EXPLORING THE CAUSES OF INFORMAL HOUSING IN CALIFORNIA CITIES FROM THE DEMAND SIDE AND SUPPLY SIDE

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ABSTRACT

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In recent years, informal housing in developing countries has received widespread attention, but researchers have largely overlooked informality in developed countries, such as the United States. In fact, many types of informal housing exist in the United States. Recently, some scholars have devoted themselves to the research of informal housing in America, including its definition, types, and causes. However, none of them use quantitative methods to examine the potential causes of informal housing. This research aims to address this issue.

In my study, I chose California cities as the unit of analysis due to the large numbers of informal housing units in California. With the definition of informal housing – housing units which are not permitted by local housing regulations or codes – I calculated the share of newly-built informal housing in California cities in the 2000s using previous scholars' methods. I then used fractional response regression models to examine the potential causes of informal housing produced from 2000 to 2010. The results reveal that informal housing arises both from the demand and the supply side. The variables on the demand side suggest that demographic factors – namely immigrants, Hispanics, and African Americans – play different roles in the production of informal housing. The lack of income on the demand side also results in informal housing. Additionally, on the supply side, the result suggests that the future housing provision and existing housing provision play an important role in the production of informal housing, while existing housing conditions, such as the share of single-family houses, is not related to informal housing production.

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KEY TO ABBREVIATIONS

OECD	Organization for Economic Co-operation and Development
ADU	Accessory Dwelling Unit
IPUMS	Integrated Public Use Microdata Series
ACS	American Community Survey
CDHCD	California Department of Housing and Community
CDP	Census-Designated Place
USGS	U.S. Geological Survey
SRTM	Shuttle Radar Topography Mission
IQR	Interquartile Range

CHAPTER 1. INTRODUCTION

It is estimated that the people who live in informal settlements accounts for about 25% of the global population; and the number of people who are living in informal settlements has increased by 213 million since 1990 (UN-Habitat, 2013). Recently, scholars are not only focusing their research on informal housing in developing countries, but also extending to developed countries like the United States. From the *colonias* in the US-Mexico border, where research on informality first attracted public attention in the 1990s, to the illegal "squatting" in Detroit, scholars are increasingly studying informal housing that exists in the United States (Herbert, 2018; Ward, 2004).

The definitions of informal housing given by the Organization for Economic Co-operation and Development (OECD) mainly focuses on residents' non-compliance with housing regulations. This study defines informal housing as construction that does not comply with local housing laws and regulations. In accordance with this definition, two types of informal housing will be the focus of this research: unpermitted conversions and additions to the housing stock. It is estimated that large numbers of informal housing exist in California. Baer (1986) discovered the existence of "shadow housing" all across America, while Wegmann and Mawhorter (2017) calculated the number of informal housing units in each city in California with existing housing data.

Due to the lack of data on informality and the public/government's ignorance of the phenomenon, most studies on the causes of informal housing are limited to qualitative research and do not systematically examine the connection between informal housing and potential causal factors. Many experts and scholars have sporadically mentioned these potential causes, but few of them use quantitative methods to estimate the relationship between these factors and the prevalence of informal housing. I examine this gap in the literature.

In this study, I summarize the potential causes of informal housing and use quantitative methods (regression analysis) to examine their relationship. First, the demand side contributes to the production of informal housing by giving rise to demand for new forms of housing, new types of occupancy or tenure, or new approaches to housing construction that are not currently supplied by or permitted in the formal housing market (Loukaitou-sideris & Mukhija, 2014; Neuwirth, 2008; Ward, 2004). Second, the supply side also leads to informal housing because of constrained housing provision restricted by the government and the terrain (Spillman et al., 2016; Ward, 2014).

In this research, I attempt to find the answer to the question: what factors lead to the prevalence of California's informal housing? In the literature review, I define informal housing based on the current scholarship that deals with the causes, implications, and methods associated with informality around California's housing needs. In the methodology, I describe in detail the data collection and the regression model that I used. In the results and discussion chapter, I focus on the findings and interpretations of my regression results. In the final chapter, I link my findings with previous scholars' ideas, provide my suggestions for informal housing in California, and discuss implications for future research. Overall, in this report, I aim to 1) help the public have a better understanding of informal housing, 2) examine the potential factors that lead to informal housing; and 3) enrich theories of urban informality.

CHAPTER 2. LITERATURE REVIEW

2.1 Definition of informal housing

In this moment of rapid urbanization at the global level, urban informality has entered all aspects of life (AlSayyad, 2004). Broadly defined, "informality" refers to economic activity that fails to comply with or is not governed by standards, codes, or laws (De Soto, 1989). One important branch of informality is informal housing (Doebele, 1977). Although most research on informal housing has focused on the developing world, recent research illustrates that informal housing also exists in the United States (Durst & Wegmann, 2017; Mukhija, 2014; Ward, 2004; Wegmann, 2014).

From the Organization for Economic Co-operation and Development's (OECD) definition, informal settlements are:

> 1) areas where groups of housing units have been constructed on land that the occupants have no legal claim to, or occupy illegally; or 2) unplanned settlements and areas where housing is not in compliance with current planning and building regulations (unauthorized housing) (UNSD, 1996, p. 43).

This definition focuses both on people's illegal occupation of legal housing units and housing units that are not compliant with local housing regulations. In this study, I focus on the latter definition: housing that is not in compliance with regulations. In the other words, informal housing in this research encompasses housing units which are built without building permits or land use approvals.

2.2 Physical Forms of Informal Housing

Scholars in the U.S. first began to use the term "informality" to describe the *colonias*, which is one type of informal housing in Texas (Ward, 2004). Later more forms of informal housing were

found, such as phantom apartment in New York City and squatting in Detroit (Herbert, 2018; Neuwirth, 2008; Ward, 2004). In this chapter, I will discuss the typical forms of informal housing in America, especially the types of informal housing that are prevalent in California.

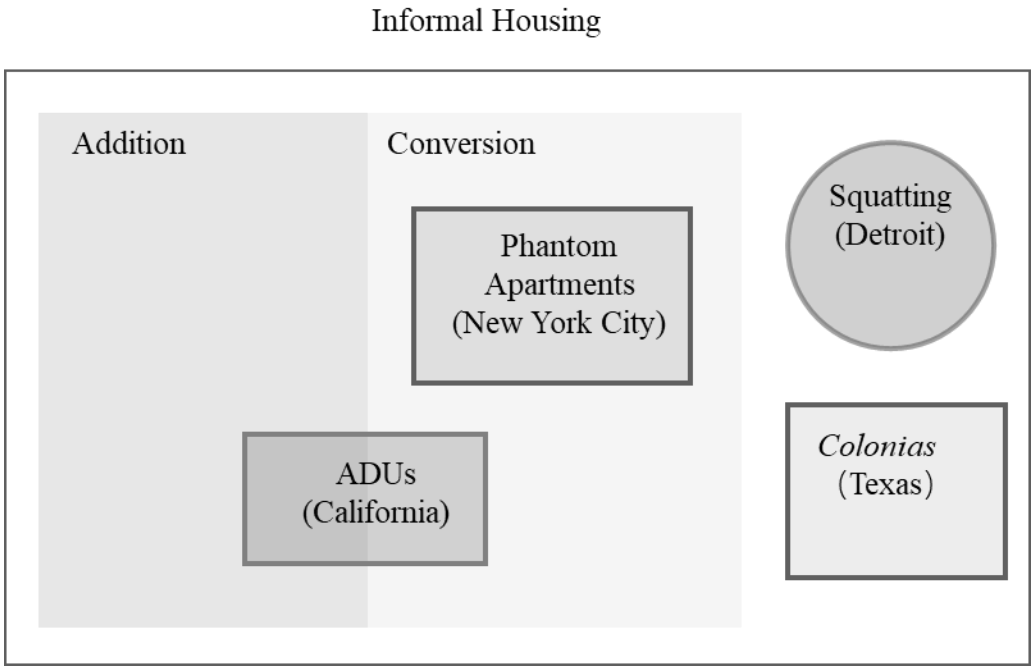

Figure 2.2.1. Cases of Informal Housing

As shown in Figure 2.2.1, the first type of informal housing known to the public is *colonias* – informal neighborhoods in Texas and other states along the U.S.-Mexico border. *Colonias* are largely unregulated residential subdivisions that were developed without water, wastewater, and electricity services; without paved roads, sidewalks, or streetlights; where housing is often built by residents themselves (i.e., via self-help); and where property is often sold through highly exploitative and poorly regulated contracts (Durst & Ward, 2014; Ward, 2004). *Colonias* are often referred to as informal because the process of land and housing production or transfer is typically unregulated or substandard; land and housing in *colonias* are not so much out of compliance with regulations but rather are developed under weak regulatory standards that differ widely from those enforced in other parts of the U.S. (Durst, 2018; Durst & Wegmann, 2017).

In 2008, Neuwirth revealed informal housing units in New York, which is referred to as "phantom apartments". Phantom apartments, defined as housing units built without the approval from the government, arise from overcrowded living situations (Neuwirth, 2008), which reflects the shortage of affordable housing in New York City. Local residents' behavior of converting non-residential spaces to residential space -- such as using partitions to create more living space, converting spare basements into the residential areas, and renovating commercial lofts to accommodate more people – is defined as informal because the physical alteration of the housing changes the structure of apartments, poses a threat to the public safety (such as fire hazards or unstable housing structures), and violates local housing regulations (ibid.).

Similarly, Herbert (2018) identified squatting behavior in Detroit as informal. Squatting is one form of precarious housing on a spectrum that includes street sleeping or doubling up in an apartment (Herbert, 2018). Contrary to the appearance of phantom apartments, squatting arises from the surplus of vacant housing units (43,000, according to Data Driven Detroit, 2018) and residents living in poverty. Squatting is a type of informal housing because it violates property law (Herbert, 2018).

In California, informal housing is diverse and complex. But in general, informal housing units could be classified as additions or conversions (Wegmann, 2014). Unlike Detroit's declining population, the population in California is increasing every year (US Census, 2019). Addition or conversion, which aims to expand the living space, often through self-construction, is the reasonable but unpermitted response to pressure from population growth (Wegmann, 2014).

The physical forms of addition could be "An inhabited travel trailer permanently parked behind a main house and illegally connected to water and sewer lines or a separate freestanding structure located behind the main house." (Wegmann & Mawhorter, 2017, p. 119). And physical

forms of conversion are “garages converted into apartments”, or “a single-family home subdivided into multiple units with separate entrances” (Wegmann & Mawhorter, 2017, p. 119), which is similar to phantom apartments. Both forms are also in low level compliance with the zoning regulations (Wegmann, 2014). The unpermitted addition of living space makes the horizontal landscape denser, increases fire hazards, and violates housing regulations (ibid.). Conversion changes physical housing structures and fails to comply with zoning regulations and housing codes (ibid.). For example, the conversion from a garage into a living space violates zoning regulations; and the transformation of houses into collective housing is contrary to many standard housing regulations (Mukhija, 2014; Wegmann, 2014).

Accessory dwelling Units (ADUs) iare a special type of informal housing in California, which could be addition or conversion. ADUs – also called granny flats, in-law units, or backyard cottages – are secondary residential units with independent living facilities for one or more people (California Department of Housing and Community Development, 2016; Mukhija, 2014). The typical construction of ADUs is to convert the garage into the living space or build an additional housing unit on the lot (ibid.).

One thing to notice is that California government leaders have shown interest in developing ADUs as California’s housing crisis deepens, though many ADUs are illegal because of homeowners’ unpermitted addition of living space (California Department of Housing and Community Development, 2016). The huge amount of single-family homes, especially in two of California’s major metropolitan areas – Los Angeles and San Francisco – provide the potential space for the construction of ADUs and lay the foundation for their development (Garcia, 2017). Based on this consideration, the California government adopted SB 1069 and AB 2299 in 2016, as well as follow-up legislation in 2017 – land use regulations aiming to regulate the construction

of ADUs – to recognize the legitimacy of ADUs (ibid.). The new law published in the beginning of 2019 also provides opportunity for ADU owners to bring their ADUs into compliance (California Department of Housing and Community Development, 2019).

In this section, I discussed the physical types of informal housing in America and focused on the two types of informal housing in California cities: addition and conversion. However, the illegal behavior like overcrowding, which is one cause of conversion, is not the focus of this report. Instead, I concentrate on the physical structure in order to determine instances of informal housing. As a result of this focus, in the next section, I will discuss scholars' methods of measuring informal housing in North America.

2.3 Measuring Informal Housing

The first task to study the causes of informal housing is to quantify the number of informal housing units. In this section I will discuss three basic methods of calculating the number of informal housing units in North America. Those three methods have their own applicability based on the size of the geographical research area and features of informal housing.

Table 2.3.1. Different Methods of Calculating Informal Housing

Methods	**Judging criteria**	**Scope of application**	**Accuracy**	**Limitation**
Manual counting (Kinsella, 2017)	Physical factors	Neighborhoods	Accurate and timely	Size of the research area
Satellite map (McGarigal & Marks, 1995)	Physical factors	City/any research areas with boundary	Accurate and timely	Apparent housing features/resolution
Housing records (Baer, 1986)	Housing documents	Cities/states/municipalities	It depends	Accuracy of Housing documents

As shown in Table 2.3.1, the first method is to manually calculate the number of informal housing units by observing its physical factors. Kinsella (2017) used 18 physical criteria, such as

"more than one mailbox per single-family dwelling," "unit numbers on single-family dwellings," "more than one electric meter," and "lawns converted for parking of multiple vehicles" (Kinsella, 2017, p. 510), to visually judge whether the secondary units is legal in both urban and suburban neighborhoods in Canada. The manual counting of informal housing is relatively accurate because it provides the researchers timely information about housing units. However, such methods are limited when the research area is a big city or several cities, which may take significant time.

The second method is to use satellite images to identify the number of informal housing units. Satellite map identifies informal housing by its housing orientation, length-width ratio (or diagonal), colors, or locations (McGarigal & Marks, 1995); those physical factors which could be seen from the aerial map. Durst (2019) used the satellite map and county property records to conservatively define the number of informal subdivisions in four census regions throughout the country. Using remote sensing satellite images to calculate the number of houses or to observe activities is feasible nowadays because of satellite mapping's strengths including wide spatial coverage and high temporal resolution (Bégué, Vintrou, Ruelland, Claden, & Dessay, 2011; Wu, Shibasaki, Yang, Zhou, & Tang, 2008). But sometimes the physical housing appearance is not apparent or is ambiguous, which requires scholars to add more criteria to define its features (Guo et al., 2016). Such a method is also limited by the resolution of the satellite map. Low-resolution maps always increase the difficulty of counting (Laliberte, Browning, & Rango, 2012).

