln Expenditure | Non-linear ln Expenditure |
| Tourists Arrivals | 1.09*** | | | | | |
| | (0.05) | | | | | |
| Tourists Arrivals$^2$ | -0.00*** | | | | | |
| | (0.00) | | | | | |
| Per Capita Personal Income | 17.45*** | 0.00*** | 0.00*** | 15.00*** | 0.00*** | 0.00*** |
| | (0.19) | (0.00) | (0.00) | (0.25) | (0.00) | (0.00) |
| Inflation Rate | 17509.09*** | 0.03*** | 0.03*** | 17532.79*** | 0.02*** | 0.02*** |
| | (992.74) | (0.00) | (0.00) | (1057.22) | (0.00) | (0.00) |
| Unemployment Rate | 3686.85*** | 0.02*** | 0.02*** | 972.61 | -0.00 | 0.00 |
| | (682.08) | (0.00) | (0.00) | (826.99) | (0.00) | (0.00) |
| Population Density | -0.19*** | -0.00*** | -0.00*** | -0.19*** | -0.00*** | -0.00*** |
| | (0.01) | (0.00) | (0.00) | (0.01) | (0.00) | (0.00) |
| ln Tourists Arrivals | | 0.12*** | -0.18*** | | | |
| | | (0.00) | (0.03) | | | |
| ln Tourists Arrivals$^2$ | | | 0.02*** | | | |
| | | | (0.00) | | | |
| Tourism Expenditure | | | | 897.69*** | | |
| | | | | (37.21) | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Tourism Expenditure$^2$ | | | | -0.67*** | | |
| | | | | (0.04) | | |
| ln Tourism Expenditure | | | | | 0.15*** | 0.13*** |
| | | | | | (0.00) | (0.02) |
| ln Tourism Expenditure$^2$ | | | | | | 0.00 |
| | | | | | | (0.00) |
| _cons | -384620.52*** | 9.93*** | 11.43*** | -288702.98*** | 11.19*** | 11.21*** |
| | (9668.93) | (0.04) | (0.14) | (12405.23) | (0.02) | (0.03) |
| Observations | 15347 | 15347 | 15347 | 12475 | 12475 | 12475 |
| R-squared | 0.46 | 0.52 | 0.53 | 0.35 | 0.40 | 0.40 |

*Standard errors are in parentheses*
*** p<.01, ** p<.05, * p<.1*

**Table 3:** VIF output for Tourism Arrivals log regression (2), refer to table 2.

| Variable | VIF | 1/VIF |
|---|---|---|
| ln_tourarr | 2.120 | 0.471 |
| PopD | 1.900 | 0.527 |
| EMPLOYR | 1.540 | 0.651 |
| INCOME | 1.350 | 0.743 |
| INFLATION | 1.160 | 0.864 |
| Mean VIF | 1.610 | |

**Table 4:** VIF output for Tourism Expenditure log regression (5), refer to table 2.

| Variable | VIF | 1/VIF |
|---|---|---|
| PopD | 1.960 | 0.511 |
| ln_tourexp | 1.740 | 0.575 |
| INCOME | 1.280 | 0.781 |
| EMPLOYR | 1.120 | 0.897 |
| INFLATION | 1.070 | 0.938 |
| Mean VIF | 1.430 | |

**Table 5:** Results with fixed and random variables for Hausman test.

| | (1) Arrivals fixed | (2) Arrivals random | (3) Expenditure fixed | (4) Expenditure Random |
|---|---|---|---|---|
| ln_tourarr | 0 | 0 | | |
| | (0) | (0) | | |

| | | | | |
|---|---|---|---|---|
| INCOME | 0*** | 0*** | 0*** | 0*** |
| | (0) | (0) | (0) | (0) |
| INFLATION | .04*** | .04*** | .02*** | .02*** |
| | (0) | (0) | (0) | (0) |
| EMPLOYR | -.01*** | -.01*** | -.01*** | -.01*** |
| | (0) | (0) | (0) | (0) |
| PopD | 0*** | 0*** | 0*** | 0*** |
| | (0) | (0) | (0) | (0) |
| ln_tourexp | | | .02*** | .02*** |
| | | | (0) | (0) |
| _cons | 10.99*** | 11.11*** | 12.11*** | 11.9*** |
| | (.04) | (.05) | (.03) | (.05) |
| Observations | 15347 | 15347 | 12475 | 12475 |
| Pseudo $R^2$ | .z | .z | .z | .z |

