A Tale of Two Crises:

The Housing Shortage and Homelessness

0 Executive Summary:

To the Secretary of the U.S. Department of Housing and Urban Development,

"Home is the nicest word there is." – Laura Ingalls Wilder

Unfortunately, this isn't the case for all individuals. In the twenty-first century, the rise of skyscraper skylines have attempted to reach new horizons across the United States' largest cities. For the general urban population, however, this rise is contrasted at the bottom by the lack of affordable housing and widespread homelessness. These crises represent one of the greatest challenges for American cities: providing greater opportunity for the poor. This paper investigates the crux of the housing and homelessness issues and develops mathematical models in a thorough attempt to provide an effective, sustainable solution for city legislatures.

The first task was to develop a model that predicts changes in the housing supply in Seattle, Washington and Albuquerque, New Mexico in the next 10, 20, and 50 years. Using the data that was provided from the 2024 M3 Challenge's spreadsheet, we were able to model two logistic regression equations for these two cities using MATLAB software. These findings used derived carrying capacities to model the estimated growth of housing supply and were contextualized with the 2008 Great Recession and the 2020 COVID-19 pandemic [1].

The second task was to estimate changes in the homeless population of Seattle and Albuquerque in the next 10, 20, and 50 years. Similarly, we created two sum of sine regression models, which predicted that the homeless population in Albuquerque would decrease and that of Seattle would increase over time. However, national events such as the 2008 recession and the COVID-19 pandemic may have caused extremities in the data, offsetting the curve.

By interpreting our results from these housing and homeless statistic models, we were able to devise mathematically-estimated, sustainable solutions that would increase the supply of housing and mitigate the homeless rate in Seattle and Albuquerque that would be applicable in other larger American cities.

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1 Q1: It Was the Best of Times

1.01 Addressing the Problem

Ironically, in the richest country in the world, millions of Americans find themselves unable to find or buy a home due to the nationwide housing shortage that plagues renters and buyers alike. Housing has become unaffordable for almost half of renters due to rising housing costs, and prospective buyers find themselves unable to afford a suitable home, as others are bidding far higher prices than what the house is worth [2]. Although economists argue about the extent to which the U.S. lags behind in providing housing for its citizens, the necessary number has been estimated to be as high as 3.8 million homes [3]. It is clear that the rate at which housing is being built is outstripped by the growth of America's population.

1.02 Local Assumptions

The primary consideration taken into account when developing this model was a finite population/carrying capacity to which a city can sustain. Given the numerous geographic, economic, and social contingencies involved with calculating an accurate carrying capacity, it is reasoned that if Seattle's population increases to around 950,000 in 2040 [4] and keeps its area of 83.9 mi^2, its population density would be 11,323 people/mi^2. Taking Seattle's current population density of 8,775 people/mi^2 [5] and finding the average rate of change, we found that Seattle's population density grew by 127 people/mi^2 yearly. However, we also took into account that the population would grow at a decreasing rate rather than linearly due to the carrying capacity. Assuming that the maximum population density for Seattle is around 13,000, considering that modern housing development techniques such as volumetric housing and in-fill housing are used, Seattle's population would increase at a decreasing rate to its maximum population of 1.09 million. With an average household size of 2.02, there would be a maximum of approximately 545,000 households.

For Albuquerque, we estimated its population growth using a similar method. With a larger square mileage, household size, and lower population than Seattle, Albuquerque would be able to increase its population density by more than Seattle. With a population of 562,599 in 2022 and an area of 189 mi^2, thus a population density of 2926.3 people/mi^2 [5], Albuquerque would have a maximum population density of around 5000 people/mi^2 and a population of around 950,000. With an average household size of 2.32, this translates to a maximum of 409,000 households (for simplicity, our graph uses 400,000 as the carrying capacity). Although this change to a greater population is numerically smaller than Seattle's, the % change in households for Albuquerque is still greater [6].