Different from the first two methods which are based on the housing physical factors, the third method relying on the existing legal housing records to calculate informal housing provides some convenience. In 1986, Baer discovered the existence of informal housing – known as "shadow housing"; he used a pie chart, which covers each share of housing units changed by conversion, merger, demolition, new construction, and mobile homes to reveal that the housing

commonly ignored gap of two time points – "shadow housing" – was playing an important role in the housing market. Baer (1986) concluded that 40% of housing units for extreme low-income individuals are from the shadow housing market. Though he failed to calculate the number of informal housing units in any municipalities, his estimation provided the basic idea of counting informal housing units. In 2018, with a similar method, Wegmann and Mawhorter measured the number of informal housing units each city produced from 2000 to 2010 in California. Generally, using the existing housing records to calculate the housing number over a large area or in multiple cities is straightforward. However, this method requires that cities have complete legal housing records; any missing part of the records could influence the accuracy of informal housing data. That is to say, data from various sources may adopt different ways of calculation or points in time, which could also influence the results (Wegmann & Mawhorter, 2017). Normally scholars may adopt a conservative estimation of the results (Baer, 1986; Wegmann & Mawhorter, 2017). To summarize, this method mainly depends on the accuracy of other data sources.

The first method is precise but limited due to its labor-intensive data collection requirements, particularly if the research area is large. The second method is also restricted if high-resolution images are not accessible. In this study, based on the reliable housing data at the city level, I adopted the third method to calculate the newly built informal housing units, which is my dependent variable in my Methodology section.

2.4 Possible Causes of Informal Housing

Previous scholars have made achievements in categorizing informal housing and methods of measuring informal housing, but the causes of informal housing have not, however, been systematically studied. In this section, I list the possible or potential causes of the informal housing and summarize them from the demand side and supply side.

Existing housing provisions aim to meet people's living or investing requirements, which follows the law of supply and demand (Chappelow, 2019). The production of informal housing, as a special component of the housing market, is also influenced by demand and supply. In this section, I analyze the factors from both the demand side and supply side, explore the dynamics between the appearance of informal housing and each factor, and provide a basis for my subsequent empirical analysis.

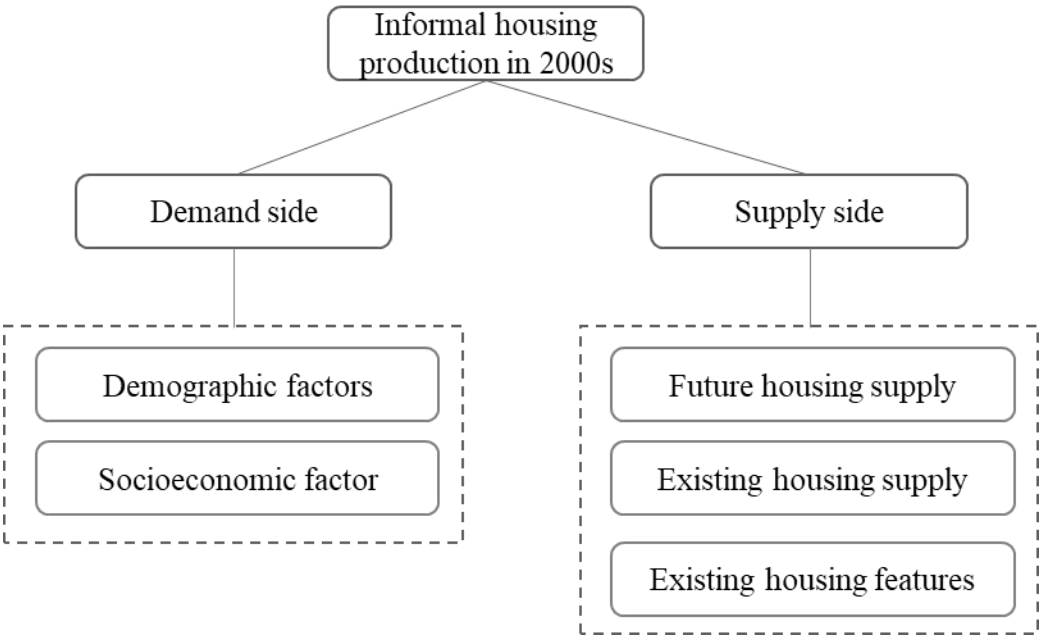

Figure 2.4.1. Conceptual Framework of Causes of Informal Housing

2.4.1 Demand side

The demand side of causes of informal housing mainly focuses on the demographic factors and the socioeconomic factor. From the demographic factors, African American population may be related to the production of informal housing, not because its growing number, but as a result of poor enforcement in African American communities may result in more informal housing production than other communities. Racial issues left from the 1990s leads to the poor enforcement in African American communities and provide the extralegal space for the informal living space

(Pendall, 2000; Wegmann, 2014). The land use system with racially exclusionary effects reduced the number of rental housing units in some neighborhoods, which resulted in the exclusion of low-income and minority residents (Pendall, 2000). This "chain of exclusion" during the last century separated the residential area by race. As a result, the African American neighborhoods may simply be less regulated (Wegmann, 2014; Pendall, 2000) and thus may have higher rates of informal housing production.

For another demographic factor, the increasing demand for rental housing from different backgrounds (i.e. the elderly, Hispanics/Latinos, and immigrants) may be associated with the production of informal housing (Leopold, Getsinger, Blumenthal, Abazajian, & Jordan, 2000). First, the increasing elderly population in California may contribute to informal housing. As the Baby Boomers age, there may be increases in demand for alternative forms of housing – such as conversions and additions – to accommodate housing for elderly parents who want to live on the same property as their children (Loukaitou-sideris & Mukhija, 2014). By converting a garage to a dwelling unit or using ADUs, property owners can make space for their elderly parents to live close by (ibid.). "Granny flats" could be developed informally where they are not allowed by city code (California Department of Housing and Community Development, 2016; Loukaitou-sideris & Mukhija, 2014). Second, communities with higher share of Hispanics/Latinos could have higher shares of informal housing because of reliance on self-help building (thereby circumventing permitting and inspection requirements) and preference for living close to their families. Third, immigrants from other countries may not have stable jobs or income, such as students or blue-collar workers, and are less likely to have housing loans (Hernandez, 2018). Even if there is a formal housing market locally, they may not able to buy a house. But entering informal housing market requires less property transfer/rent procedures, and thus provide fewer barriers to entry

(Mukhija, 2014). What's more, immigrants' lack of awareness of local codes and standards may increase their likelihood of turning to informal housing, which may be less expensive.

A lack of income may also limit new residents' ability to participate in the formal housing market. Baer (1996) claimed that informal housing arises from the huge demand of extremely low-income individuals. As the state with highest housing prices in the last decade (US census, 2010), the widening gap between housing prices and household income deprives people under the poverty line of their right access to the formal housing market (Wegmann, 2015; Darrel, 2016). For people with lower incomes, cheaper living options like garages become acceptable, although the conditions may be inferior.

2.4.2 Supply side

The potential supply-side factors that contribute to informal housing mainly focus on the future housing supply, existing housing supply, and existing housing features. The future housing supply may influence the production of informal housing because the limited area reserved for the future development is likely to fail to provide enough living space as needed. If the city keeps developing and attracting more people, non-residential space such as garages may be converted to provide shelter. In California, especially for the coastline cities, the mountainous terrain and developed land put restrictions for the growth of cities' formal housing market. Wegmann and Mawhorter (2017) revealed that the proportion of informal housing along coastline cities is relatively higher than that of inland cities, indicating that cities with limited future housing supply could lead to the production of informal housing.

Moreover, existing housing provision may also contribute to production of informal housing. Shadow housing (Baer, 1996), which results from discontinuous funding support of affordable housing projects, is one of the outcomes of the shortage of affordable housing

(California Department of Housing and Community Development, 2016). The housing production indicated by future and current housing provision point toward a constrained housing market as a potential cause of informality, while the existing housing conditions may also play a role in the production of informal housing. For example, increases in single-parent households may increase demand for conversions and additions, since these housing types may allow single parents with small kids to live in rental housing on property owned by relatives or friends, thus ensuring that potential caretakers are close by in case of need (Baer, 1986; Loukaitou-sideris & Mukhija, 2014). It is estimated that over 75% of the total land area is comprised of neighborhoods where single-family homes make up at least 60% of the community's housing stock (Garcia, 2017). Those houses provide the chance for the production of ADUs, which, if not permitted, constitute a form of informal housing.

The definitions of informal housing, the types of informal housing in the United States, methods to measure informal housing, and some speculated causes of informal housing have been detailed. However, quantitative analysis of the causes of informal housing has never been adopted in the U.S. In this research, I examine the causes of the informal housing with quantitative analysis to fill this gap. In the next chapter I will specifically explain how I select and define the variables based on the causes of informal housing, how I use the models, and how I design the research.

CHAPTER 3. METHODOLOGY

In this chapter, I discuss the scale of the research, the collection of the dependent variable, the collection of independent variables according to the literature review, the data preprocessing, and model specification.

3.1 Research Design

In this study, I used California cities as the unit of analysis. The dependent variable is the percentage of new housing developed between 2000 and 2010 in California cities that is informal. The independent variables are collected according to the factors summarized in the previous chapter. After completing the model determination and data collection process, I performed data preprocessing, such as using the natural log to transform the data to make it fit a normal distribution. I then conducted fractional response regression to test how different factors are associated with the production of informal housing.

3.2 Scale of Analysis: California Cities

Based on the considerations mentioned above, I chose cities in California as the research scale. I used the polygons of the 2010 census places across America provided by the National Historical Geographic Information System (NHGIS) database (Minnesota Population Center, 2011) to define the boundary of all places in California. Based on the existing data on informal housing of cities in California, I picked 483 places as the original observations.

I chose California as the research area because of a large amount of informal housing units in California (Baer, 1986; Wegmann & Mawhorter, 2017) and data on the number of informal housing units provided by prior scholars (Wegmann & Mawhorter, 2017). Baer (1986) used the Components of Inventory Change (CINCH) report to research informal housing in 1986 and found the existence of "shadow housing" in the United States. Hardman (1996) confirmed this view in

later literature. As for the housing data, the CINCH report made by the US Census Bureau, combined with city-level characteristics, makes it possible to measure the number of housing units lost (i.e., demolished, destroyed) each decade (Wegmann & Mawhorter, 2017). Local housing departments such as the California Division of Finance (CDOF) also provide data on the number of annexed housing units and permitted construction for each incorporated city. Wegmann and Mawhorter (2017) used these data to conduct a city-scale study of California and obtain a good estimation of the number of informal housing units in each city in California.

3.3 Dependent Variable: Change of Informal Housing from 2000 to 2010

In this study, I used the share of newly built informal housing in California cities from 2000 to 2010, provided by Wegmann and Mawhorter (2017), as the dependent variable. It is nearly impossible to accurately measure the exact number of informal housing units due to the large number of housing, incomplete housing records and other factors (Baer, 1986; Wegmann & Mawhorter, 2017). Wegmann and Mawhorter (2017), use U.S. Census data, the CINCH dataset, and other governmental documents, to identify "shadow housing" in the housing market, and calculated the number of informal housing in California cities on the city scale (n = 483). Their approach is to subtract the change of all the legal housing units (permitted units built, annexed units, and housing units lost) from the total housing changes during 2000 and 2010. And the result is the number of informal housing produced in each city in California.

In this study, I used the number of newly built informal housing in 2000-2010 as the numerator, the sum of the number of newly built informal housing units in the 2000s and the permitted housing units built in the 2000s as the denominator, instead of total housing unit changes, to measure the proportion of newly built informal housing in each city.

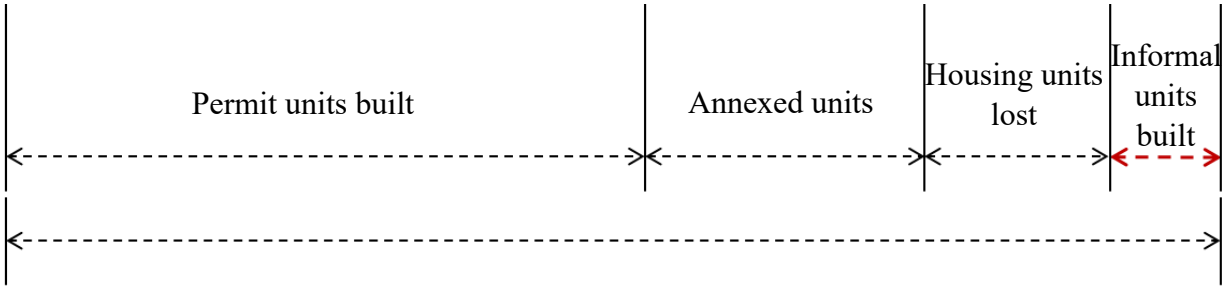

Figure 3.3.1. Wegmann And Mawhorter's Approach of Calculating Number of Informal Housing Produced From 2000 To 2010

I excluded some observations due to previous authors' underestimation. Due to the different measurement scales and different sources of data, Wegmann and Mawhorter (2017) adopted a conservative estimation and their approach underestimated the actual number of informal housing produced from 2000 to 2010. As a result, the number of informal housing units in some cities is negative (Wegmann, 2014; Wegmann & Mawhorter, 2017). They dealt with this issue by converting those negative values into "0". This step does not fully reflect the status quo of the city's informal housing market. For my research, in order to reduce the vague data's influence on the research results, I eliminate those cities with 0% of informal housing changes (n=67) and use the rest cities as observations (n=416).

As shown in Table 3.3.1, within the 407 observations (9 observations are lost during the data preprocessing), the mean of newly built informal housing units from 2000 to 2010 is 44%; the minimum is 0.007 (.7%) and the maximum number of 1 (100%). That is to say, all cities in California have some informal housing produced in the 2000s, more or less. But for some cities, their housing increase from 2000 to 2010 is all from the informal housing market, which is surprising. The histogram shown in the Figure 3.3.2 indicates that the change of informal housing from 2000 to 2010 varies widely across cities.