*Standard errors are in parentheses*
*** p<.01, ** p<.05, * p<.1*

**Table 6:** 2SLS Linear Regression results

| | (1)<br>Linear Arrivals | (2)<br>Linear Expenditure |
|---|---|---|
| Tourists Arrivals | 0.56*** | |
| | (0.02) | |
| Per Capita Personal Income | 16.69*** | 13.42*** |
| | (0.18) | (0.26) |
| Inflation Rate | 20386.67*** | 18865.47*** |
| | (980.92) | (1065.85) |
| Unemployment Rate | 3748.31*** | -421.80 |
| | (708.76) | (890.99) |
| Population Density | -0.21*** | -0.22*** |
| | (0.01) | (0.01) |
| Tourism Expenditure | | 478.54*** |
| | | (21.12) |
| _cons | -317126.46*** | -169785.60*** |
| | (8360.00) | (10972.41) |
| Observations | 15345 | 12201 |
| R-squared | 0.45 | 0.34 |

*Standard errors are in parentheses*
*** p<.01, ** p<.05, * p<.1*

Tourism Arrivals Endogeneity Test
Tests of endogeneity
H0: Variables are exogenous
Durbin (score) chi2(1) = 21.6068 (p = 0.0000)
Wu-Hausman F(1,15338) = 21.6274 (p = 0.0000)

Tourism Expenditure Endogeneity Test
Tests of endogeneity
H0: Variables are exogenous
Durbin (score) chi2(1) = 30.8044 (p = 0.0000)
Wu-Hausman F(1,12194) = 30.8647 (p = 0.0000)

**Table 7:** 2SLS Linear ln Regression results

| | (1) Linear ln Arrivals | (2) Linear ln Expenditure |
|---|---|---|
| ln_tourarr | 0.13*** | |
| | (0.00) | |
| Per Capita Personal Income | 0.00*** | 0.00*** |
| | (0.00) | (0.00) |
| Inflation Rate | 0.03*** | 0.02*** |
| | (0.00) | (0.00) |
| Unemployment Rate | 0.02*** | -0.00*** |
| | (0.00) | (0.00) |
| Population Density | -0.00*** | -0.00*** |
| | (0.00) | (0.00) |
| ln_tourexp | | 0.15*** |
| | | (0.00) |
| _cons | 9.80*** | 11.21*** |
| | (0.05) | (0.02) |
| Observations | 15345 | 12201 |
| R-squared | 0.52 | 0.40 |

*Standard errors are in parentheses*
*** p<.01, ** p<.05, * p<.1*

**Table 8:** 2SLS Margins regression results

| | (1) Non-linear Arrivals | (2) Non-linear Expenditure | (3) Non-linear ln Arrivals | (4) Non-linear ln Expenditure |
|---|---|---|---|---|
| Tourists Arrivals | 3.87*** | | | |
| | (0.54) | | | |
| TOURARR_sq | -0.00*** | | | |
| | (0.00) | | | |
| Per Capita Personal Income | 17.71*** | 14.12*** | 0.00*** | 0.00*** |
| | (0.35) | (0.40) | (0.00) | (0.00) |
| Inflation Rate | 7374.49*** | 19109.55*** | 0.04*** | 0.02*** |
| | (2294.73) | (1231.89) | (0.00) | (0.00) |
| Unemployment Rate | 6399.79*** | -3825.83*** | 0.01*** | -0.02*** |

| | | | | |
|---|---|---|---|---|
| | (1020.08) | (879.67) | (0.00) | (0.00) |
| Population Density | 1.43*** | 0.87*** | 0.00*** | -0.00 |
| | (0.27) | (0.31) | (0.00) | (0.00) |
| 1bn | | | | |
| Honolulu County | -1035842.68*** | -697659.53*** | -0.80*** | 0.65*** |
| | (192039.06) | (224835.52) | (0.14) | (0.17) |
| Kauai County | 406089.78*** | 355722.82*** | 0.45*** | 0.28*** |
| | (42424.13) | (45000.48) | (0.03) | (0.03) |
| Maui County | 164868.89*** | 144148.56*** | 0.21*** | 0.57*** |
| | (12506.99) | (15279.69) | (0.02) | (0.06) |
| Tourism Expenditure | | 1697.39*** | | |
| | | (170.79) | | |
| TOUREXP_SQ | | -1.72*** | | |
| | | (0.24) | | |
| ln_tourarr | | | -1.29*** | |
| | | | (0.14) | |
| c | | | 0.07*** | |
| | | | (0.01) | |
| ln_tourexp | | | | 0.83*** |
| | | | | (0.17) |
| c | | | | -0.09*** |
| | | | | (0.02) |
| _cons | -1030604.66*** | -660681.72*** | 16.65*** | 9.73*** |
| | (98691.99) | (73700.62) | (0.73) | (0.32) |
| Observations | 15345 | 12201 | 15345 | 12201 |
| R-squared | 0.34 | 0.39 | 0.50 | 0.46 |

