

# Exploring United States Housing Affordability

*Nikolai Myllymäki, William Paul, Sriharsha Kondapally, Liam Shi*

## Abstract

The main metric that is referred to in this paper is burden. Burden is defined by the proportion of household income that is spent towards the cost of housing. This metric is then further dissected by analyzing against various variables and collating data on contributing factors, such as income. The first data explored is income data across the four designated regions in the United States (Northeast, Midwest, South, West). The adjusted incomes (per persons and per bedroom) are also considered, as certain regions may have different averages for household and property sizes, which could skew the unadjusted income data. The behavior of household income, bracketed in ranges in accordance to census data over time, is displayed to provide a better understanding of the changes in burden over time. The household incomes are then compared versus burden over time. It is found that the higher income levels generally have lower housing burdens, and those burdens actually decreased over time, while burdens in the lower income brackets were generally higher and increased over time. Also, the housing burdens in the Northeast and West are generally higher than the Midwest and South. Finally, to elucidate the gap in burden levels across high and low incomes, the household burden amongst owners and renters, and those with and without government assistance is considered. Here it is found that owning households tend to have lower burden levels, as do those households with no assistance.

A common issue addressed throughout this paper is the anomaly in datasets around the 2007-2011 period, which roughly marks the duration of the financial crisis. In particular, the lag in the downward spike after 2007 between the Northeast and the other regions is discussed. This section of the data helps in understanding the dynamics of burden and income, as the financial crisis was recent and nationwide.

# Introduction

The dataset was taken from the American Housing Survey (AHS), which derives sets of data from 1985 and on. The data set includes categorizing each housing unit by factors such as affordability, income through fair market rent, burden, and the adjusted median income. Certain factors, such as poverty income, is based on the Census Bureau's official thresholds.

The goal is to determine whether housing affordability has increased or decreased over the last few decades. Our initial hypothesis assumes that housing affordability within the United States has decreased due to key, significant events that have occurred within the last few years. The United State's growing income inequality can be attributed to the current state of housing affordability, and is a clear indicator of the shifting income brackets between who is poor and who is rich. Another major event that has potential consequences on the current state of housing affordability, is the 2007 Housing Market crash. According to Business Insider, the end of 2010 saw a staggering 23.1% of all U.S. homeowners with a mortgage owed more on their homes than what their homes were worth.<sup>1</sup> Amongst all of the foreclosures, loan defaults, and stock market crash, we will closely examine the years between 2007 and 2011 to capture a better sense of the status of the housing market's affordability.

## Cleaning the Data

Initially, the dataset is split into fifteen datasets, one for each odd year between 1985 and 2013. Due to differences in how the survey was conducted over the years, each dataset has varying column names and positions, and, for surveys performed earlier than 2003, missing columns. To standardize the data, we used the format of the more modern datasets, i.e the datasets from 2003 to 2013. Thus, we begin by appending a column onto each dataset to mark which year that data was gathered, remove an extraneous column from the 2009 dataset, and then simply combine the datasets. For the older years, the datasets must again be split into two groups as some columns are named differently and do not fit with our standard. Once we rename the columns, we add the missing columns that dictate the raw, adjusted by growth, and adjusted by people income limits for each household. These income limits specifically determine what the extremely low income bracket is for the area each household is in. For each list of datasets, we reorder the columns to exactly match that of our base, the datasets gathered from 2003 onward. Finally we combine every list of datasets into a single dataset, and then store it in a comma separated file called `combined_years`.

The `combined_years` data was read into a dataframe using the `read_csv` function. Then, the combined years dataset was cleaned using the piping methods in `dplyr`. The data was rather messy, with unnecessary quotations around character values and inconsistent letter cases in the column names. This was rectified by setting all the column names to lowercase and removing all the quotations from character values. One the main premises of this paper is comparing the burden of household that are owning and renting. Since there was no explicit labeling of data corresponding to owning and renting households, the "ownrent" column was mutated to a factor with the correct labels. Finally, the data was written to a `clean_years` csv file. The source files used different nonsensical integers (negative numbers) to indicate NA values. These were converted to NAs while reading the dataset in so that the output data and graphs made statistical sense - negative numbers where the values should be positive skew the dataset.