Table 3.3.1. Descriptive Statistics of Dependent Variable

Variable	Observation	Mean	Std. Dev.	Min	Max
Percentage of informal housing	407	0.441	0.28	0.007	1

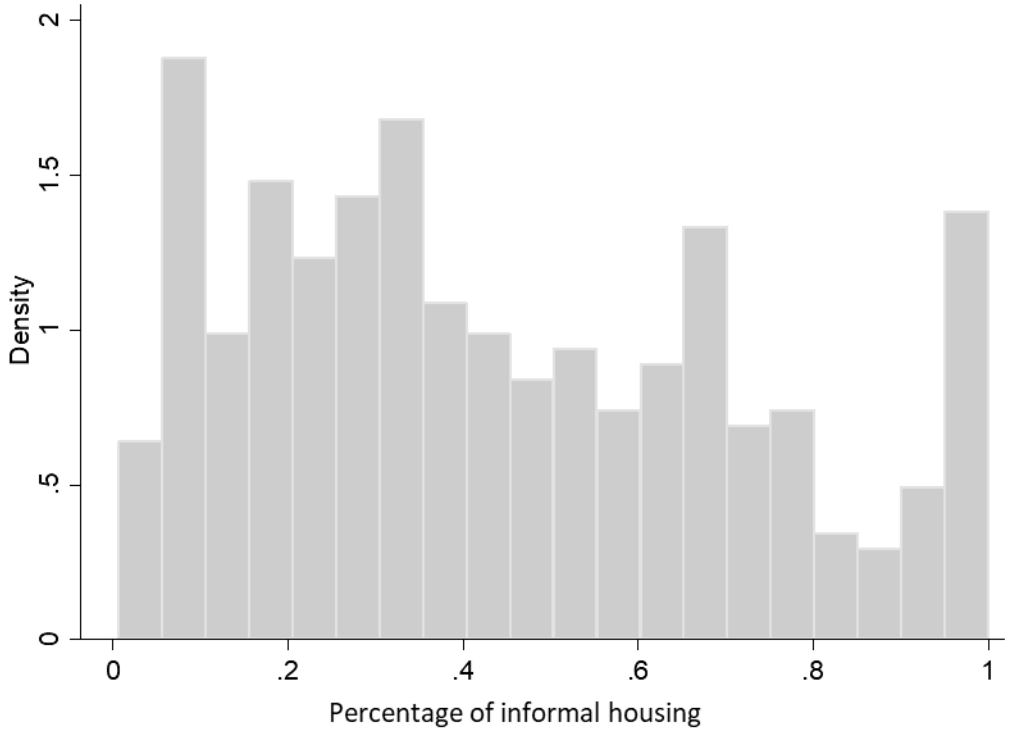

Figure 3.3.2. Histogram of Dependent Variable

3.4 Model Specification

As described earlier, a variety of factors may contribute to the proliferation of informal housing. In my research, I used fractional response regression to study the relationship between informal housing and those independent variables because the dependent variable – share of new informal housing of each city from 2000 to 2010 – ranges from 0 to 1.

Suppose that Y is the share of new informal housing that appeared in each city in California between 2000 and 2010, and X_1, X_2, X_m are factors influencing the degree of informality. Suppose

that there are k independent variables. The general form for fractional response regression is as follows:

$$\ln L = \sum_{j=1}^{N} w_j \, y_j \ln\{G(x'_j\beta)\} + w_j \left(1 - y_j\right) \ln\{1 - G(x'_j\beta)\}$$

where *N* is the number of cities, Y_j is the dependent variable, W_j denotes the optional weights.

3.5 Independent Variables

In the literature review I summarized the potential causes of informal housing. In this part, I will focus on two aspects, namely the supply side and demand side to describe how I used data to quantify the variables mentioned in the literature review (Table 3.5.1 and Figure 3.5.1).

Table 3.5.1. Variable Description

Categories	Variables	Definition	Data Source
Demand side	Africa American population	Percentage of African American population in 2000	US Census Bureau
	Aging	Percentage of aging population in 2000	US Census Bureau
	Hispanic	Percentage of Hispanic population in 2000	US Census Bureau
	Immigrants	Percentage of Immigrants in each city in 2000	US Census Bureau
	Median household income	Median household income of each city in 2000	US Census Bureau
Supply side	Developable land	Percent of developable land of each city in 2010	USGS; SRTM
	Median housing value	Median household income of each city in 2000	US Census Bureau
	Housing number	Total housing units of each city in 2000	US Census Bureau
	Standardized housing increase	Metro housing increase/city housing increase from 2000 to 2010	US Census Bureau; IPUMS
	Single family detached homes	Percent of single-family detached homes in 2000	US Census Bureau
	Vacant housing units	Percentage of vacant housing units in 2000	US Census Bureau
	Owner-occupied housing units	Owner-occupied housing units in 2000	US Census Bureau

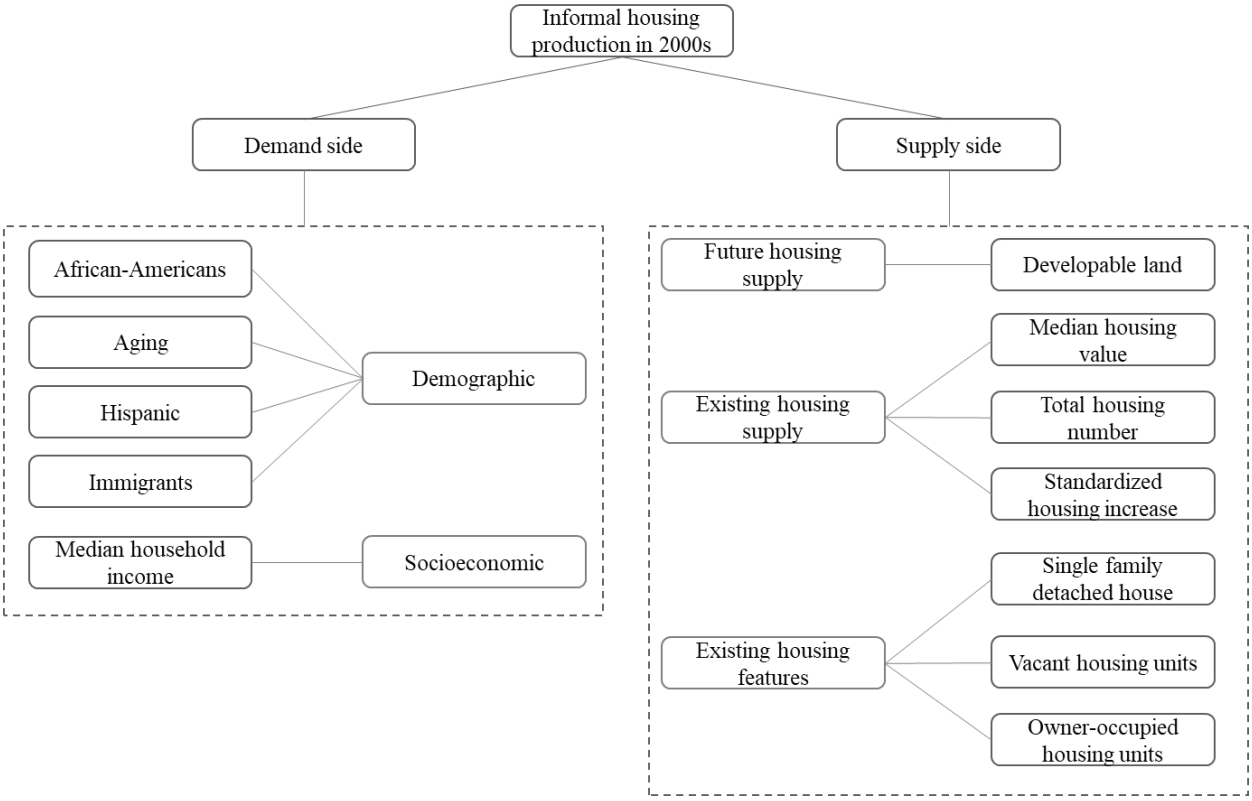

Figure 3.5.1. Independent Variables

3.5.1 Demand Side

In this part I used several indicators to measure people's demand for housing. The natural logarithm of the percentage of residents who were African American in each city in 2000 is the first variable to indicate the demand side. It is believed that communities with a higher share of African Americans may have higher share of informal housing because such communities may experience weaker enforcement of land use and housing regulations than other communities do, and possibly have more informal housing units. Based on people's race, I calculated the natural logarithm for percentage of residents who are African American by the number of African American/ total population in 2000.

The natural logarithm of the percentage of elderly in each city in 2000 is used to show the elderly's influence on the production of informal housing. Communities with higher shares of elderly residents may have more informal housing units because these residents may prefer to live with their children, which requires the homeowners to create more living space to accommodate then. The elderly population is defined as people aged 65 and over (OECD, 2018). Here I calculated the natural logarithm for percentage of the elderly by using the number of aging population/total population.

Natural logarithm of the percentage of Hispanics/Latinos is used to measure the relationship between the share of Hispanics and the production of informal housing. With the tradition of self-built housing and living with families and relatives, communities with higher share of Hispanics possibly produce more informal housing units. Based on people's background, I calculate the natural logarithm of percent of Hispanic by using the number of Hispanic / total population.

The natural logarithm of the percentage of immigrants is used to examine whether immigration may play a role in the production of informal housing. Immigrants may be more likely to living in informal housing units because their unawareness of housing code and lack of housing loans. Based on the information on Nativity provided by IPUMS, people are divided as native or foreign-born. I use number of immigrants/total population to define the percentage of immigrants. Then I used natural logarithm for the percentage.

Natural logarithm of the median household income is used in the demand side to measure economic resources. Based on the data provided by IPUMS, I use the natural logarithm of median household income of each city in California in 2000 to indicate the income disparity.

3.5.2 Supply Side

Regarding the housing supply side, I use developable land to indicate the future housing supply, use median housing value, housing number, standardized housing increase to indicate the existing housing supply, and share of single family, share of vacant housing units, and share of owner-occupied housing units to indicate the existing housing features.

The natural logarithm of the share of developable land in each city is used to examine the land available for future housing development. Cities with crowded city landscape normally have difficulty accommodating more residents. Informal housing may arise if the city population keeps increasing. This variable shows the potential developable land for the cities in California in 2011. As shown in Figure 3.5.2, I used the methods below to get the value of this variable. I downloaded the raster image of the 2011 Land Cover Data with a 30m*30m cell resolution from U.S. Geological Survey (USGS). I also downloaded the raster image of the 2010 Digital Elevation Model (DEM) with a 30m*30m resolution from Shuttle Radar Topography Mission (SRTM).

As shown in Figure 3.5.2, the calculation of developable land considers two factors, the land cover and its elevation. In the land cover, the land is divided into two categories. The first category is the constructed land, such as residential areas, industrial areas, and other human use areas. The second category is unconstructed land, which can also be divided into buildable land and unbuildable land.

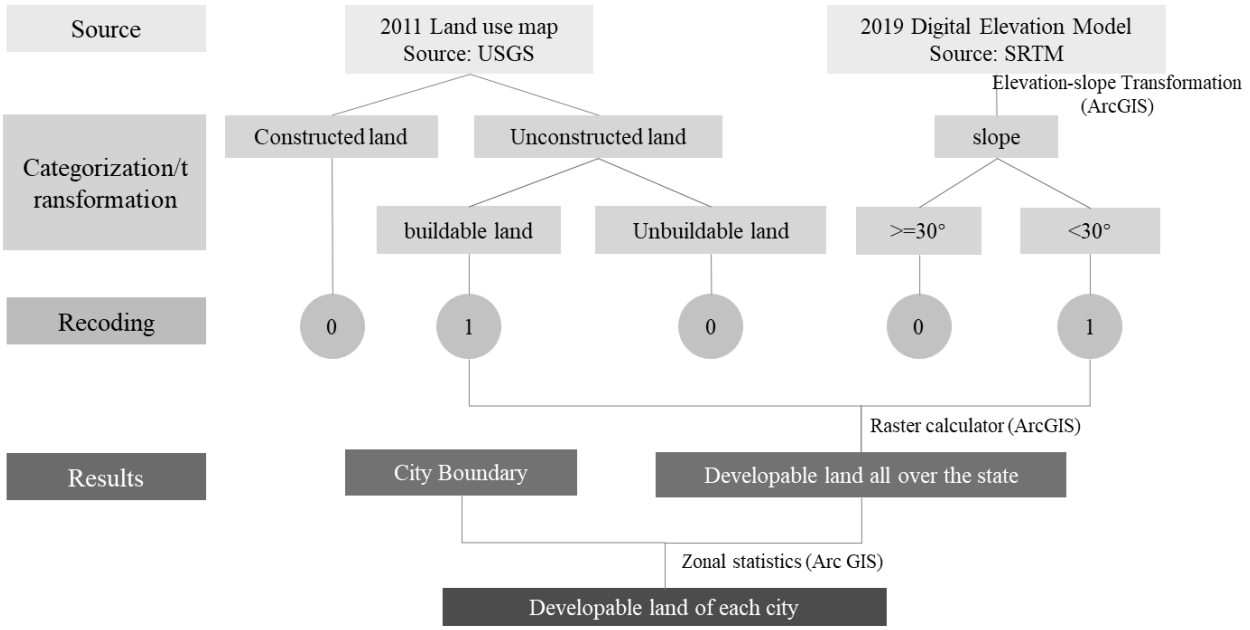

Figure 3.5.2. The Structure of The Calculation of The Developable Land

I recoded all types of land according to the explanation of each type of land provided by USGS. The buildable land under the unconstructed land classification will be marked as 1, and the unbuildable land will be marked as 0. The second type is the elevation data. The slope data is obtained by the elevation-slope transformation from the elevation data in ArcGIS. I stipulated that the undevelopable land has a slope of 30 degrees or over. In actual construction, based on different types of land use, the slope is more demanding. But the mountainous terrain of California leads to some mountainous cities' having little developable land. In order to obtain the possible developable land of these cities to show their differences, I used a more gradual slope to calculate the developable land. Similarly, the attributes of these areas are divided into 0 and 1. Then, the

two types of land (buildable land & land with slope of less than 30 degrees) are overlaid, and the land shown both as 1 is identified as developable land. Finally, the percentage of developable land in each city can be obtained after being combined with the boundaries of the city.

As can be seen from Figure 3.5.3, California's developable land is concentrated in central California and parts of the coastal region. First, much of California's land is occupied by undevelopable land (rivers, forests) and constructed land. The mountains are mainly located on the border between California and Nevada, in northern California (including the large area of national forest, such as Klamath National Forest, Six Rivers National Forest, Shasta-Trinity National Forest, Modoc National Forest, Lassen National Forest, Plumas National Forest, and Mendocino National Park) and some areas along the coast of California (such as Pfeiffer Big Sur State Park and Los Padres National Forest). The constructed land is concentrated in the central part of California and part of the coastal area, but much of the constructed land in the coastal area has been developed (for example, the Los Angeles metropolitan area, the San Francisco metropolitan area, etc.). Thus, the remaining developable land is concentrated in the central and small coastal areas of California.