*Standard errors are in parentheses*
*** *p<.01,* ** *p<.05,* * *p<.1*

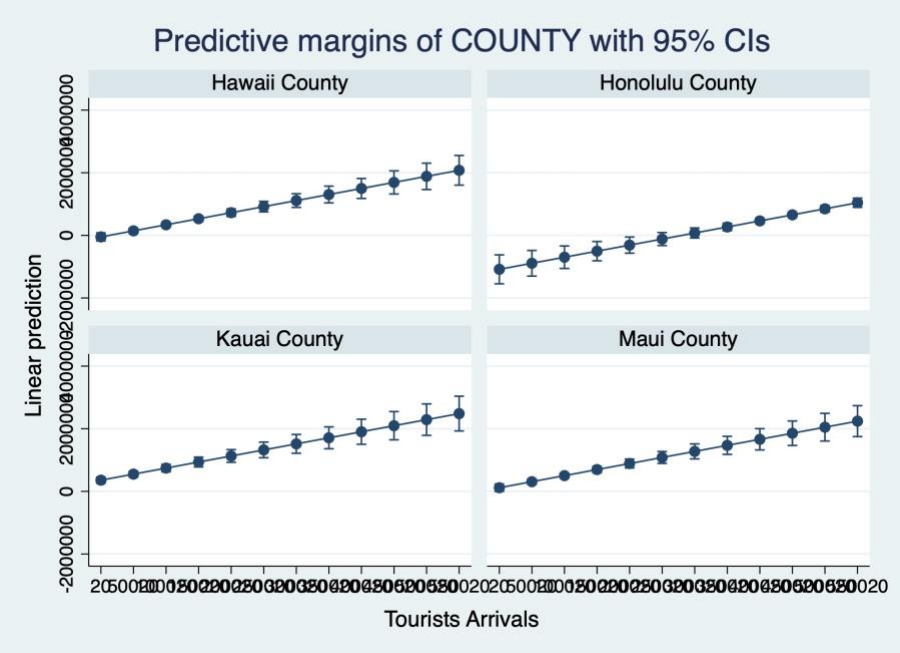


**Figure 3.** Linear prediction of tourist arrivals and housing prices by county.

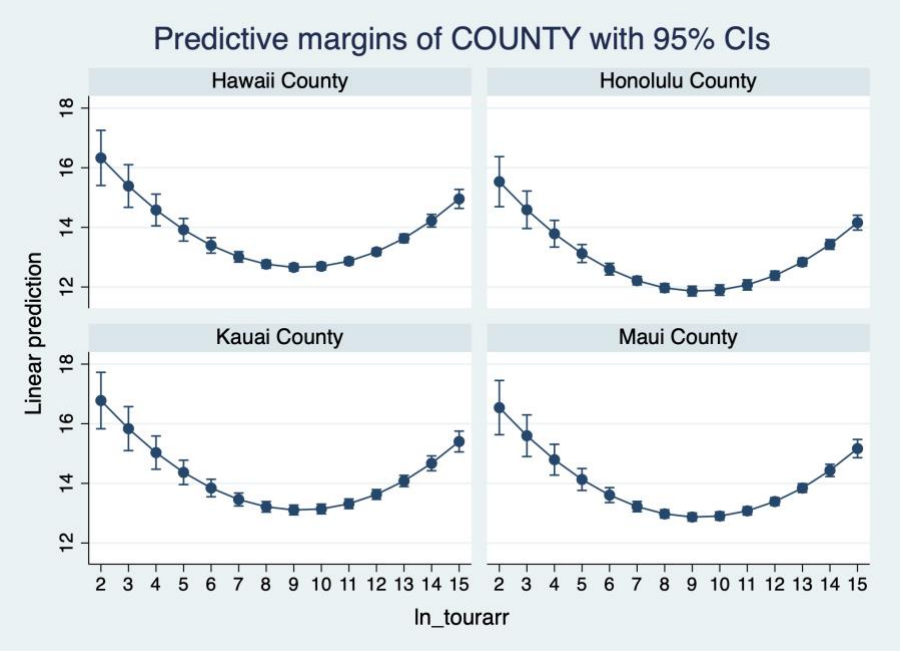


**Figure 4.** Non-linear prediction of tourist arrivals and housing prices by county.

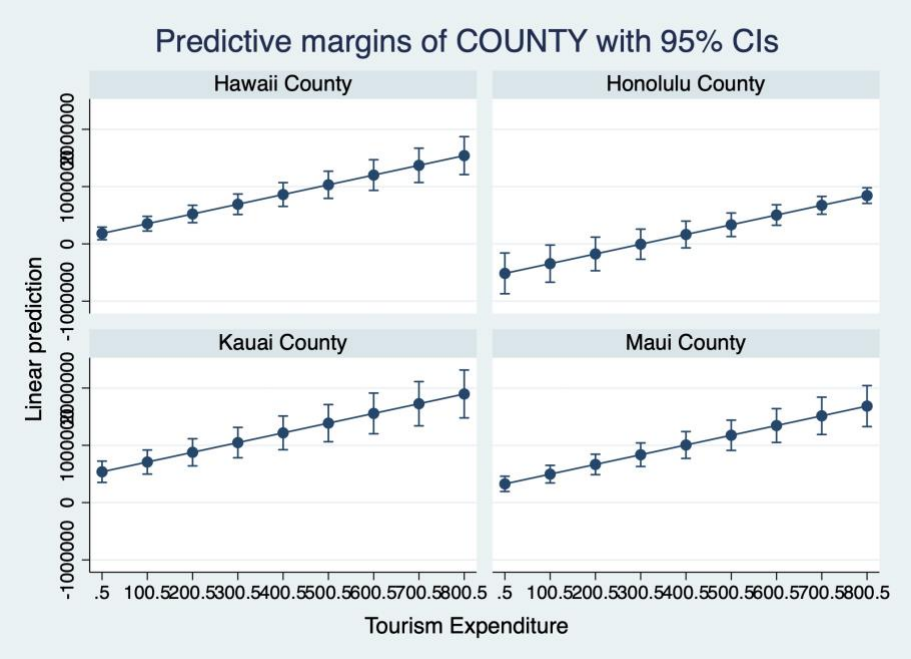


**Figure 5.** Linear prediction of tourism expenditure and housing prices by county.

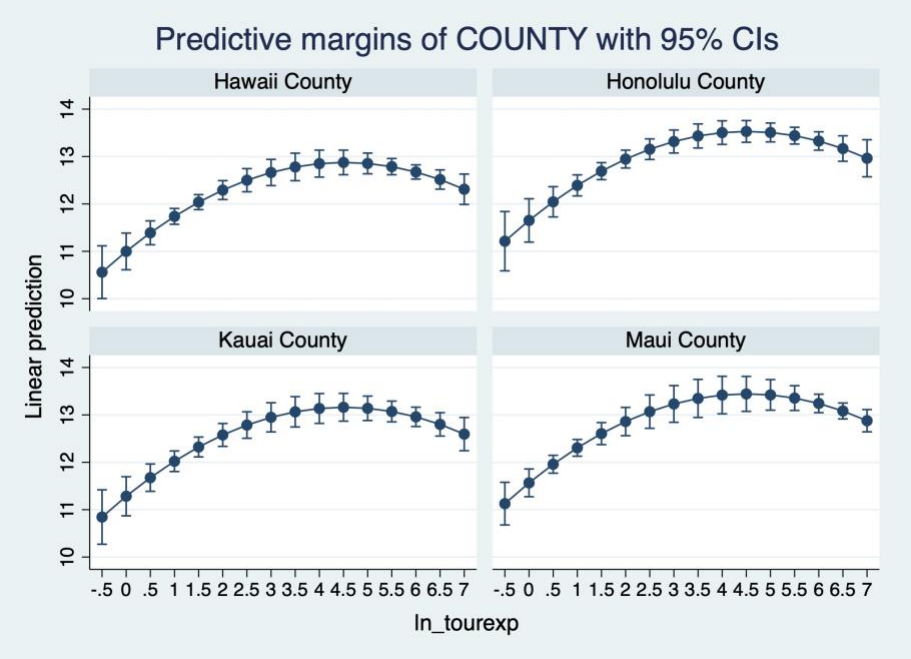


**Figure 6.** Non-linear prediction of tourism expenditure and housing prices by county.

**Table 9:** Summary statistics of variables used for short-term rental regression models.

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| time | 240 | 22452.02 | 528.18 | 21551.00 | 23354.00 |
| County as a categorical variable | 240 | 2.50 | 1.12 | 1.00 | 4.00 |
| Average Housing Prices per county | 240 | 733993.51 | 193931.28 | 380057.30 | 1117828.72 |

| | | | | | |
|---|---|---|---|---|---|
| Short Term Rentals Supplied per county | 240 | 163860.06 | 64143.44 | 26395.00 | 323332.00 |
| Short Term Rentals Demanded per county | 240 | 101651.98 | 57660.75 | 3479.00 | 255485.00 |
| Unit occupancy as percentage of supply used | 240 | 0.58 | 0.21 | 0.04 | 0.88 |