1.03 Our Models

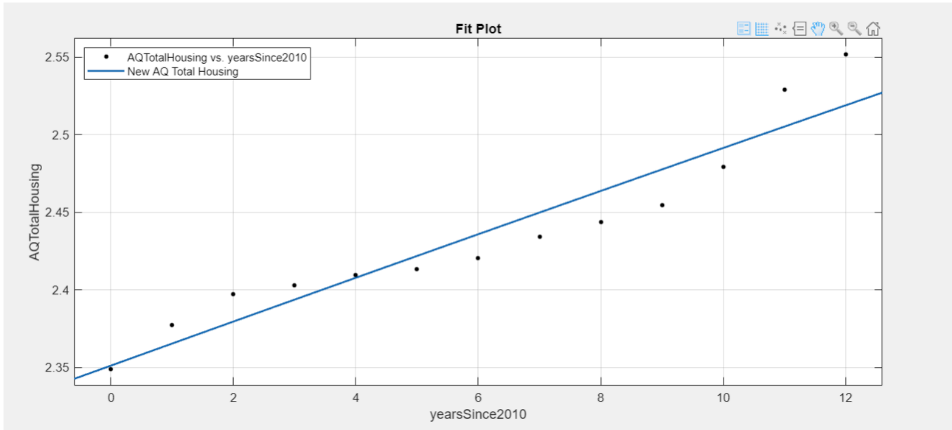

Figure 1: Logistic Regression Model of Albuquerque's Housing Supply Derived in MATLAB [7]

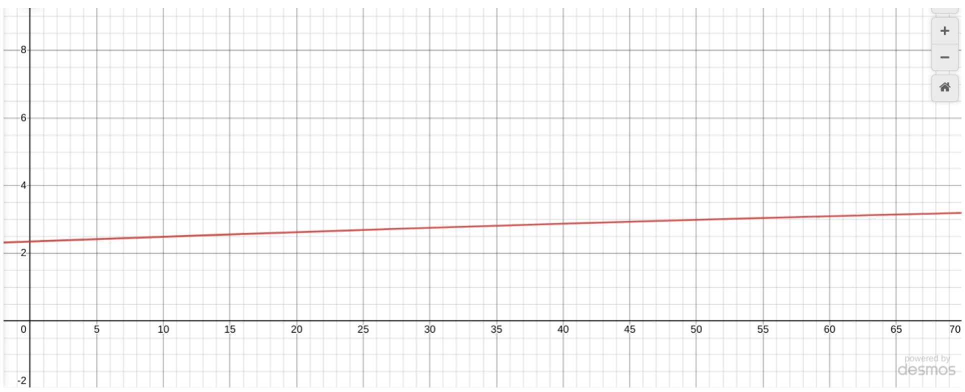

Figure 2: Logistic Regression Model of Albuquerque's Housing Supply Extended to 2080 [8]

Eqn: $y = \frac{4}{1+e^{-0.01468x-0.3549}}$ where x = the number of years since 2010 and y = the predicted housing supply in hundreds of thousands

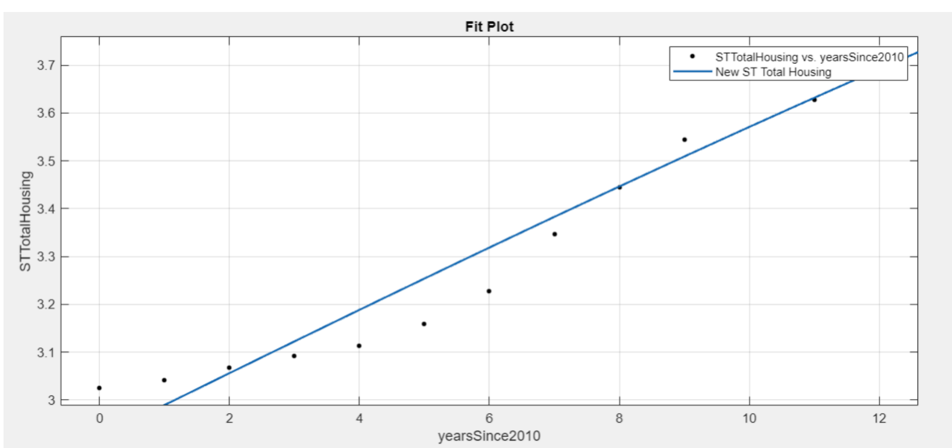

Figure 3: Logistic Regression Model of Seattle's Housing Supply Derived in MATLAB [7]