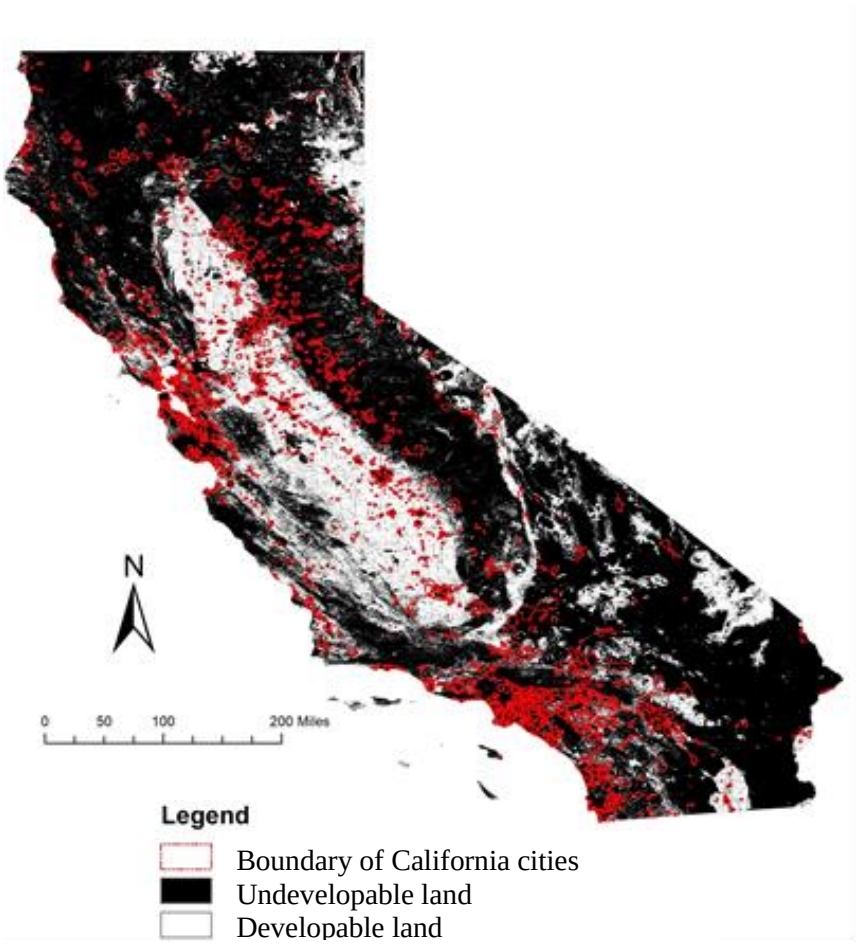

Figure 3.5.3. The Developable Land of Each City in California

Meanwhile, California cities are mainly distributed in areas with much buildable land, and many cities have almost completely utilized the city's buildable land (such as Maywood city, Capitola city, Citrus Heights city, Artesia city, Belvedere city, Emeryville city, Cudahy city, West Hollywood city, Manhattan Beach city, and Hawthorne city). As shown in Figure 3.5.4, those cities' neat road grids, dense building arrangements, and almost exhausted urban green spaces shown in satellite maps suggest the crowded urban landscape is under rapid development. For cities in the central region of California, a considerable number of cities can obtain more land for construction through urban expansion, but coastal cities have insufficient space for future expansion.

Figure 3.5.4. Satellite Map of Maywood City and Artesia City

The natural logarithm of the median value of owner-occupied housing is used to measure the cost of housing units in California cities. People with low income have may have limited ability to enter the formal housing market if cannot afford the high cost of housing. Here I downloaded the data from IPUMS and used the GIS join (FIPS) code to match the city name and its median household value.

The natural logarithm of the total housing number is used on the supply side to measure the availability of existing housing units. Cities failing to provide affordable housing units as needed are likely to produce informal housing, which could be the only option for the extreme low-income residents.

In order to measure cities' relative contribution to regional housing supply, I use the natural logarithm of what I call the "standardized housing increase." To do so, I measured the metropolitan-level increase in housing units from 2000 to 2010 divided by the city's increase in housing units during the same time period. The metro housing increase was obtained by several steps. First, I segmented all California area with the 2010 metro boundary, divided all of California into 39 regions (metro areas), summarized the number of housing units in 2000 and 2010 in each metro area, and calculated the percentage change over that time period. This method does not

consider the increase or decrease in the number of houses in Census-Designated Places (CDPs). I then did the same for each city before dividing the metro-level change by the by the city level change in housing units. This approach normalizes the rate of housing production, thus accounting for the size of the city and the relative change in the number of housing units at the metropolitan level. For example, if the standardized housing increase is larger than 1, it means the housing increase within the city during the 2000s was less than the metro housing increase during the same time period. As a result, cities that fail to provide their fair share of housing are likely to produce informal housing units.

In addition, the share of single-family detached houses, the share of vacant housing units, and the share of owner-occupied housing units are used to measure the characteristics of existing housing. Cities with a higher share of owner-occupied housing units are likely to have lower shares of informal housing, because with fewer rental housing units, cities may be easier to regulate, though could be more expensive to live in. Also, it is believed that communities with a high share of vacant housing units are likely to produce informal housing units because the vacant housing provides space for informal activities to happen, such as conversion or squatting.

3.6 Data Preprocessing of Independent Variables

The dependent variable, the share of newly built informal housing units from 2000 to 2010 (n=416), excludes cities that incorporated between 2000 and 2010. Further, the entire dataset is the integration of the time periods of the data for 1990, 2000, and 2010. That leads to the fact that 8 observations are missed during the matching process because in 1990-2000, 1) the city's code changed because the city was incorporated, disappeared, or any other changes (n = 4) (e.g. Lake Forest city; Calabasas city; Malibu city; Menifee city); 2) city name changed (n = 1); and 3) the data was unmatched because of code error (n = 4). I will use 407 records to do the further analysis.

In this part, I 1) examined the data with descriptive statistics to find some extreme values, and then looked into other academic sources to confirm if it was an error; 2) verified the distribution and accuracy of the data with histograms and box plots; 3) tested the relationship between each independent variable and dependent variable with scatter plots; 4) defined and removed outliers; and 5) conducted data transformations for the independent variables.

Table 3.6.1. Descriptive Statistics

	Descriptive statistics for the original dataset						Descriptive statistics after natural log transformation				
Variable	Obs	Mean	SD	Min	Max	Unit	Obs	Mean	SD	Min	Max
Aging	408	0.120	0.058	0.034	0.462	%	408	-2.219	0.438	-3.390	-0.772
African American population	408	0.041	0.060	0.000	0.471	%	404	-3.946	1.236	-7.283	-0.752
Hispanic	408	0.297	0.241	0.022	0.974	%	408	-1.580	0.918	-3.839	-0.026
Immigrants	408	0.216	0.130	0.000	0.575	%	407	-1.736	0.700	-4.360	-0.553
Median household income	408	52375.43	25884.12	19863	200001	$	408	10.774	0.412	9.897	12.206
Developable land	408	0.133	0.150	0.000	0.788	%	398	-2.981	1.797	-10.350	-0.238
Median housing value	408	258024.8	203231.9	50200	1000001	$	408	12.231	0.650	10.824	13.816
Housing number	408	22767.09	75310.77	26	1337706		408	9.075	1.396	3.258	14.106
Standardized housing increase	405	3.711	19.897	-44.007	277.930		390	0.416	1.063	-2.620	5.627
Single family detached homes	408	0.623	0.157	0.062	0.996	%	408	-0.513	0.309	-2.773	-0.004
Vacant housing units	408	0.060	0.076	0.011	0.731	%	408	-3.160	0.727	-4.481	-0.314
Owner-occupied housing units	408	0.611	0.142	0.160	0.956	%	408	-0.524	0.259	-1.833	-0.045