| Total Housing Units per county | 240 | 139078.00 | 131774.42 | 30147.00 | 373875.00 |
| Housing Units used as vacation rentals | 240 | 7329.60 | 2269.34 | 4064.00 | 11268.00 |
| Share of housing used as vacation rentals | 240 | 9.70 | 5.33 | 1.90 | 16.00 |

**Table 10:** OLS Short-term rental (STR) regression results

| | (1) STR supply | (2) STR supply non-linear | (3) STR supply ln non-linearr |
|---|---|---|---|
| Short Term Rentals Supplied per county | -0.80*** | -1.72* | |
| | (0.22) | (0.99) | |
| Unit occupancy as percentage of supply that is used | 180932.22*** | 192508.37*** | 0.27*** |
| | (65664.11) | (66816.30) | (0.10) |
| Total Housing Units per county counted in years | 0.34*** | 0.36*** | 0.00*** |
| | (0.10) | (0.10) | (0.00) |
| Rsup_sq | | 0.00 | |
| | | (0.00) | |
| Log of Short-term Rentals Supply | | | |
| ln_Rsup_sq | | | -0.08*** |
| | | | (0.02) |
| _cons | 712605.83*** | 773815.19*** | 15.23*** |
| | (40761.06) | (76638.36) | (0.55) |
| Observations | 240 | 240 | 240 |
| R-squared | 0.08 | 0.09 | 0.09 |

*Standard errors are in parentheses*

*** p<.01, ** p<.05, * p<.1*

**Table 11:** VIF output for STR supply linear regression, refer to table 9.

| VIF | 1/VIF |
|---|---|
| 1.380 | 0.727 |
| 1.270 | 0.790 |