# Findings

## Initial Findings

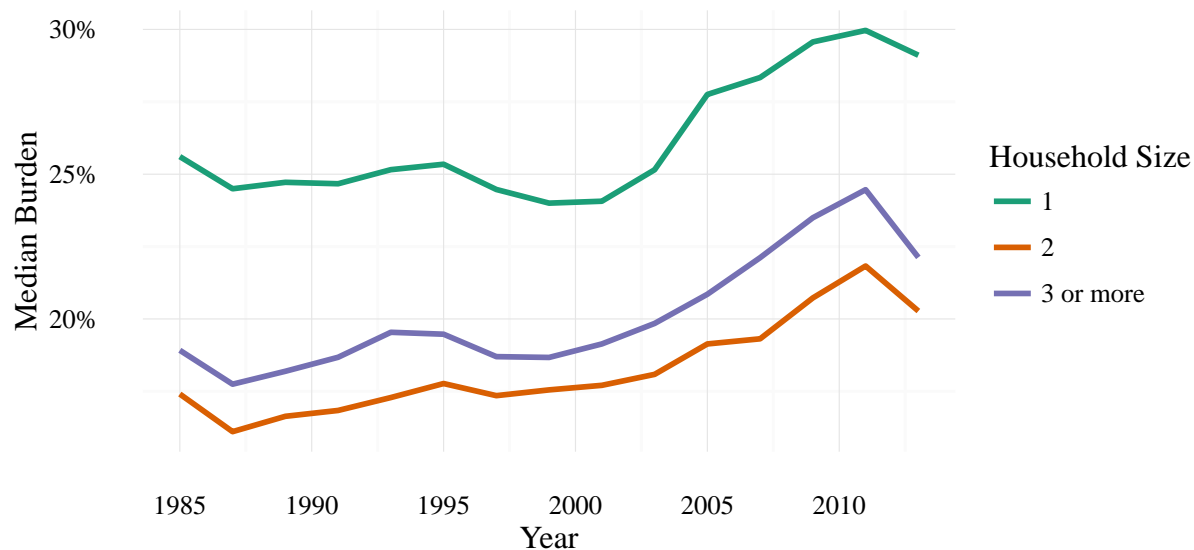


Figure 1: Median burden across years and household sizes

Figure 1 shows the development of median burden (proportion of housing costs relative to household income) from 1985 to 2013. The median burden varies dramatically between households of different sizes. The highest burden through the years has been on households of one person. This is understandable, since people living alone cannot split any costs between other earners.

Surprisingly, households of two people have the lowest burdens overall. Our hypothesis is that this is due to a large proportion of two-earner couples in this group. As housing cost burden is simply a household's monthly housing cost divided by its monthly income, households where all members are earners have a higher monthly income and a lower resulting burden. In households of 3 or more people, the burden picks up again. This is likely due to a larger amount of children and/or retirees in larger households. Also, households with 3 or more members tend to have only one earner.

Another interesting thing is the dramatic increase of burden during the buildup to the financial crisis 2000-2007. The most probable explanation is the housing market price bubble. Once the crisis hit in 2007, the effect of dropping incomes continued to increase burdens until 2011. Only in 2013 data did the burdens start to fall from the unprecedentedly high levels.

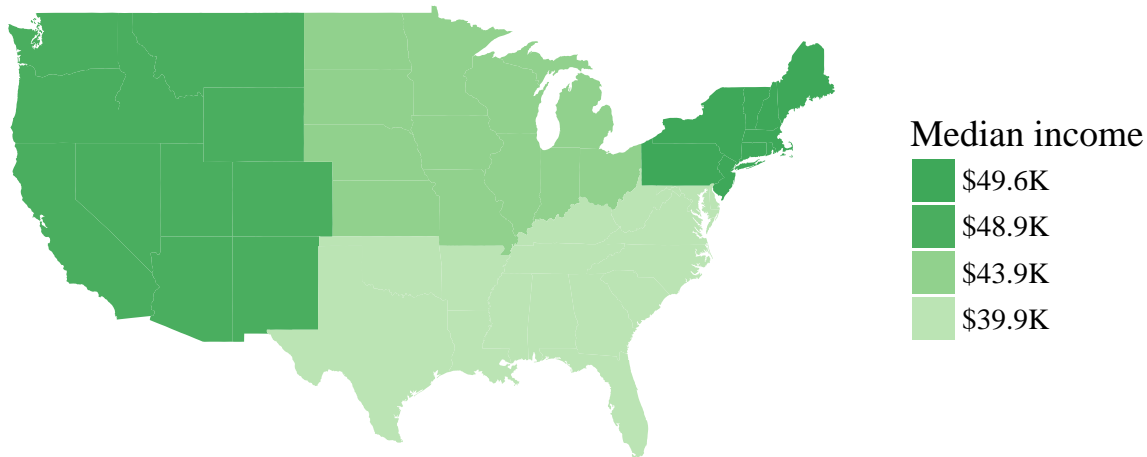


Figure 2: Median Income Across Census Regions

To map income levels in different areas we used the four census regions in the dataset and joined them with a scraped table from mapsoftheworld.com. Using the table we could connect census regions to state names and thus colour a map of the continental US with census region incomes. We used median incomes instead of mean incomes to avoid skewing the results with outliers, and filtered the map to include the most recent year, 2013.