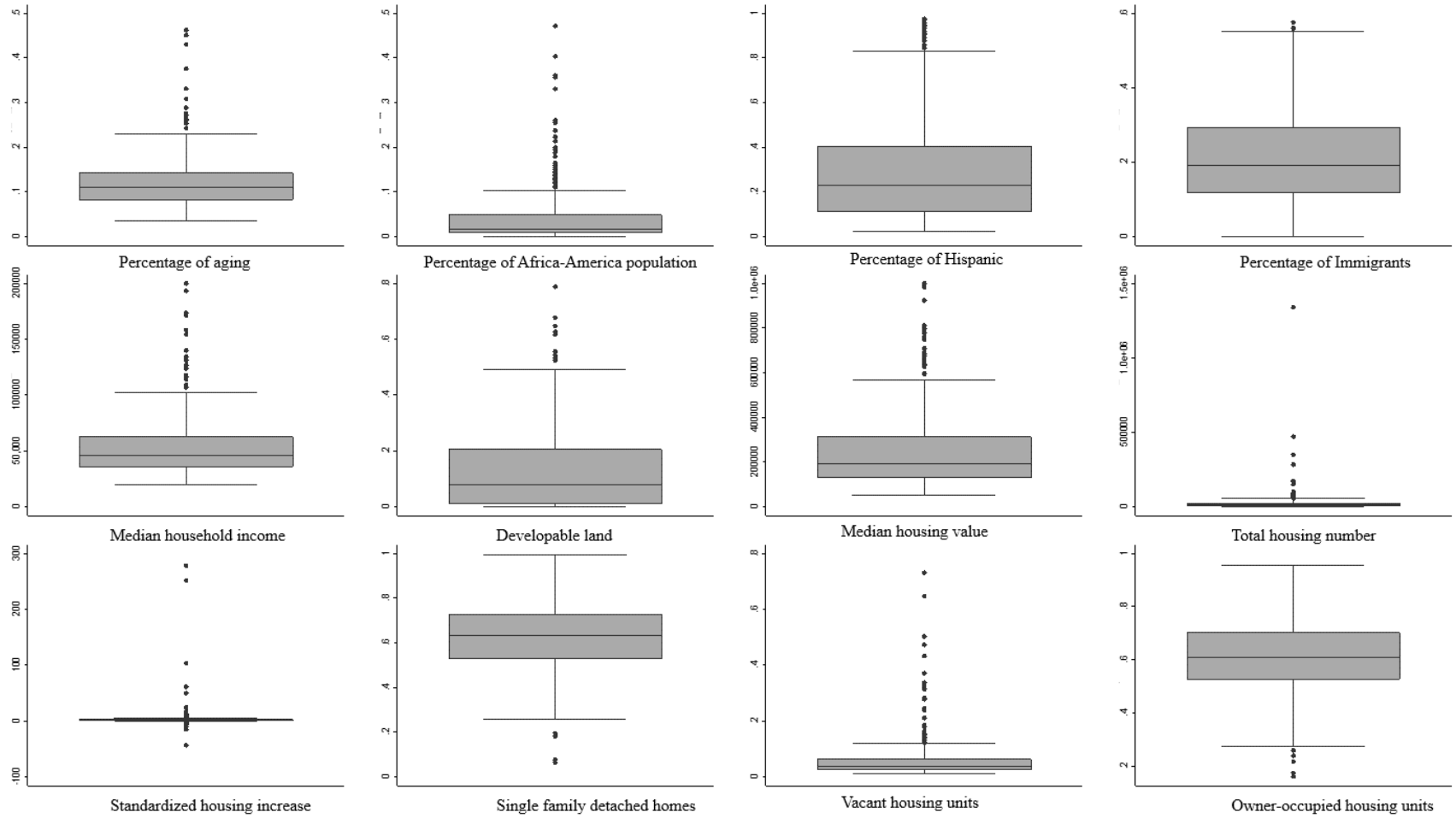

Figure 3.6.1. Box Plots for All Independent Variables

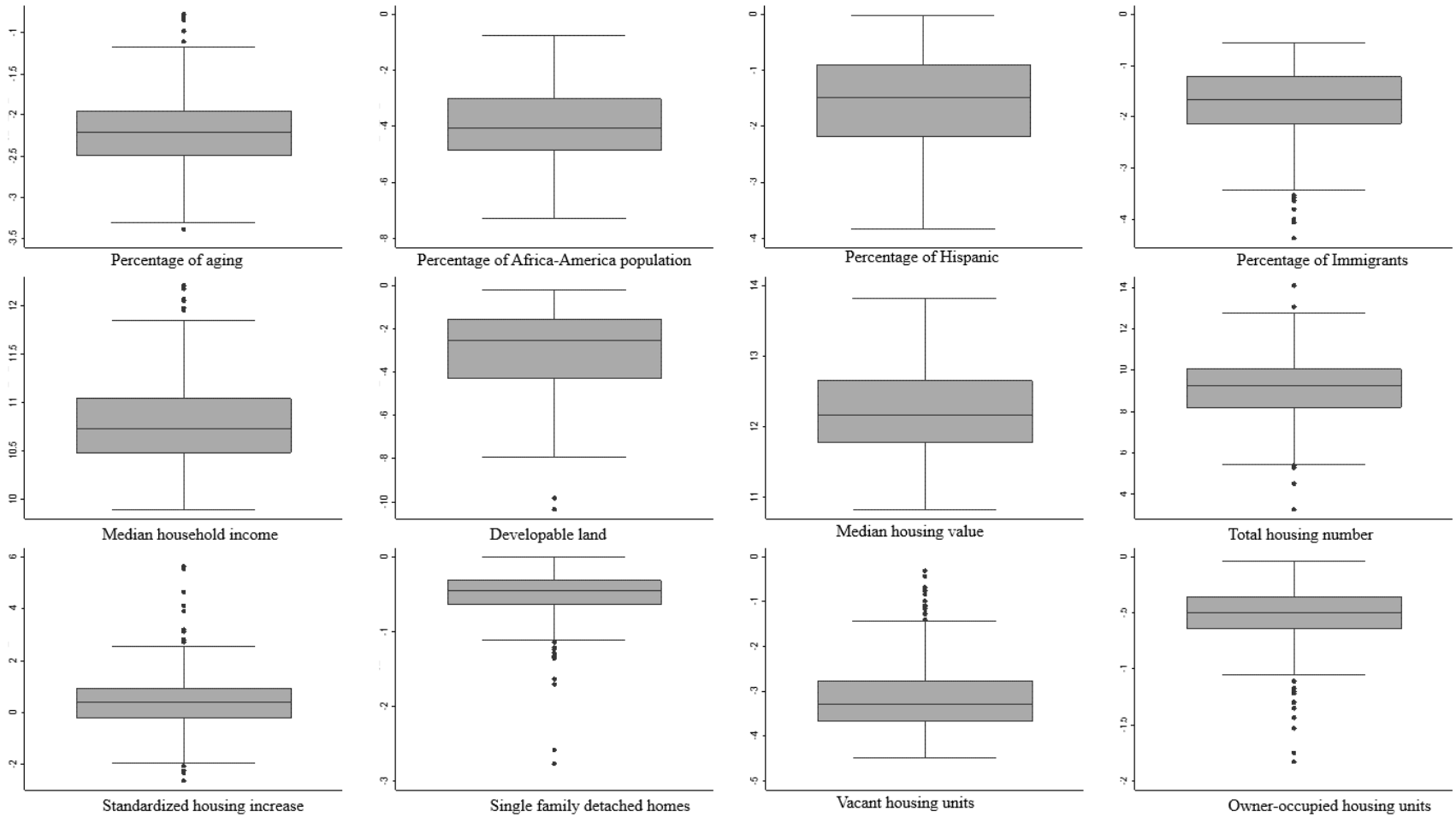

Figure 3.6.2. Box Plots for All Transformed Independent Variables

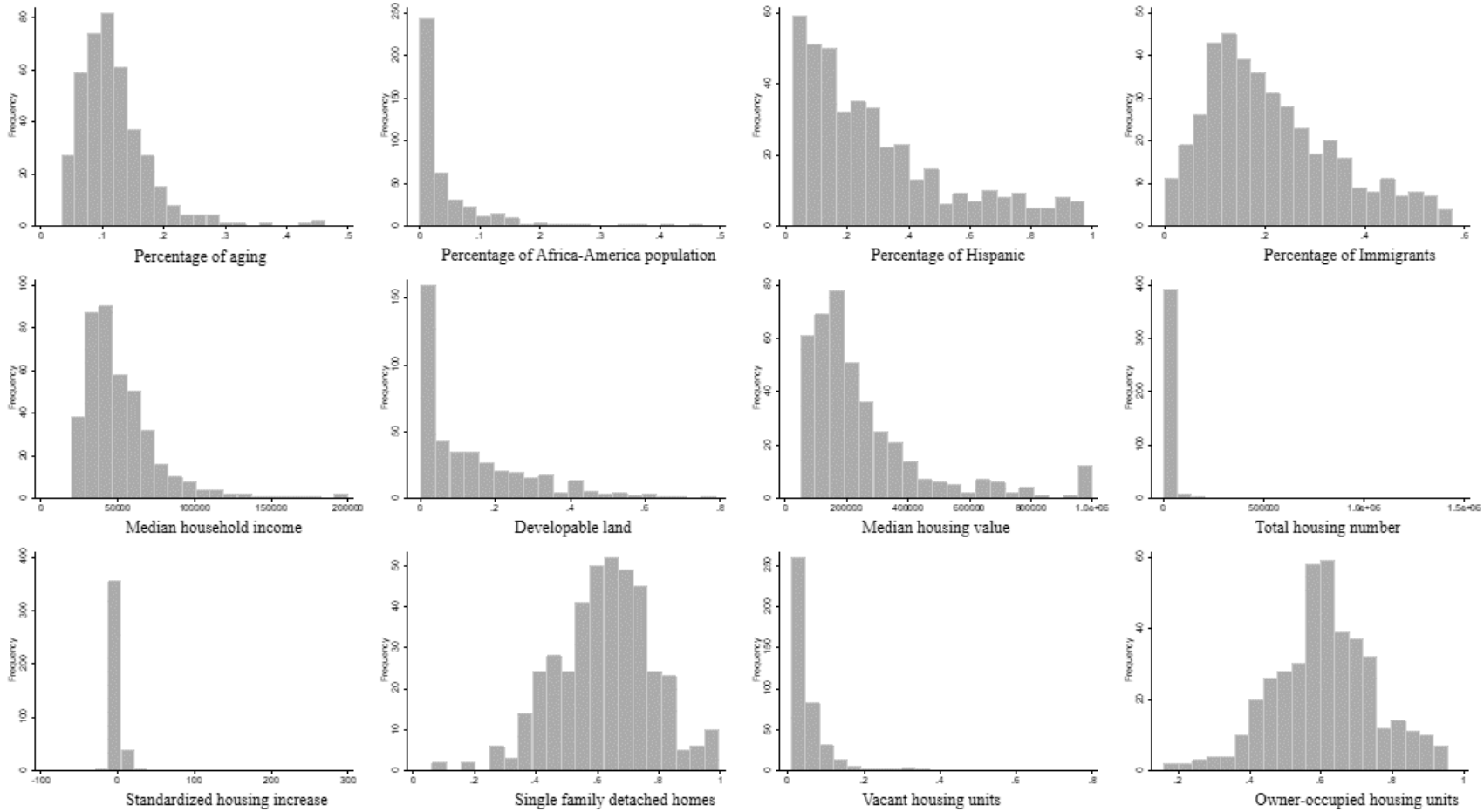

Figure 3.6.3. Histograms for All Independent Variables

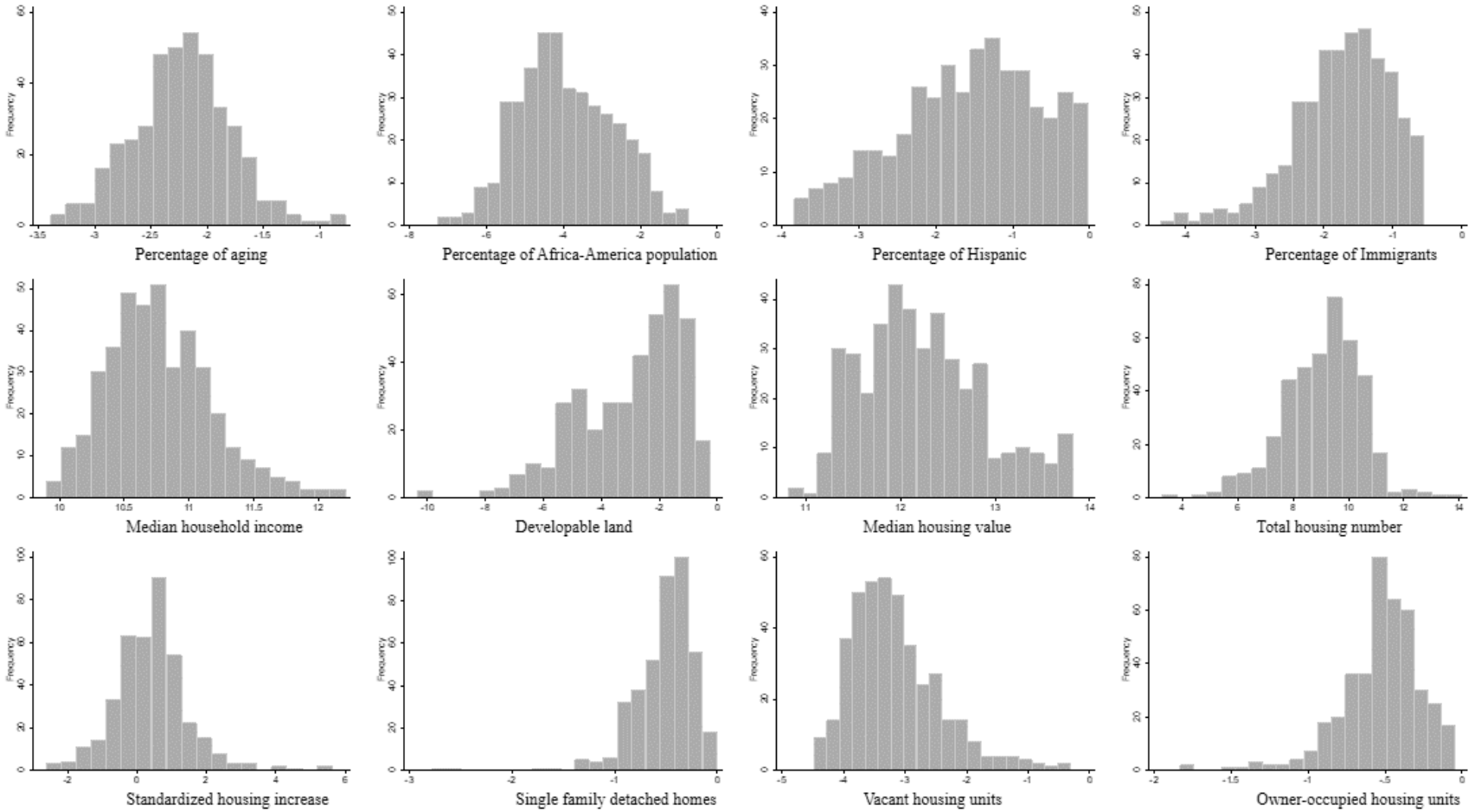

Figure 3.6.4. Histograms for All Transformed Independent Variables

Based on this process, one thing to notice is that no outlier is defined after I used the natural log to transfer the data. Outliers are defined as values more than the upper hinge + 1.5 Interquartile Range (IQR) or less than the lower hinge – 1.5 IQR (Tukey, 1977). As shown in the Figure 3.6.1, there are a considerable number of outliers in the original data, but not after transformation. One good example is the median housing value in each city. The maximum median housing price displayed by IPUMS in 2000 is $1,000,001 (11 observations in my dataset share the same maximum price). Zillow's data shows that the actual median housing prices in those cities are far more than one million. But those data are not outliers after transformation using the natural log. Similarly, Figure 3.6.2 suggests only a few outliers exist, and some of them are still close to the upper range or the lower range. Thus, I decided to keep all the observations.

The other thing to notice is that conducting data transformation is feasible when the value of the original data is a percentage. As shown in the Figure 3.6.3, most of the variables are right-skewed, instead of in a normal distribution. This tends to lead to ambiguous relationships between independent and dependent variables in the model. In this way, transforming the data to be normally distributed is preferred. What's more, such a data transformation method is equally applicable to an independent variable whose value is a percentage (Wooldridge, 2013). Thus, more than half of the variables are transformed in my model (Figure 3.6.4).

CHAPTER 4. RESULTS & DISCUSSION

4.1 Introduction

Informal housing, defined as construction built without building permits or land-use approvals, is a significant phenomenon in California cities. In this research, I focus on informal housing produced at the city level in California from 2000 and 2010 and examine the potential causes of this type of development. Previous scholars' research has examined the potential causes of informal housing, and for this study I used a two-part typology to summarize them: supply side and demand side. After collecting data, fractional response regression was used to analyze these typologies. For the demand side, I emphasized two main topics to interpret my results: demographic and socioeconomic factors. Similarly, potential future housing provisions, current housing provisions, and current housing characteristics were the three main concepts that emerged for the supply side.

In my analysis, I used two models, as well as marginal effects plots, to examine the causes of informal housing. Results are presented in Table 4.1.1. Using two models enabled me to compare control for additional demographic factors that might shape patterns of informal housing production. For variables that showed a significant relationship with informal housing production, I used marginal effects plots, which are all based on the Model 2, to further examine the relationship between the dependent variable and independent variables. Then I compared my results with my hypothesis and previous literature before providing my own explanation.

Table 4.1.1. Fractional Response Regression Results

	(1) Percent of informal housing from 2000 to 2010	(2) Percent of informal housing from 2000 to 2010
Natural logarithm for percent of aging in each city in 2000	-0.011	-0.137
	(0.195)	(0.213)
Natural logarithm for percent of immigrants in each city in 2000	0.045	0.343*
	(0.100)	(0.133)
Natural logarithm for median household income in each city in 2000	-0.860+	-1.477**
	(0.470)	(0.507)
Natural logarithm for percent of developable land of each city in 2010	-0.159***	-0.147***
	(0.044)	(0.043)
Natural logarithm for median housing value of each city from 2000 to 2010	0.637*	0.682*
	(0.270)	(0.307)
Natural logarithm for total housing number of each city from 2000 to 2010	-0.261***	-0.270***
	(0.051)	(0.056)
Natural logarithm for standardized housing increase of each city from 2000 to 2010	0.200***	0.191**
	(0.059)	(0.058)
Percent of single family detached homes in 2000	-0.290	-0.097
	(0.719)	(0.733)
Percentage of vacant housing units in 2000	-0.452	-0.460
	(0.867)	(0.918)
Percentage of owner-occupied housing units in 2000	0.060	0.473
	(0.927)	(0.983)
Natural logarithm for percent of Black in each city in 2000		0.117*
		(0.058)
Natural logarithm for percent of Hispanics in each city in 2000		-0.403**
		(0.143)
Constant	3.234	9.138**
	(2.235)	(2.823)
N	379	376
R^2	0.0495	0.0539

Standard errors in parentheses

+ $p < .1$, * $p < .05$, ** $p < .01$, *** $p < .001$

The natural logarithm transformation leads to the infinitely small value if the original value is zero, which cannot be recognized by Stata when running the regression. Thus, some variables lose several pieces of data.

The values in parentheses suggest the standard error of coefficients, which show an estimate of the standard deviation of the coefficient.

4.2 Demand Side

Informal housing becomes a logical response when the formal housing market fails to meet the growth of housing demands (Nassar & Elsayed, 2018; Ward, 2004). In this part I focus first on the demand side, examining its relationship with informal housing production. Then I categorize the variables and use two topics – demographic and socioeconomic factors – to frame my findings. The results show that the share of immigrants has a positive association with the production of informal housing when the share of Hispanics is controlled for; the share of African Americans is also positively associated with informal housing production; lastly, people's lack of income appears to be one of the main contributors to informal housing production.

Cities with a higher percentage of African Americans appear to have a higher share of informal housing. As shown in Model 2, the coefficient of African American is 0.117 and is significant at the .05 level. Because this is a fractional response regression model, interpreting the coefficients is challenging. I therefore use marginal effects plots, as shown in Figure 1, to visualize the relationship between the share of African Americans and informal housing production. The starting point indicates that cities with the lowest percentage of African Americans (0.06%, ln 0.0006 = -7.3) have the lowest share of informal housing (35%). As the share of African Americans in the city increases by 1 unit on a natural log scale, the share of informal housing increases by 0.03. When the city's percentage of African Americans is close to 1 (ln 1 = 0), the share of newly built informal housing from 2000 to 2010 is at its highest level, which is 55%.

This result is consistent with previous scholars' findings that African American neighborhoods tend to have higher shares of informal housing. Population shifts that occurred in California in the 1960s left African American neighborhoods isolated, especially in southern California (Wilson 2012; Wacquant 2008). Due to the limited law enforcement found in these

areas, African American communities were less regulated and featured higher crime rates (ibid.), which also resulted in the production of illegal housing types, such as overcrowding or housing conversions (e.g., transforming non-residential space into living quarters). Moreover, California municipalities' efforts to exclude low-to-moderately-priced dense rental housing led to a "chain of exclusion", which negatively influenced the low-income African American renters hoping to find affordable living space in desirable locations (Pendall, 2000). The overt and subtle discrimination that African Americans met as a result of these policies prevented them accessing respectable housing units (Department of Housing and Community Development - State of California, 2018). Under these conditions, illegal dwellings are more accessible for earners facing rental discrimination (Gurran, Pill, & Maalsen, 2019). My analysis adds support for the conclusion that informal housing is more common in African American cities.