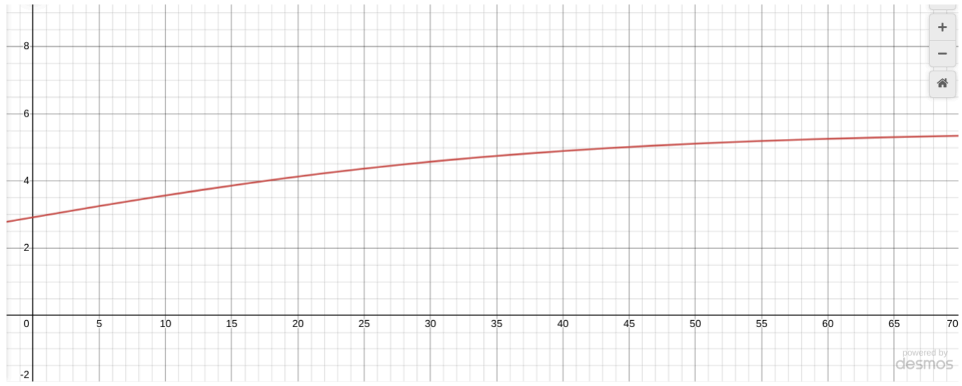

Figure 4: Logistic Regression Model of Seattle's Housing Supply Extended to 2080 [8]

Equation: $y = \frac{5.5}{1+e^{-0.04905x-0.1253}}$ where x = the number of years since 2010 and y = the predicted housing supply in hundreds of thousands

1.04 Interpreting the Models

Based on the models, we estimated the housing supply in Albuquerque and Seattle with 95% confidence through the use of MATLAB's Curve Fitting Application [7]. Based on the graphs and equation from Figures 1 and 2, the estimated housing supply in Albuquerque will be 267,900 in 10 years, 280,600 in 20 years, and 314,000 in 50 years. Since the estimated housing supply for 2024 in Albuquerque is 254,600, the increase in housing supply will be 13,300 in 2034, 26,000 in 2044, and 59,400 in 2074. The graphs and equation from Figures 3 and 4 estimate the housing supply in Seattle to be 432,400 in 10 years, 471,500 in 20 years, and 529,800 in 50 years. Thus, the estimated housing supply for 2024 in Seattle is 380,900, which indicates that the increase in housing supply will be 51,500 in 2034, 90,600 in 2044, and 148,900 in 2074 [8].

1.04.1 Evaluating the Results

The graphs above show a clear positive trend in the supply of residences in the housing market, although they do not match the demand posed by each population. One reason for this is the aftermath of the 2008 Great Recession; in the graphs of total housing in Seattle and Albuquerque, the curve flattens between the 2012-2014 period. Economists state that the U.S. fell behind in the construction of homes during this time period and that their effects inflated the housing market for a decade. After its brief collapse as a result of the COVID-19 pandemic in 2020, the housing market accelerated back to record highs once again. [2]

1.04.2 Strengths and Weaknesses

Both the Seattle and Albuquerque housing curves use data points from 2010-2022 to accurately predict the growth of housing units in 10, 20, and 50 years. Logistic regression uses a data-estimated carrying capacity to qualify a total housing amount that is representative of each city's current growth, social externalities, land area, and population density. By using a logistic regression fitted curve, it is assumed that there is linearity between the independent (number of years) and dependent (total housing) variables, and thus cannot account for natural disasters that would alter the predicted growth of housing units.

1.05 Global Challenges

1.05.1 2008 Housing Crisis

In our study, we took into account events that had a significant impact on the U.S. housing market, namely the 2008 Great Recession and the COVID-19 pandemic, which had varying effects. In the context of the 2008 crash, there was an oversupply of houses rather than a shortage, which led to lower house prices and lax loan policies. But the crash caused housing prices to plummet, falling 27.4% from their peak in 2006 to their low point in 2012. [9] This led to a major home shortage, which explains the dip in vacant housing in 2012. Figure 5 below displays the large number of houses that were built and oversupplied until 2008, and then the rapid price drop and eventual price rise as supply decreased. The oversupply of housing in 2008 discouraged the building of new homes, leading vacant housing to drop by 2012.