The resulting figure 2 shows household median monthly incomes vary between different census regions from \$39,900 in the South to nearly 25% higher, \$49,600, in the Northeast. The West trails closely behind the Northeast with \$48,000, and the Midwest is closer to the South with a median income of \$43,900.

While the dataset doesn't have more granular location data, even these four regions are very distinct from each other. The large high-income cities in the Northeast and the West likely contribute to the higher respective median incomes, while more rural Midwest and South are poorer.

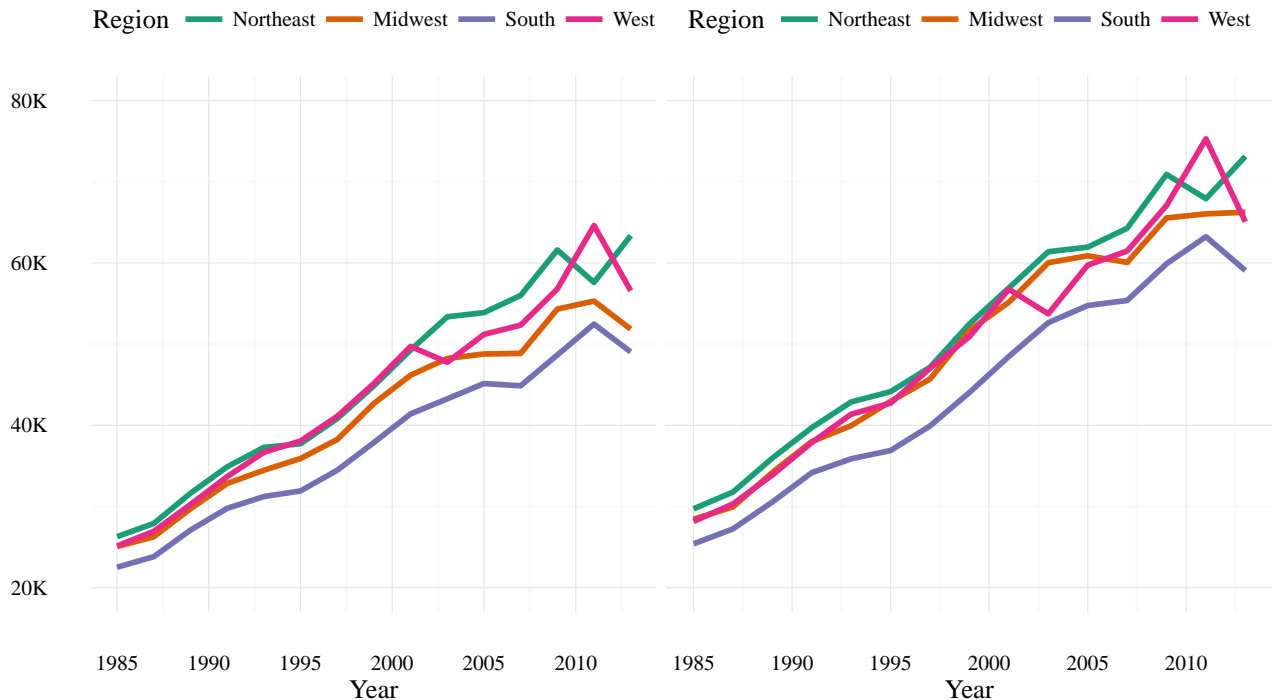


Figure 3: Median Adjusted Income per person (left) and per bedroom (right)

In order to better understand the regional differences in income, the incomes were adjusted by certain variables. The first plot of Figure 3 compares the median income adjusted for number of persons by year (APLmed) for the four regions in the United States (Northeast, South, Midwest, West). APLmed is the adjusted median household income per person. This was precalculated using Housing and Urban Development (HUD) indexes. For example, a one person household's income is adjusted by a factor of 0.70, two by 0.80, and so on with a four person household being adjusted by 1.00 (or having no change from the median household income). The reason for no adjustment to a four person household income is because the median household size in the United States is about four persons. It is also clear that the Northeast and the West are the most expensive regions. This makes sense given that the northeast and West are by far the most productive (by GDP) regions in the United States.