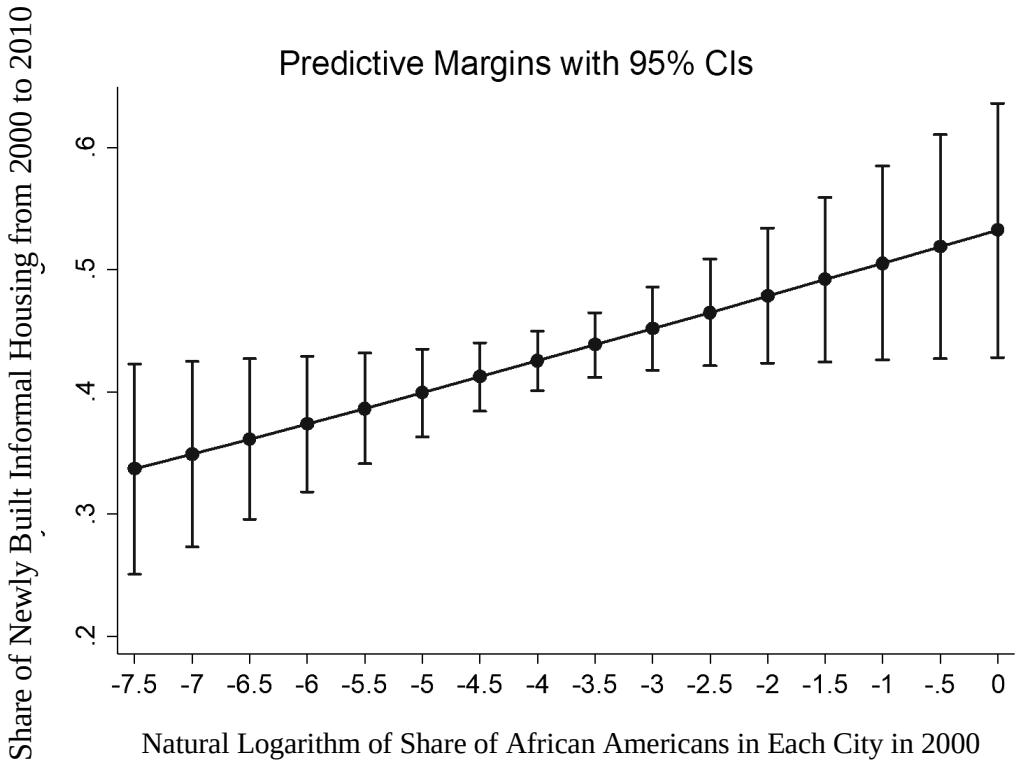

Figure 4.2.1. The Margin Plot between Share of African Americans in Each City in 2000 and Share of Newly Built Informal Housing in California

There appears to be a complicated relationship between various demographic factors and the production of informal housing in California. For example, in Model 1 the share of immigrants is not significant at the .05 level. However, after controlling for the share of Hispanics and African Americans in Model 2, the coefficient for the share of immigrants increases in magnitude and is statistically significant. This suggests that cities with high shares of immigrants have higher rates of informal housing production once the racial and ethnic composition of these cities are controlled for. Notably, however, after controlling for the share of immigrants, the share of Hispanics is negatively associated with informal housing production. Cities with fewer Hispanics have more informal housing production, which could be counterintuitive. As shown in Model 2, the coefficient of Hispanics is -0.403 and is significant at the 0.01 level. As shown in Figure 4.2.2, the

starting point indicates that cities with the lowest share of Hispanics (2.1%, ln 0.021 = -3.8) have the highest share of informal housing (65%). As the share of Hispanics in the city increases by 0.1 unit on a natural scale, share of informal housing decreases by 15%. When the city's share of Hispanics is close to 1 (ln 1 = 0), the share of newly built informal housing from 2000 to 2010 is at its lowest level, which is 30%. That is to say, once the share of immigrants is controlled for, the share of Hispanics appears to have a negative association with informal housing production.

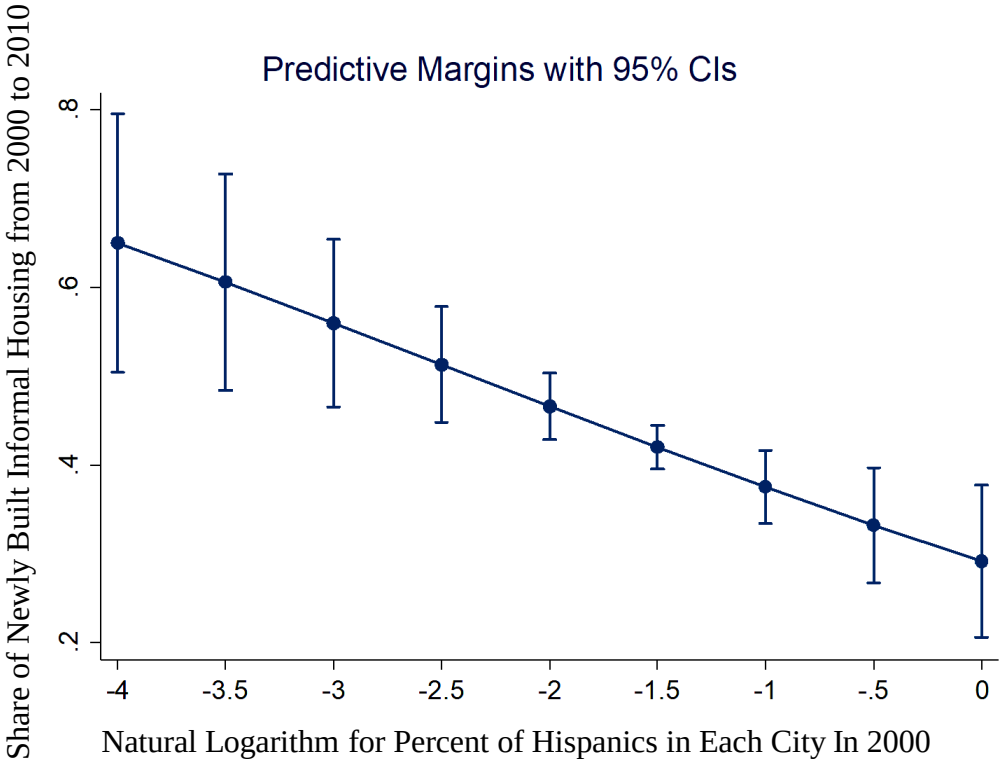

Figure 4.2.2. The Margin Plot between Share of Hispanics in Each City in 2000 and Share of Newly Built Informal Housing in California

The models also suggest that cities with more immigrants may have higher shares of informal housing. As shown in Table 1, the coefficient of immigrants is not significant. After adding two variables (African American and Hispanics) to Model 1, immigrants in Model 2 has coefficient of 0.343 and is significant at the 0.05 level. As shown in Figure 4.2.3, the starting point

indicates that cities with the lowest share of immigrants (0.012, ln 0.012 = -4.36) have the lowest share of informal housing (25%). As the share of immigrants in the city increases by 0.1 unit on a natural log scale, the share of newly built informal housing increases by 8%. When the share of immigrants reaches 58% (ln 0.58 = -0.55), the share of newly built informal housing is at its highest level, which is 50%.

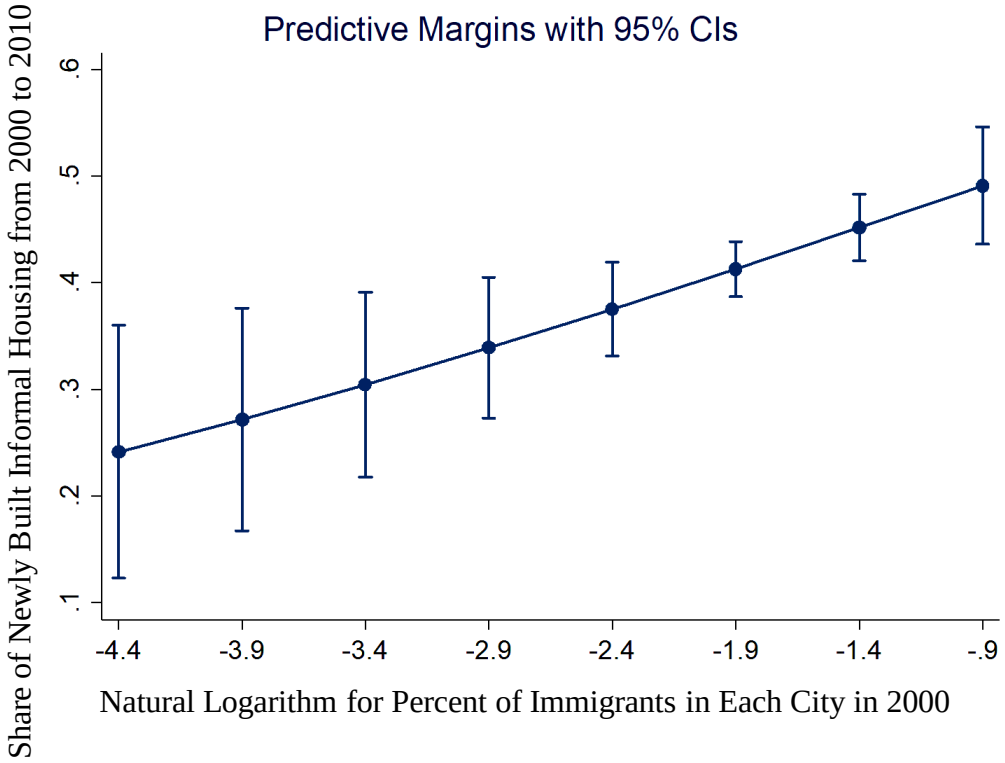

Figure 4.2.3. The Margin Plot between Share of Immigrants in Each City and Share of Newly Built Informal Housing in California

Table 4.2.1. Correlation Analysis between Percentage of Hispanic, Percentage of Immigrants, and Percentage of Overcrowding Families

	Percentage of Hispanic	Percentage of immigrants	Percentage of overcrowding families
Percentage of Hispanic	1	-	-
Percentage of immigrants	0.6539	1	-
Percentage of overcrowding families	0.8846	0.7893	1

I use correlational analyses to further examine this relationship. The coefficient shown in Table 4.2.1 indicates that there is a positive relationship between the percentage of Hispanics and the percentage of immigrants. But based on my results, immigrants and Hispanics may have distinct associations with the production of informal housing. Controlling for these both immigration status and ethnicity may be important for accounting for such differences. For example, although many Hispanic residents in California may be immigrants, and informal housing may be more common in immigrant communities (as my results suggest), non-immigrant Hispanic communities may in fact be less likely to have high rates of informal housing production.

Regarding the potential socioeconomic drivers of informal housing production, my analysis suggests that income is negatively related to share of newly built informal housing from 2000 to 2010, which means that people's lack of income may contribute to the production of informal housing. As shown in Model 1 and Model 2, the coefficient of median household income is -0.860 and -1.477, and is significant at the 0.10 and 0.05 levels, respectively. As shown in Figure 4.2.4, cities with median household incomes of $20,000 (ln 20,000 = 9.8) had shares of informal housing of approximately 75% between 2000 to 2010, which is at the highest level. As median household income increases by 1 unit on a natural log scale, the share of newly-built informal housing decreases by 15%. When median household income reaches $134,270 (ln 134270 = 12.2), the share of newly built informal housing is about 10%, which is at its lowest level. Such evidence is consistent with previous scholars' conclusions that informal housing is weighted toward the lower end of the market (Baer, 1986; Bohn & Danielson, 2016; Ward & Peters, 2007; Wegmann & Mawhorter, 2017). Baer (1986) estimated that "shadow housing market" – another term for informal housing at that time – accounted for 40% of additional housing stock from 1970 to 1980

used by low-income individuals. Even thirty years later, a lack of income appears to influence a person's capacity to buy a house, and it is still one important factor leading to production of informal housing.

Previous scholars found that informal housing production was associated with lower household incomes at the city level in the 1990s and 2000s (Wegmann & Mawhorter, 2017). According to the U.S. Department of Housing and Urban Development's definition of affordable housing (2016), housing is considered affordable when a person pays no more than 30% of income toward housing costs, including utilities. The housing price in 303 cities in my dataset is viewed as not affordable, accounting for about 75%, as shown in Figure 4.2.5. My results illustrate that an individual's lack of ability to buy house may lead them to seek out informal housing units, which is cheaper.

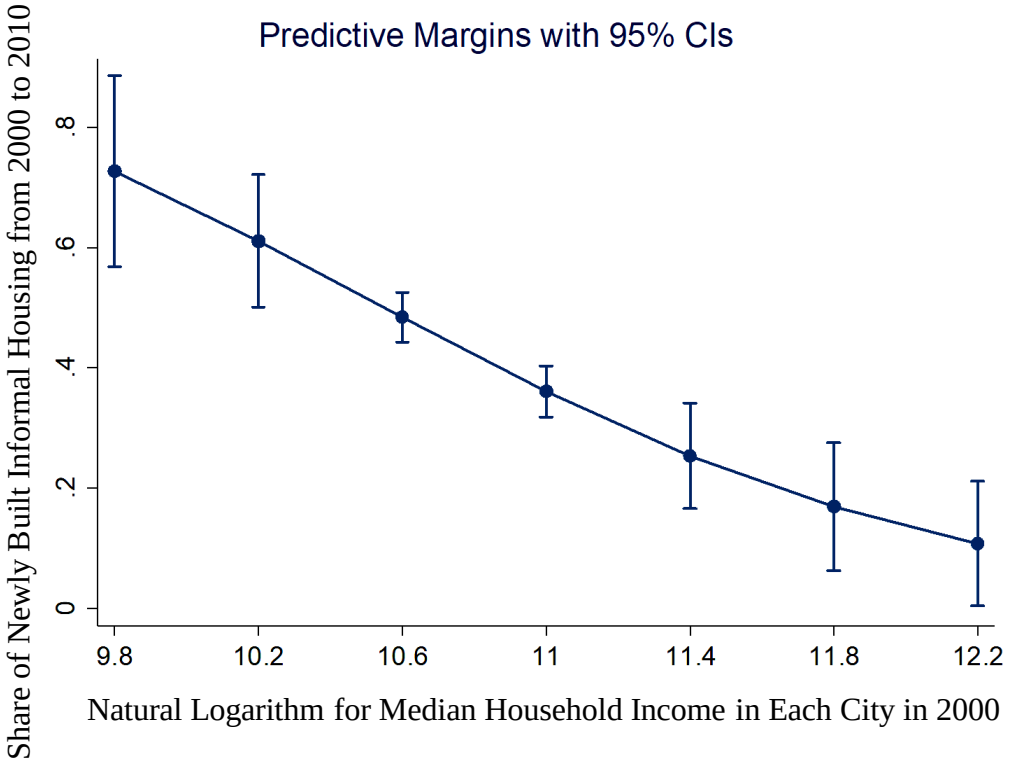

Figure 4.2.4. The Margin Plot between Median Household Income in 2000 and Share of Newly Built Informal Housing in California