Since the 2008 Housing Crisis, it has become difficult for a wide range of people to have access to the housing they need. Since 2008, 64% of all housing authorized has been single-family homes, limiting the number of units that provide shelter for 2 to 4 residents as well as 5 or more residents [10]. This is an issue because not every person or family at risk for or facing homelessness fits into the same size category.

Figure 5: % Changes of Housing Price and Supply from 1999-2021 [10]

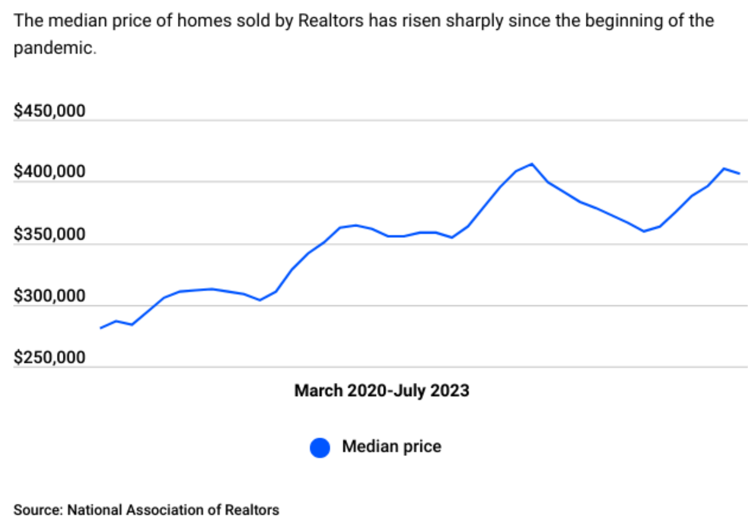

Figure 6: Median Price of U.S. Homes Since the COVID-19 Pandemic [Bankrate]

1.05.2 COVID-19 Pandemic

The COVID-19 pandemic largely contributed to the housing shortage by stalling construction and causing supply chain issues. Additionally, demand for housing increased due to remote work, and interest rates were at a record low. Investment firms stocked up on real estate property when many Americans were eager to buy a house. However, inflation and interest rates have increased since 2020, stalling supply in the face of high demand. Nonetheless, the housing market has quickly recovered its losses from the COVID-19 dip and is estimated to follow our logistic curve model.

The COVID-19 pandemic has also greatly influenced employment. As businesses closed and restrictions began, businesses struggled to pay employees, eventually laying off millions of workers, mostly those with low-wage jobs [11]. These workers struggled to find new jobs and pay for their housing amidst the pandemic [12]. As people struggled to pay for rent and utilities, they not only needed jobs but more affordable places to live. The shortage of affordable housing at this time made it difficult for the unemployed to overcome these issues, leading to an increase in homeless rates.

Before COVID-19, 8-11 million U.S. residents were homeless or on the verge of becoming homeless; during the height of the pandemic, 30-40 million were at risk of becoming homeless [13]. The sudden drop in employment and inflated housing prices caused a dramatic increase in homelessness in America.

1.06 Domestic Challenges

1.06.1 Zoning Laws

A notable aspect of urban planning is zoning, in which boundaries are demarcated to establish various areas (i.e. residential, commercial, etc.). To discriminate between wealthy neighborhoods and poor neighborhoods, zoning is commonly practiced to protect property values. This practice, however, has not only created a socioeconomic imbalance between social classes but has also deprived urbanites of quality standards of living.

1.06.2 Quality of Life

The U.S. Housing Crisis also serves as a detriment to Americans' quality of life. As a result of overpopulation in low-income urban neighborhoods, the demand for housing has outstripped the supply of new apartments and houses. This influx of homebuyers versus a shortage of available homes has led to a major increase in housing prices, making city life an unattractive and unaffordable lifestyle for many. In fact, it is estimated that half of U.S. tenants pay more than 30 percent of their income for housing. Additionally, overpopulation has overwhelmed the infrastructure in low-income neighborhoods, as signified by the increasing amount of traffic congestion and limited parking spots on the road [2].

1.06.3 Vacant Units

Another caveat of the U.S. housing crisis is the surplus of vacant units. In 2022, it was recorded that the number of vacant housing units in Seattle and Albuquerque is 27,190 and 15,378, respectively [1]. While there appear to be available housing units in these urban areas, the housing shortage has caused a skyrocketing of vacant housing prices to the extent that they have become unaffordable for the average U.S. buyer.