The median adjusted income increases steadily (roughly linearly) over time. There is a decrease in income around 2010, correlated to the economic recession with a 2 year lag between the Northeast and the rest of the regions. The reason for this lag may be due to the fact that the financial center of the United States lies in the northeast, around New York City. So, when the 2008 crisis occurred the repercussions were immediately felt in the Northeast (Wall Street) while the other regions took some time to correct for the downturn in the financial market. The second plot of Figure 3 depicts the development of median income adjusted for the number of bedrooms in a household's living quarters. The adjusted median income was calculated using precalculated HUD indexes. Here, zero bedrooms was adjusted by a factor of 0.70, two bedrooms by 0.90, and so on. Three bedroom properties were adjusted by a factor of 1.04, because the median number of bedrooms in a property is roughly three bedrooms

It is interesting to note that the disparity between the incomes increases between the Northeast and Western regions and the Midwest and South. This is likely because those living in the Midwest and South tend to live in larger homes, housing more bedrooms on average, relative to their incomes due to the higher housing affordability. However, this should mean that their incomes go 'further,' as they have more purchasing parity given the lower cost of living compared to the Northeast and the West. This is not shown in the graphs, which indicate that the income levels are significantly different. However, if housing affordability was factored into the calculation, the income disparity would be far less if not almost nonexistent. The lag in the downward trend after 2008 still occurs in the plots.

With the income information in hand, the burden data can be explored in further detail.

## Further Exploration

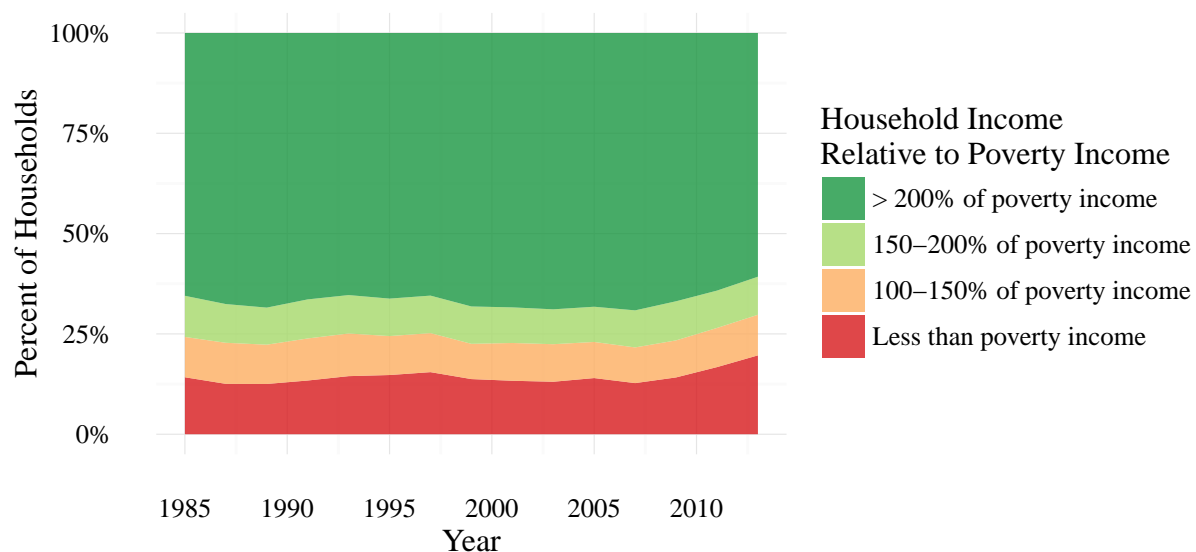


Figure 4: Amount of households relative to poverty line

Figure 4 shows the amount of households in a given income group in a given year. Each household has been calculated a poverty threshold according to the Census Bureau's official thresholds, based on family size and number of children.

As can be seen from the plot, the amount of people in different income groups stayed relatively constant between 1985 and 2007. The majority of people earned over twice the poverty income, while little under a fifth of the population was in poverty. This stable relationship broke noticeably in the financial crisis of 2007 and the following recession, when the amount of people in poverty started a quite steep and steady climb upwards.

Interestingly, the income brackets of 100%-200% stayed almost exactly the same size as before, while the increase in poverty was in effect solely the result of the dwindling of the highest (over 200% of poverty income) income bracket. A reasonable explanation would be the effect of increasing unemployment, with previously employed well-off people dropping to unemployment and thus small or no income. The reality can be more nuanced, with people dropping to the middle income groups and a simultaneous equally large movement from these brackets to poverty, but the big picture of large impacts in poverty following the financial crisis stays the same.