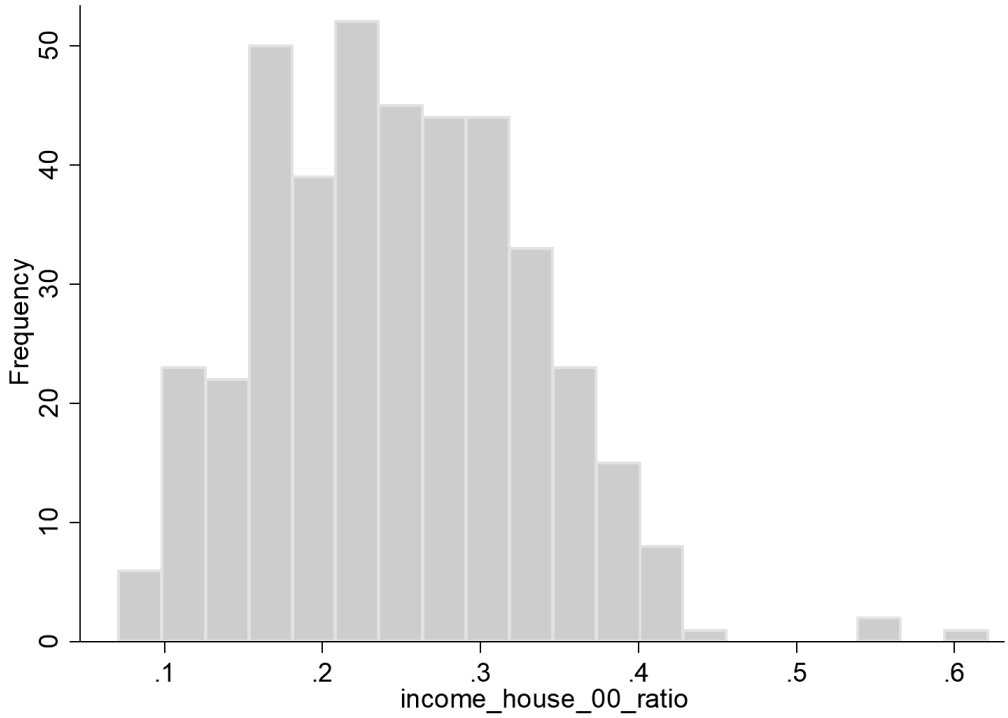

Figure 4.2.5. The Histogram of Ratio of Income and Housing price

To summarize, demand-side factors appear to be associated with informal housing production. Specifically, demographic factors indicate the demanding need for living space, while the socioeconomic factor suggest people's lack of income to afford living/renting a home, which finally leads to the production of informal housing in the 2000s.

4.3 Supply side

The supply side captures the housing provision by the government and private market. The constrained housing market may lead to the lack of living space (Wegmann & Mawhorter, 2017). In this section I used three topics to measure the California housing supply, namely, cities' potential future housing provision, existing housing provision, and existing housing conditions. The results show that housing provision is closely related to the production of informal housing, while existing housing conditions is not.

Cities' lack of future housing provision may lead to production of informal housing. I used the percentage of developable land in each city in 2010 in this research to capture the future land supply. Developable land entails the potential area for construction. As shown in Model 1 and Model 2 in Table 1, the coefficient of developable land is -0.159 and -0.147, and are both significant at the 0.001 level. As shown in Figure 4.3.1, the starting point shows that cities with no developable land in 2010 have the highest share of informal housing production from 2000 to 2010, accounting for about 70% of total housing units. As the share of developable land increases by 1 unit on a natural log scale, share of newly built informal housing decreases by about 5%. When the share of developable land reaches 80% (ln 0.8 = -0.2), which means more than half of the city land is developable, the share of newly built informal housing decreases to its lowest value at about 35%. This research is in line with previous scholarship. Holding sufficient developable land ensures a city's future construction and helps the city accommodate projected population and employment growth to avoid the displacement of growth to other regions (Paulsen, 2011). However, the mountainous terrain and a large amount of national forests restricts growth in many cities in central California. The land covered by construction also indicates that not so much area remains to be developed in the coastline area, which align with Wegmann and Mawhorter's findings that informal housing occurs mainly in the big cities and their surrounding cities along the coastline. The lack of developable land in 2010 indicates the limited future housing provision, affects the housing supply, and finally leads to the production of informal housing in the 2000s.

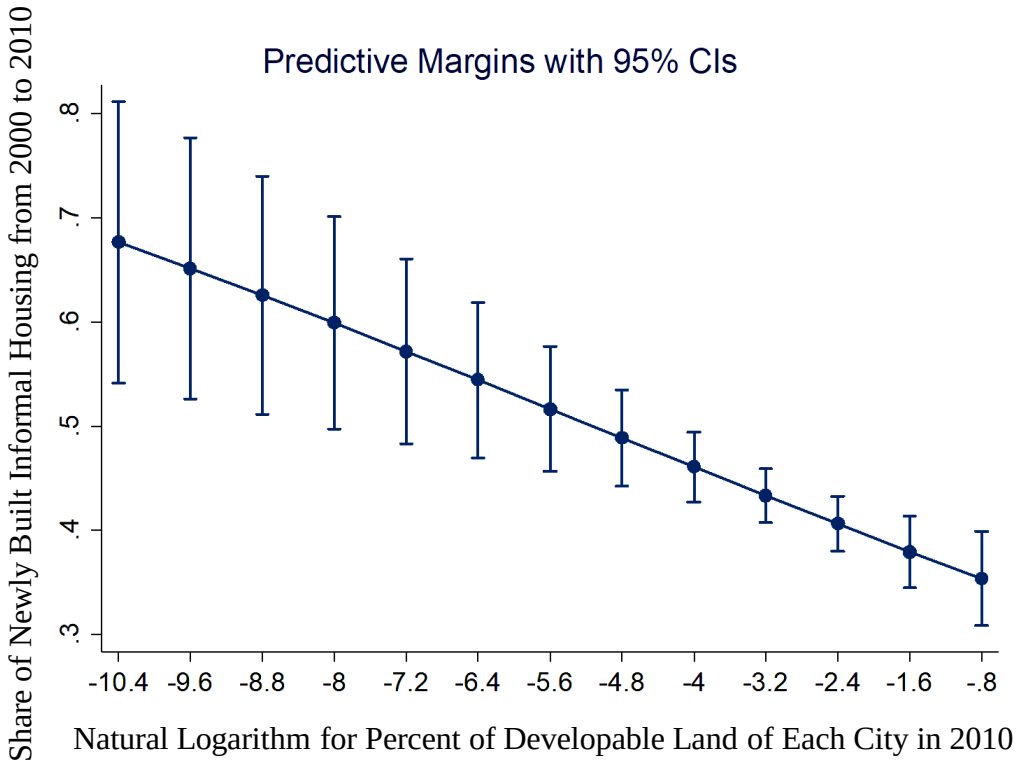

Figure 4.3.1. The Margin Plot between Share of Developable Land and Share of Newly Built Informal Housing in California

Cities' future housing provision influences the production of informal housing. Similarly, cities' existing housing provision also constitutes the supply side and appears to influence the production of informal housing. Cities with a shortage of affordable housing supply tend to have higher rates of informal housing production. In this section, I used three variables – median housing value, total housing number, and standardized housing increase – to indicate the city's insufficient housing provision.

High housing value lead to less affordable housing options; the supply of low-cost housing failed to meet the demand for it. The coefficient of median housing value in 2000 is 0.637 and 0.682 and is both significant at 0.05 level. To interpret the results from the fractional response regression model, I used marginal effects plots to show the relationship between median housing

value and share of newly built informal housing. The starting point represents that the lowest housing value for cities at approximately $50,200 (ln 50200 = 10.8); the share of informal housing production in such cities is 25%, which is also at its lowest level. As median housing values increase by 0.1 units on a natural log scale, the share of newly built informal housing increases by 4.5%. In cities with the highest median housing value ($983,000, ln 983000 = 13.6), the share of informal housing is 65%, at its highest level. The increasing housing price makes fewer people able to afford them. The California Association of Realtors estimated that only 34% of households in California can afford to purchase the median-priced home in the state in 2016 (Department of Housing and Community Development - State of California, 2018). Moreover, the rental fee is also trending upward because the need for rental housing stayed strong from 1990 to 2014, even when adjusting for inflation (California Department of Housing and Community Development, 2016).

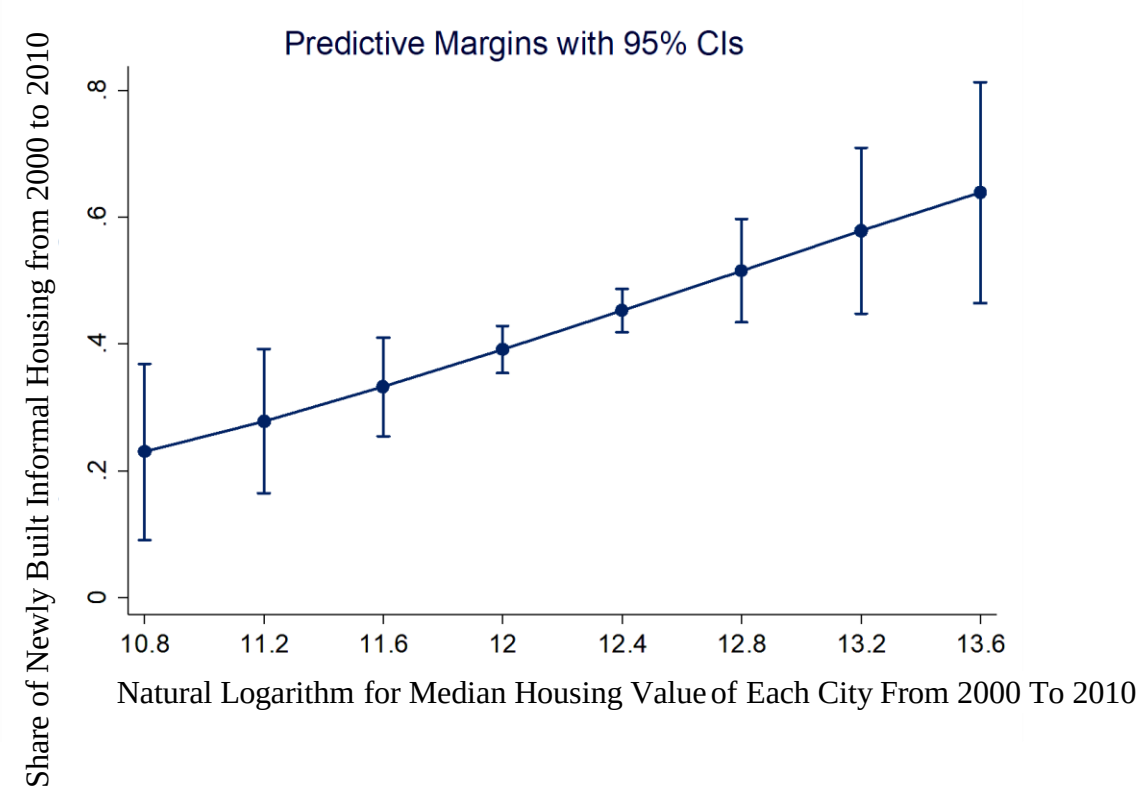

Figure 4.3.2. The Margin Plot between Median Housing Value and Share of Newly Built Informal Housing in California

Limited housing stock provides few housing units for new residents, which also results in production of informal housing. The coefficient of total housing number is -0.261 and -0.270 in Model 1 and Model 2 in Table 1, both significant at 0.001 level. As shown in Figure 4.3.3, the starting point represents a city with 26 housing units has 75% of informal housing production, which is at the highest level. As the number of total housing units increases by 1 unit on a natural log scale, the share of newly-built informal housing decreases by 6%. In the city with the most housing units (1,337,706. ln 1337706 = 14.1), the informal housing production decreases to its lowest level at 20%.

In agreement with other scholars' conclusions, my analysis suggests that a lack of housing units to a great extent influences the production of informal housing. As claimed by California Housing Partnership, 759,000 affordable units were lacked in Los Angeles, Orange, Riverside, and San Bernardino counties in 2017; less than a third of low-income families have access to affordable housing (California Housing Partnership, 2019). Moreover, unstable funding for affordable-home development makes less affordable housing units provided. The state and federal funds for building or preserving low-income housing in the four-county region decreased by almost $ 900 million (75%) from 2009 to 2018 (California Department of Housing and Community Development, 2017; California Housing Partnership, 2019). More than 1.8 million housing units are needed to address the household growth in California from 2015 to 2025, as predicted by California department of Housing and Community Development (Department of Housing and Community Development - State of California, 2018). Besides the housing shortage, the lengthy development review, lack of certainty at the local level of where and what is economically and

politically feasible to build, and local opposition make the periods longer to build the new housing units (ibid.). People without proper living space will turn to "shadow housing market". Lack of housing units led to the informal housing production in the 2000s, it is also impinging the future housing market.

The two variables above show the tight housing market in California. Scholar's argument focuses on the short supply of low-cost housing. Though my research does not cover the variable of number of low-cost housing units, it still shows the significant relationship of housing price and housing number.