| 1.100 | 0.907 |
| 1.250 | |

**Table 12:** VIF output for STR supply ln non-linear regression, refer to table 9.

| VIF | 1/VIF |
|---|---|
| 1.470 | 0.678 |
| 1.330 | 0.751 |
| 1.130 | 0.882 |
| 1.310 | |

**Table 13:** Results with fixed and random variables for Hausman test (Short-term rentals).

| | (1) Fixed | (2) Random |
|---|---|---|
| Short Term Rentals Supplied per county | 0.03 | -0.80*** |
| | (0.19) | (0.22) |
| Unit occupancy as percentage of supply that is used | 42510.30 | 180932.22*** |
| | (42801.53) | (65664.11) |
| Total Housing Units per county counted in years | 9.03*** | 0.34*** |
| | (1.46) | (0.10) |
| _cons | -550854.52*** | 712605.83*** |
| | (206961.94) | (40761.06) |
| Observations | 240 | 240 |
| Pseudo $R^2$ | .z | .z |

*Standard errors are in parentheses*
*** p<.01, ** p<.05, * p<.1*

**Table 14:** 2SLS Short-term rental regression results

| | (1) STR supply |
|---|---|
| Short Term Rentals Supplied per county | -0.94*** |
| | (0.25) |

| | |
|---|---|
| Unit occupancy as percentage of supply that is used | 213225.13*** |
| | (66628.92) |
| Total Housing Units per county counted in years | 0.35*** |
| | (0.10) |
| _cons | 718949.00*** |
| | (40685.39) |
| Observations | 238 |
| R-squared | 0.09 |