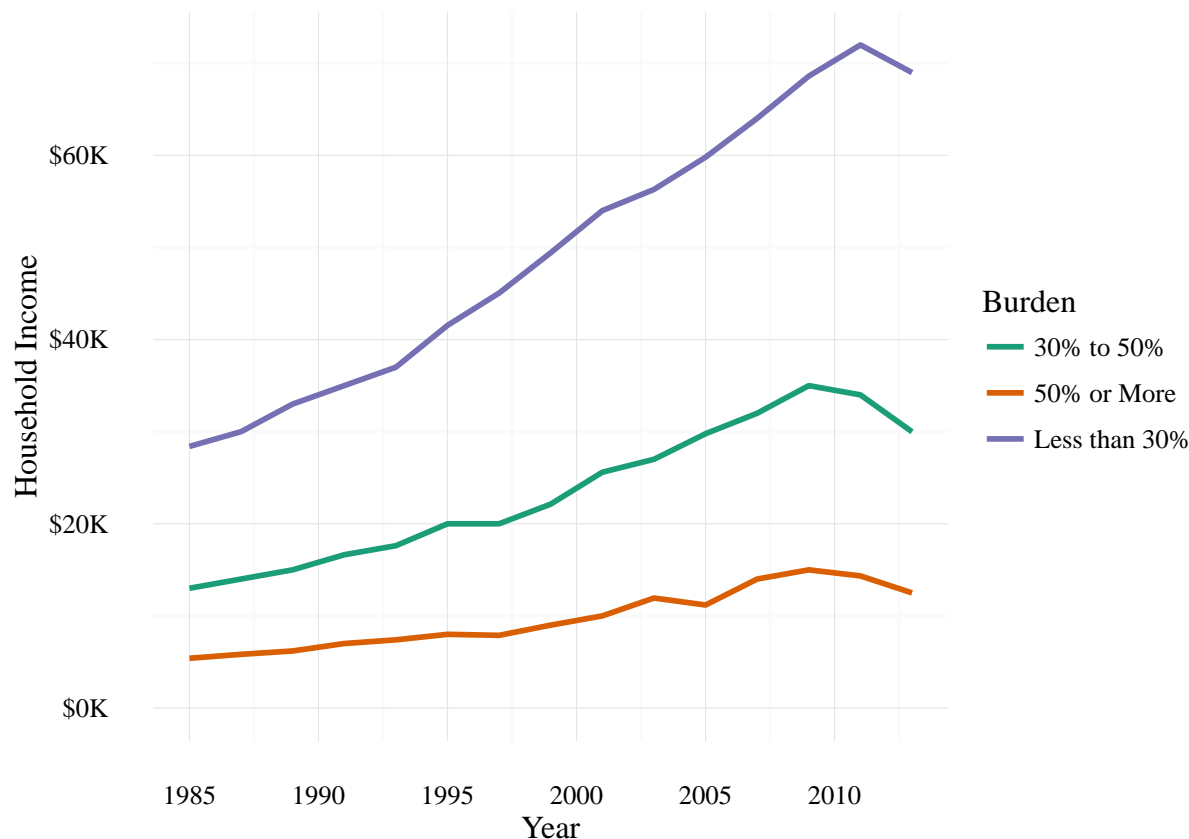


Figure 5: Relationship between Household Income and Burden

As pictured in Figure 5, the relationship between household income and burden is seen as a positive correlation. The relatively higher household income brackets are shown to have lower burdens than the lower household income brackets. Because burden is a proportion of housing cost over income, it is reasonable to conclude that higher income households will have a smaller burden due to their larger incomes. The higher income households are able to pay off their monthly costs more easily. Although the federal poverty line differs between different sized households, the average poverty threshold for families of 3 or 4 persons is ranged from \$20k to \$25K. <sup>2</sup> From Figure 5, it is easily seen that those with 50% or More burden are near and/or underneath the poverty threshold. At the onset of the 21st century to 2010, there is a spike in 2007/2008 for

the range of household income with the differing burden brackets. This spike can be attributed to the 2007 financial housing crisis, which ultimately affected the burden levels of the housing sector.