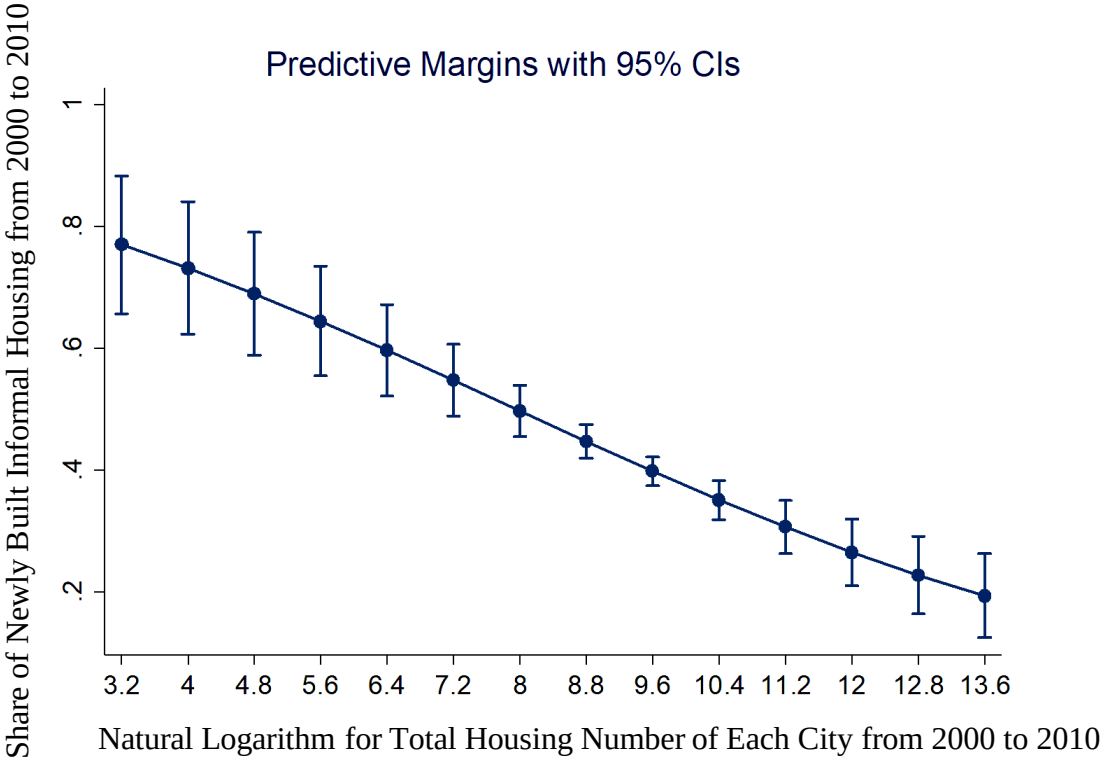

Figure 4.3.3. The Margin Plot between Total Housing Units and Share of Newly Built Informal Housing in California

In addition to the two variables of housing provision, I want to further research whether the imbalance of housing provision between the metro area and city influences the production of

informal housing. I therefore used what I call the "standardized housing increase (metro housing increase/city housing increase) to measure the changes in the number of housing units at the city level relative to the change in the number of housing units across the broader metropolitan area. My analysis suggests that cities that provided fewer housing units than other cities in the same metro area had higher rates of informal housing production. The coefficient of standardized housing increase from 2000 to 2010 is 0.200 and 0.191 in Model 1 and Model 2, respectively, in Table 1 and are significant at the 0.001 and 0.01 levels. As shown in Figure 4.3.4, the starting point represents the lowest standardized housing increase is 0.073 (ln 0.073 = -2.6), which means the city's permitted housing increase is 14 times larger than the metro housing increase (1/0.073 = 14). Such cities had the lowest share of informal housing production compared with other cities. As the standardized housing increase increases by 0.1 unit on a natural scale, the share of newly built informal housing increases by 7.5%. In cities with the highest standardized housing increase (metro housing increase/city housing increase = 278; ln 278 = 5.2), share of informal housing is 65%, also at its highest level. In other words, the end point means the housing increase of metro area far exceeds the city's housing increase, and thus the city fails to provide if fair share of housing, resulting in its high informal housing production.

Previous scholars focused on the provision of housing in individual cities and found that the lack of housing in a single city led to the production of informal housing (Wegmann & Mawhorter, 2017). However, people tend to commute between cities to seek for affordable living space (Kneebone & Holmes, 2015). Therefore, housing pressure in cities is dispersed in surrounding cities. In addition, due to industrial expansion, or the impact of the industrial chain, employment opportunities in large cities will also spill into the surrounding small cities (Kotkin, 2015). Thus, standardized housing increase examine if the city increases the equal share as the

metro area. According to my results, cities that fail to provide equal percentage of housing units as the metro area have higher rates of informal housing.

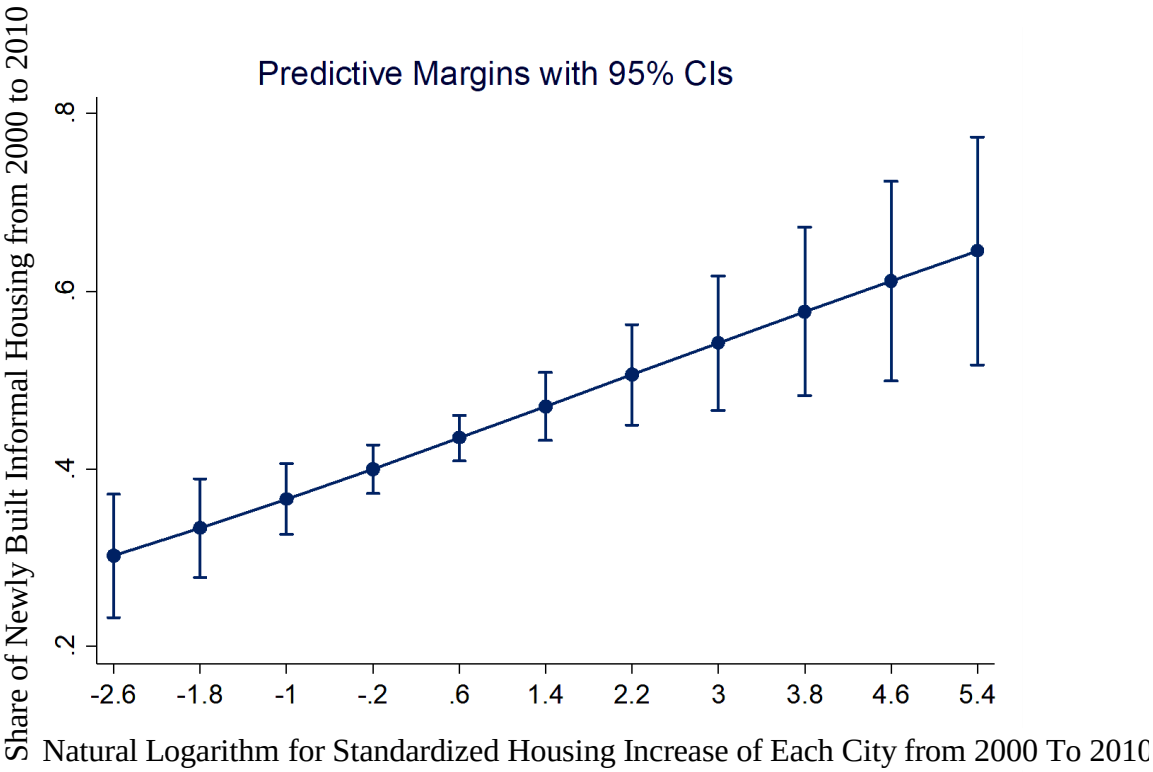

Figure 4.3.4. The Margin Plot between Standardized Housing Increase and Share of Newly Built Informal Housing in California

The existing housing conditions as of 2000 do not appear to be associated with informal housing produced during 2000 and 2010. The coefficient of the vacancy rate, percentage of single-family detached units, and homeownership rate are not significant. Previous scholars claimed that informal construction is associated with higher homeownership rate in 2000s because much informal construction involves homeowners adding units to their own homes (Mukhija, 2014; Wegmann, 2014; Wegmann & Mawhorter, 2017). Wegmann and Mawhorter also illustrate that informal housing production was associated with tighter housing market and lower rental vacancy rates in the 2000s because of more demand for low-cost housing units. However, my result does

not show evidence of the significant relationship between the housing condition variables and informal housing production in the 2000s.

4.4 Summary

Based on the results of two models, informal housing production in the 2000s is associated with both the demand side and the supply side. From the demand side, the increasing demand from people with various background and a lack of income appear to be associated with the production of informal housing in the 2000s. From the supply side, the city's housing provision – both for the future provision and current provision – is also associated with the production of informal housing in the 2000s.

CHAPTER 5. CONCLUSION AND IMPLICATIONS

5.1 Conclusion

This research aimed to examine the potential causes of informal housing produced in California in the 2000s. After summarizing the potential factors, creating the dataset, and running regression analyses to examine the influence of the variables, I find that both the supply side and the demand side may contribute to the production of informal housing. On the demand side, the increasing need for housing and the deficiency of household economic resources are closely associated with the production of informal housing. On the supply side, the future housing provision and the existing housing provision reflects the housing stock limitation, and thus may lead to informal housing production.

On the demand side, the increasing demand for living space and lack of income appear to be closely associated with the production of informal housing. From the demographic aspect, the share of immigrants and African Americans appears to be closely associated with high rates of informal housing production. This may be due to poor enforcement caused by the discrimination in the African American communities (Pendall, 2000; Wegmann, 2014) or to widespread reliance on self-building in these communities. The tradition of self-building may enable Latino population to build some extra living area besides the main building, such as ADUs (Mukhija, 2014; Ward, 2014). The unpermitted ADUs is one typical kind of informal housing. Notably, however, once other demographic factors are controlled for, the share of Hispanics is negatively associated with rates of informal housing production. Thus, though some Hispanic communities may have traditions of shared-housing and extended families (Ward, 2014), which could result in overcrowding, one type of unpermitted housing, my analysis suggests that this may be largely attributable to the fact that many Hispanic communities are also immigrant communities.

For the socioeconomic aspect, the income disparity limits the new residents to enter the formal housing market. As the state with the highest median housing value in America (US census, 2019), it is hard for the new residents to afford the expensive housing value or rent without a well-paid job to provide them housing loans.

On the supply side, the future housing provision and existing housing provision appear to contribute to the production of informal housing. The future housing provision, indicated by the developable land, shows that cities with limited surplus area for future development have higher shares of informal housing. The area stored for future development can be used as commercial, residential, industrial, or other land uses. The recognized appropriate percentage of residential area for the city is 20-32% (Land Based Classification Standards (LBCS), 2000), while in cities in California with the highest housing value, houses are more commercial and have potential to bring more profit for the local municipalities. Thus, it is believed that the share of developable land used for residential purposes in California could be higher. The residential area for the city of San Francisco is close to 80% (San Francisco Planning Department, 2018). Cities with limited developable land tend to fail to provide the correspondent housing units as needed. Informal housing could be produced under such a circumstance.

What's more, the existing housing provision, indicated by the housing price, housing number, and standardized housing increase (as measured by the metro housing increase/city housing increase), also suggests that a city's lack of low-cost housing units for residents may contribute to the production of informal housing. The significant relationship between the current housing value and informal housing at the city level reveals that limited affordable housing is one driving force for informal housing production. Also, the standardized housing increase, measured by metro housing increase/city housing increase, shows that cities with lower shares of permitted

housing provision than the metro area tend to have more informal housing units because the population mobility puts pressure on the formal housing market. Meanwhile, my results also suggest that the existing housing conditions do not play a role in producing the informal housing.

5.2 Implications

For the demand side, cities should make sure the public is aware of the extent of informal housing, the various types of informal housing that exist, and some of the challenges it poses to residents; however, cities should also acknowledge many of the demand and supply-side factors that my analysis suggests might contribute to informal housing productions.

First, my analysis suggests that immigrant, African American, and low-income communities are more likely to have high rates of informal housing production. It is unclear whether this is due to poor enforcement of land use regulations in these communities, a higher reliance on self-building of the home, limited incomes, or other factors. The prevalence of informal housing in these communities potentially adds to the affordable housing stock, thus increasing the supply of housing units in communities that desperately need it. However, many of these informal units may also pose important health and safety risks to residents. Cities should thus take care to identify impediments to the production of affordably priced housing units in these communities while also finding ways to bring informal units into compliance to reduce health and safety risks. However, as suggested by Wegmann and Mawhorter (2017), any changes to regulations should be gradually conducted to prevent eviction. Second, government's regulations and policies about informal housing or formal housing units, such as regulations regarding ADUs, should be publicized widely to prevent the unintentional creation of informal additions or conversions (Neuwirth, 2008; Wegmann & Mawhorter, 2017). Cities should ensure that the public has a basic

understanding of what informal housing is, and then guide the residents to convert the housing units appropriately to avoid the illegal issues or the potential safety hazards (Wegmann, 2014).

On the supply side, the city government should 1) pay attention to the future use of the developable land and the functional replacement of property, and 2) legalize some informal living space without safety hazards to create more living space. First, since there is limited developable land for California cities, especially the coastline cities, local government should make careful choice for the land use and keep the balance between future city development and future housing construction, and keep the balance between the increasing housing demand of new residents and the profit of the real estate companies. For cities with limited land supply, allowing for higher density housing development could be one option. Second, municipalities could publish regulations to regulate the conversion of living space, legalize the informal housing units, and eliminate some illegal housing units with great security issues. The elimination of informal housing is a long-lasting and continuous process that requires a legislative approach for progressive improvement, but it will help reduce the negative impact of informal housing. Banning informal homes can easily lead to many people being left homeless and creating new informal living spaces (Wegmann & Mawhorter, 2017).

In conclusion, policymakers or planners should 1) make sure the public's awareness of types of informal housing to avoid the production of informal living space in cities in the future; 2) encourage the legal housing conversion to provide more living space for the current or future residents; 3) improve informal units to bring them into compliance with the housing code and eliminate the housing units with serious safety issues; and 4) supply more formal and affordable housing.

5.3 Limitations of the study

This research shows several factors that may lead to the production of informal housing, but there are a number of limitations to this research. First, the low r-squared in both models indicates that the variables that I selected do not fully explain the formation of informal housing in the 2000s. 5/10 variables and 8/12 variables are significant at the .05 level in Model 1 and Model 2 separately, which indicate that those variables are related to informal housing production. However, the r-squared of the first model is 0.0495 and the R square of the second model is 0.0539; both of them are less than 10%, which means both models can only explain less than 10% of the variation in the production of the informal housing in the 2000s. The formation of informal housing is complex, and many factors may influence the production of informal housing. The low r-squared indicates that those two models can only be used to examine the relationship between the independent variables and the dependent variable. Moreover, the associations identified here do not necessarily point toward a causal relationship between the independent variables and the production of informal housing. More robust research, and particularly alternative research designs, is needed to control for other factors that might confound the relationship between these factors and informal housing production.

Second, due to the limited availability of data on land use regulations, I did not include any policy-related variables in my regression model, though they may play an important role in the formation of informal housing, as indicated by the literature review. For example, the policy of off-street parking may influence the production of informal housing in that the prohibition of off-street parking makes fewer garages available to be converted into dwelling units so that less affordable housing units by garage conversion will be provided and thus the share of new informal housing will increase (Brown, Mukhija, & Shoup, 2017). In addition, the housing policy in

California is changing frequently to adjust to the local housing market (California Department of Housing and Community Development, 2016).

5.4 Further research

Due to the limitations of the study, I expect the accuracy of the informal housing data and the data collection of different variables could be improved in the future to better describe the production of informal housing. The accuracy of the data could be improved in the future to better measure the number of informal housing units of each city. The methods of measuring number of informal housing provided by Wegmann and Mawhorter (2017) underestimates its actual number of informal housing units, resulting in the negative value of informal housing units in 68 cities. These observations are counterintuitive and eliminated in my model. More methods, such as counting informal housing by satellite map, could be conducted in the future to provide more accurate data of informal housing units.

More variables could be added to the regression to better describe the causes of informal housing. Only twelve variables are included in this research and the relatively low R-square indicates that the issue of how informal housing is produced is not fully explained. I expect future scholars to have more data from more sources to better explain the informal housing production.

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