*Standard errors are in parentheses*
*** p<.01, ** p<.05, * p<.1*

Tests of endogeneity
H0: Variables are exogenous
Durbin (score) chi2(1) = .856865 (p = 0.3546)
Wu-Hausman F(1,233) = .841895 (p = 0.3598)

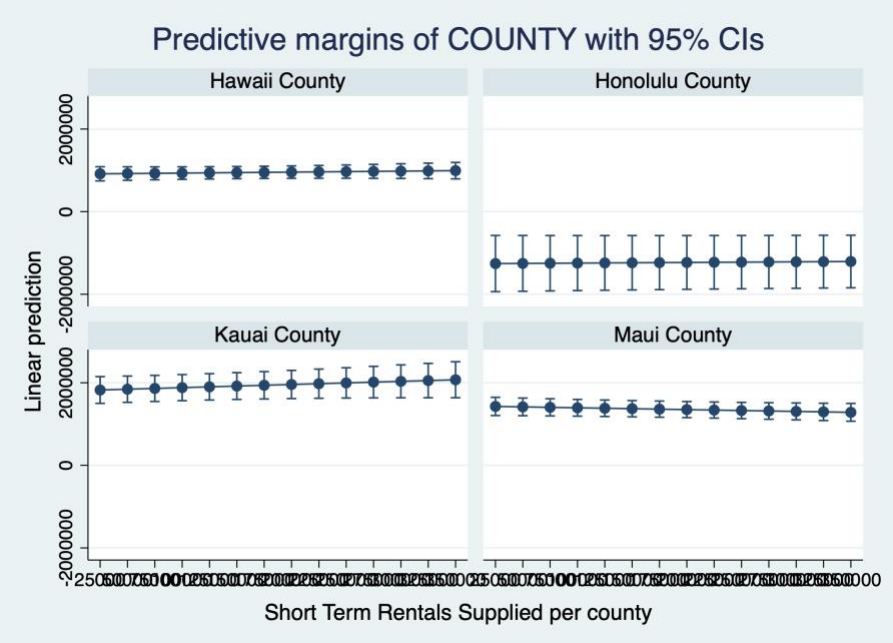


**Figure 7.** Linear prediction of short-term rental (Airbnb) supply and housing prices by county.

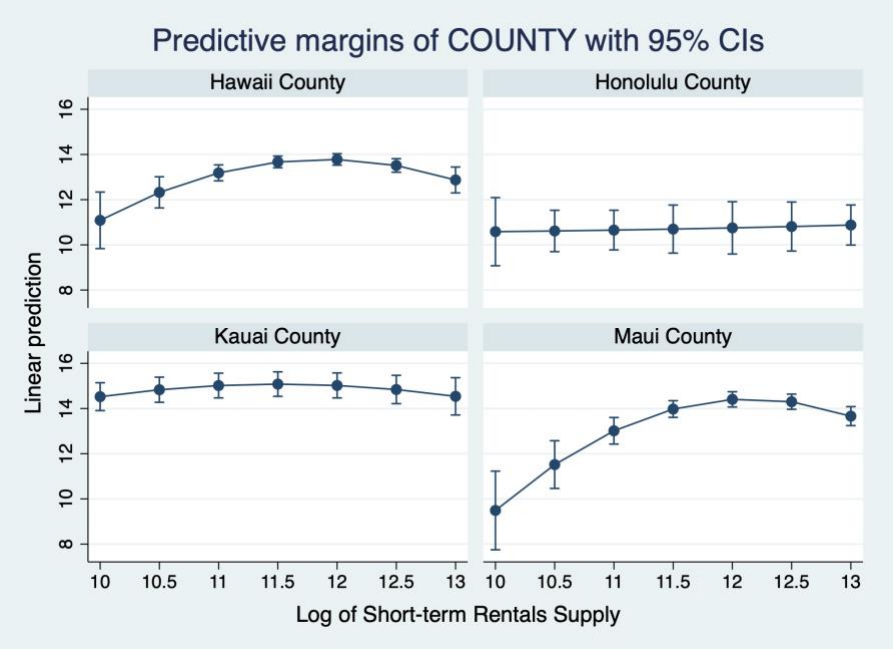


**Figure 8.** Non-linear prediction of short-term rental (Airbnb) supply and housing prices by county.

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