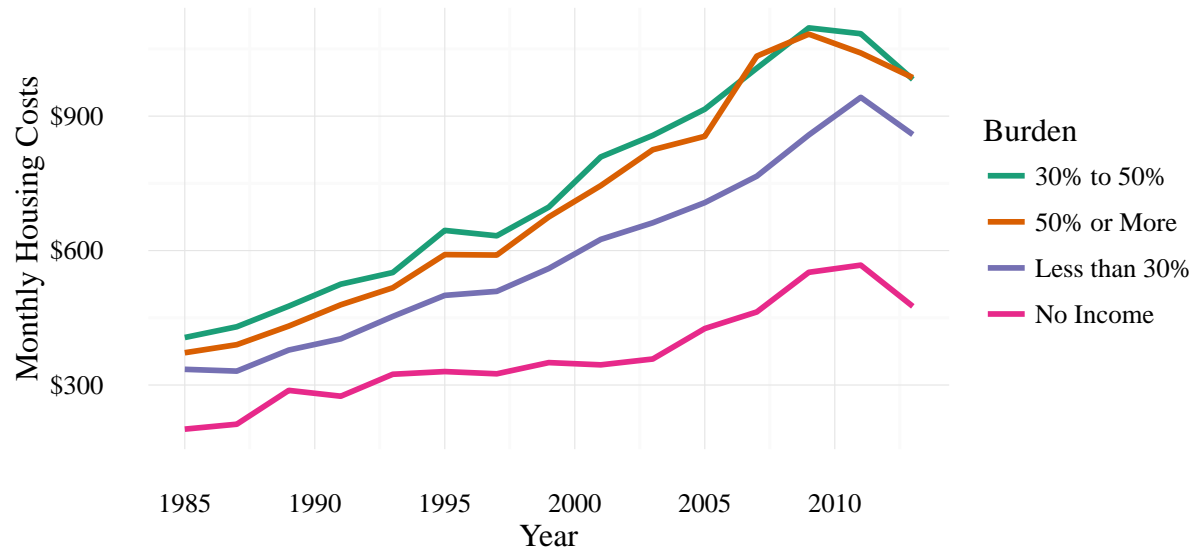


Figure 6: Relationship between Monthly Housing Costs and Burden

Figure 6 offers a more in-depth look at the relationship between housing costs and burden. It’s interesting to see that all three burden lines are close to one another, which illustrates the principle that those with more money aren’t buying more expensive houses. From Figure 5, we saw that those with higher incomes have less burden, and those with lower incomes have higher burden. At a certain point, regardless of income, housing costs stay the same. For the “No Income” bracket, there are still monthly costs present. To account for this anomaly, we assume that people who lost their jobs could still be paying these costs with zero income. Trust fund recipients and people living off savings could also be paying off these costs. Again, a spike around 2010 is prevalent, which can be explained by the 2007 housing crisis.

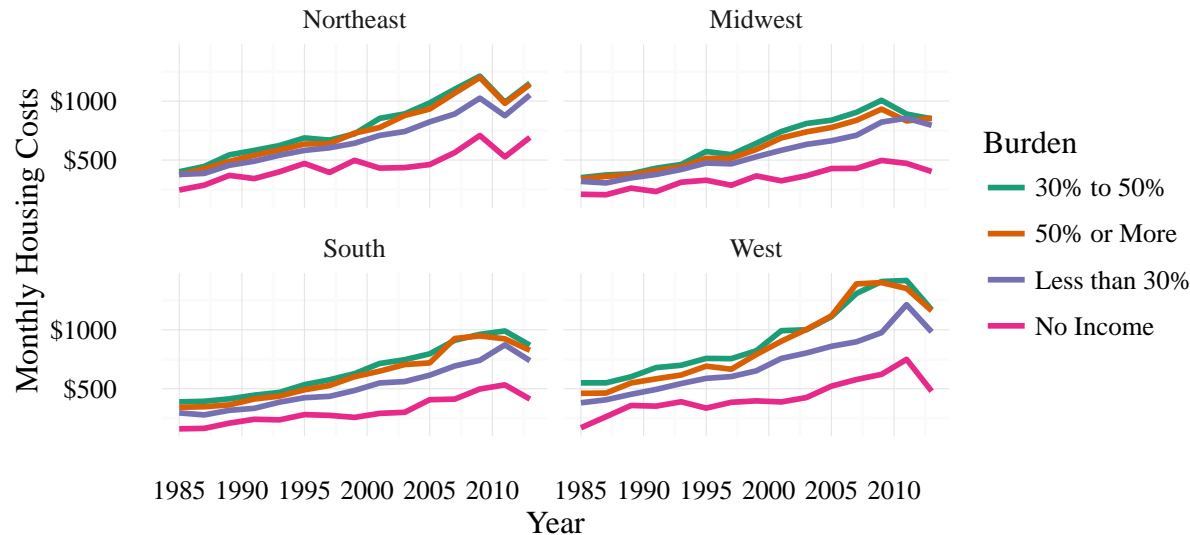


Figure 7: Relationship between Monthly Housing Costs and Burden in different regions

Figure 7 illustrates the monthly housing costs by census regions (Northeast, Midwest, South, and West). It is interesting to note that the Northeast and West have higher monthly housing costs according to the figure.

According to Forbes, a majority of the most overpriced cities are located in these two regions. <sup>3</sup> Figure 2 also supports this idea because median income is highest in these two regions. There is an interesting dip seen in the Northeast graph, which can be attributed to the Northeast being impacted earlier by the housing crisis.

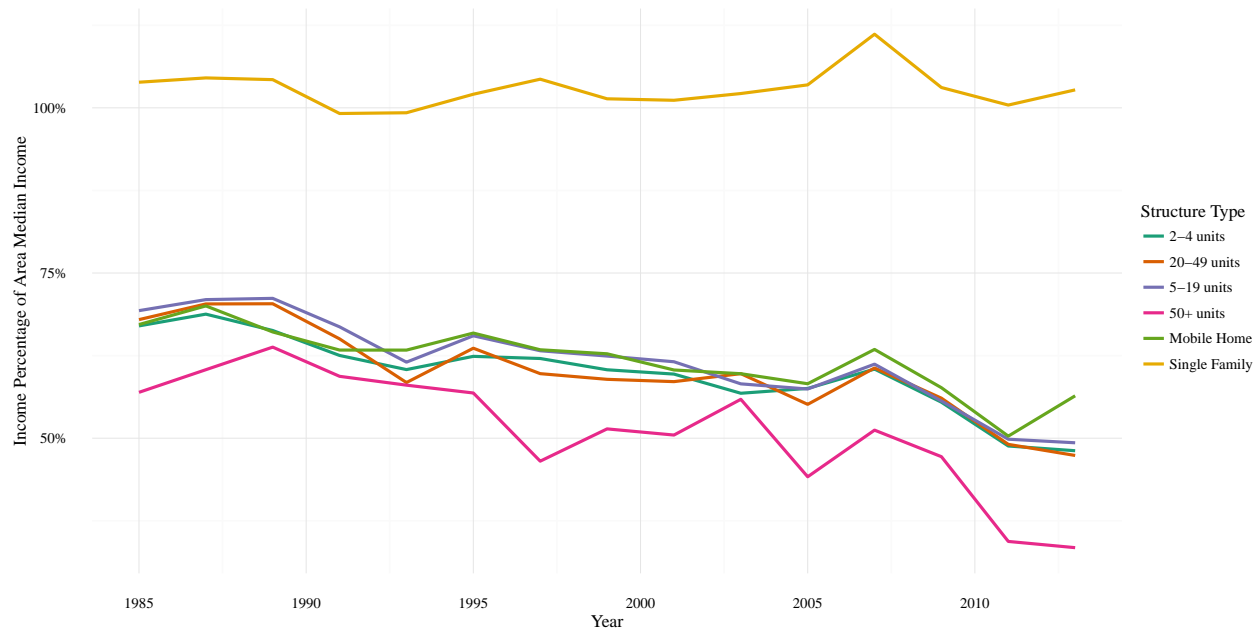


Figure 8: Income Compared to Area's Median Grouped by House Type

Figure 8 charts a time series showing how the typical income for various types of households such as single family or apartment buildings changed over the years. One major trend is that typical income of all housing types except single family homes compared to their area has fallen, accelerating after 2007. However, incomes of single family homes, barring the housing crash in 2007, have been centered on the area's median income. There are a couple of possible explanations for this disparity. The first is that, with the growth of wages, more people could afford single family homes and thus leave the buildings with higher numbers of units. As wages increased, the area's median income also grew, and so, combined with higher waged workers moving into single family houses, single family homes remained constant while all other types shrunk proportionally. This would also explain the acceleration after the housing crisis, as single family homes became much cheaper temporarily and thus allow more workers to obtain single family housing. The second explanation is that as time went on, supply of housing increased, driving prices down and allowing lower waged laborers to obtain homes. Due to the purchasing power of higher wage laborers however, single family houses, even with their falling prices, were more difficult to obtain as time went on, and thus lower wage workers had to settle for other types of housing.



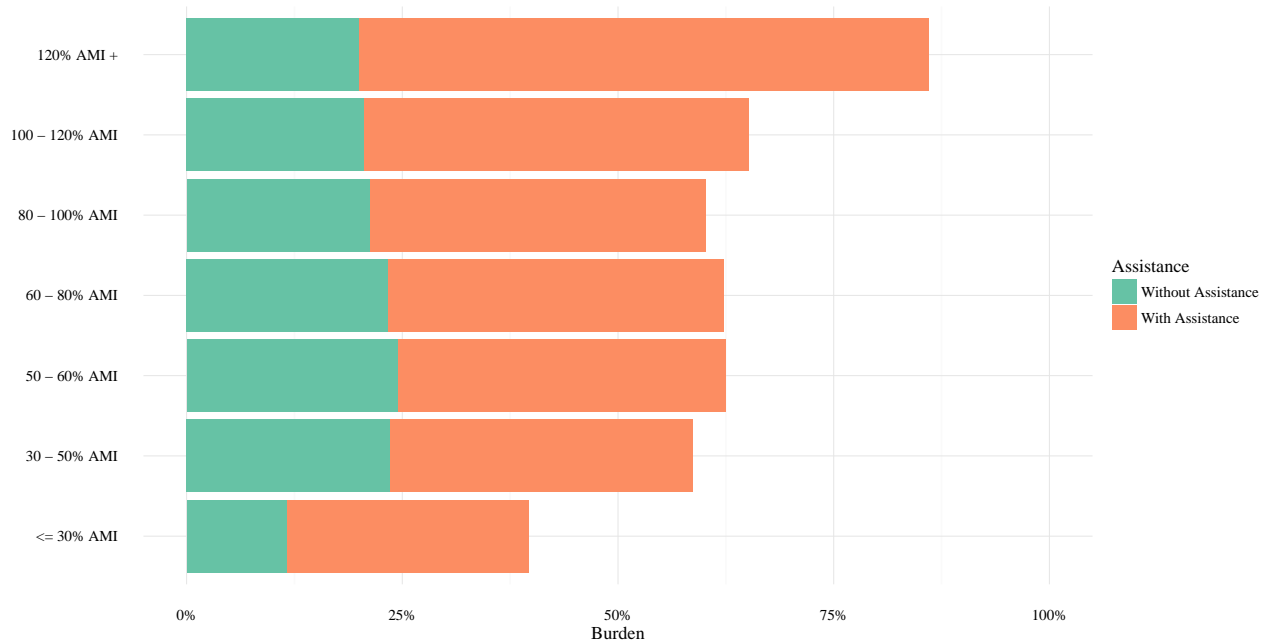


Figure 9: Burden based on Median housing cost with assistance

Further delving into the behavior of burden amongst the lower income workers, figure 9 shows how burden changes as a result of assistance based on what percentage of the area median income is their monthly housing costs. At initial observation, the burden of those who receive more assistance is higher than those who receive no assistance. This clearly makes sense, as those who need assistance are typically people who've lost their job or had some monetary crisis that would reduce their total salary. However, although assistance has around the same effect for most cost brackets, the households that have excessively high costs for their area have vastly higher burdens with assistance than all other brackets. One explanation for this is that those who purchase expensive houses in their area typically have higher salaries, and if they lose those salaries and require assistance they have to support the cost of the house. Also, single family homeowners have significantly less mobility so if they have a financial crisis they cannot easily transition to cheaper housing as opposing to those with rental properties typical of a larger number of units. The plot shows how burden changes as a result of assistance based on what percentage of the area median income is their monthly housing costs.

At initial observation, the burden of those who recieve more assistance is higher than those who recieve no assistance. This clearly makes sense, as those who need assistance are typically people who've lost their job or had some monetary crisis that would reduce their total salary. However, although assistance has around the same effect for most cost brackets, the households that have excessively high costs for their area have vastly higher burdens with assistance than all other brackets. One explanation for this is that those who purchase expensive houses in their area typically have higher salaries, and if they lose those salaries and require assistance they have to support the cost of the house. Also, single family homeowners have significantly less mobility so if they have a financial crisis they cannot easily transition to cheaper housing as opposing to those with rental properties typical of a larger number of units.

## Conclusion:

The findings in this paper help elucidate income and household burden trends overtime. However, there are many holes in the actual data. The data grabbed uses gross incomes and groups data over large regions of the United States. While the spreads of incomes and housing costs may be low, the internal variation within each region will be fairly high. As a result, this does not help portray a full picture of burden level across the United States, namely in (sub)urban versus non urban areas. Also, the usage of gross income is inaccurate, as the median net income levels varied over time (even after adjusting for inflation), since taxation levels were much higher in the 1950s and 1960s than they are now- which means the burden levels are likely undervalued in the data during those decades. Also, the data provided is given in odd years, which prevents a complete analysis of housing affordability.

Ultimately, our findings point towards the idea that housing affordability has decreased since the mid 80s. Although many graphs illustrate a dip in burden, this does not negate the overarching idea that housing affordability has decreased. According to Investopedia, major consequences of the mortgage crisis include chronically higher unemployment and smaller chances of getting loans and credit. The housing bubble has had effects on a long-term scale, where in 2009, there was a 38% increase in Americans filing for bankruptcy since 2007. <sup>4</sup> We conclude that the 2007 housing crisis is one of the most significant factors in causing the overall decrease in housing affordability.

Further analysis could involve predicting the trends for the burden and income data to corroborate whether or not a two year lag exists between the Northeast and the other regions following the financial meltdown. Also, adjusting income by cost of living would provide a better understanding of burden amongst differing regions. Regions could be further subsetting by town or district level to provide more granular data.

## Sources

1. Snyder, Michael. "27 Depressing Facts About The Housing Crash That Never Seems To End." Business Insider. 2011. Accessed August 7, 2016. <http://www.businessinsider.com/amazing-statistics-about-the-housing-crash-2011-3>.
2. "Poverty Guidelines." ASPE. 2015. Accessed August 3, 2016. <https://aspe.hhs.gov/poverty-guidelines>.
3. "America's Most Overpriced Cities In 2015." Forbes. Forbes, 4 Mar. 2015. Web. 5 Aug. 2016. <https://forbes.com/sites/erincarlyle/.../americas-most-overpriced-cities-in-2015/>.
4. "5 Consequences Of The Mortgage Crisis." Investopedia. N.p., 21 Nov. 2010. Web. 9 Aug. 2016. <http://investopedia.com/financial-edge/1110/5-consequences-of-the-mortgage-crisis.aspx>