1.06.4 Affordability

The increase in demand for housing combined with a decrease in its supply has increased both rent and home prices. The median income-maker cannot afford a median home, and low-income families are left with few options. In fact, the median income in Albuquerque is 61,503, while the average cost of a house is 309,295 [1].

1.07 Housing Innovation

Solving the housing crisis requires an innovative approach. Essentially, the supply of housing must increase to bring down inflated property prices, empower better standards of living, and accommodate a growing population. By promoting subsidized housing, improving home innovation, and optimizing land-use planning, which will all be assessed in greater detail in the third section, U.S. cities can more effectively mitigate the unavailability of suitable homes.

2 Q2: It Was the Worst of Times

2.01 Addressing the Problem

In conjunction with the housing shortage that many Americans face, homelessness is another obstacle that plagues urban populations. The rates of homelessness are already high enough for many Americans to consider it one of the most pressing problems in the U.S. today, reaching 6.9% in 2022. Although the rates of homelessness per state vary, with Washington on the higher side and New Mexico on the lower side (36 per 10,000 people and 12 per 10,000, respectively), many people, especially in cities, urge their governments to solve the homeless problem.

2.02 Local Assumptions

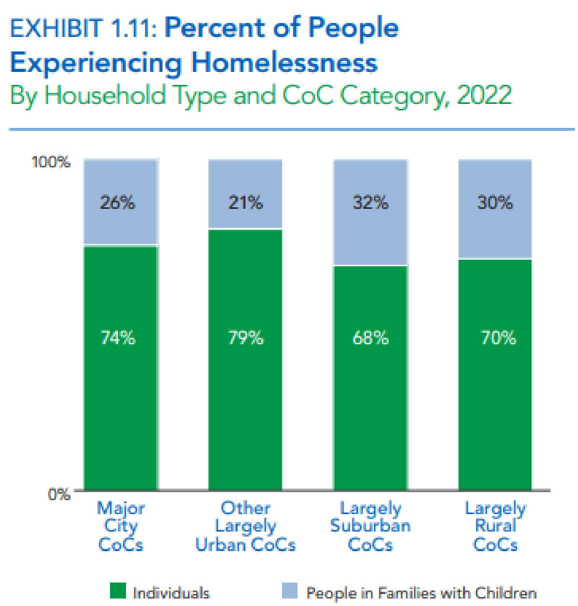

Figure 7: % of People Experiencing Homelessness

When considering the problem of homelessness, we must consider variables such as geographic location, development of infrastructure, and the degree to which the local government concerns itself with the problem. As shown by the graph above, percentages of homeless in cities and suburbs are roughly the same, but as the population density of a city is far higher, meaning more resources are dedicated to the problem, the economic upturns and downturns of states Washington and New Mexico can be strongly correlated with homelessness in the cities of Seattle and Albuquerque.

2.03 Our Models

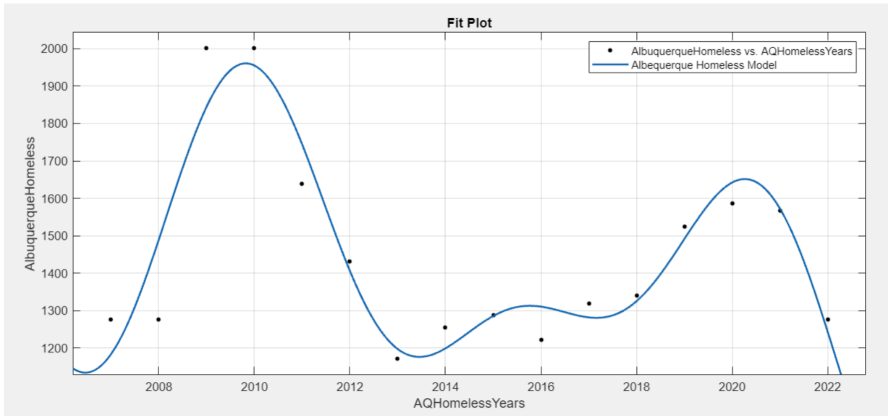

Figure 8: Sinusoidal Model of Albuquerque's Homeless Population Derived in MATLAB [7]

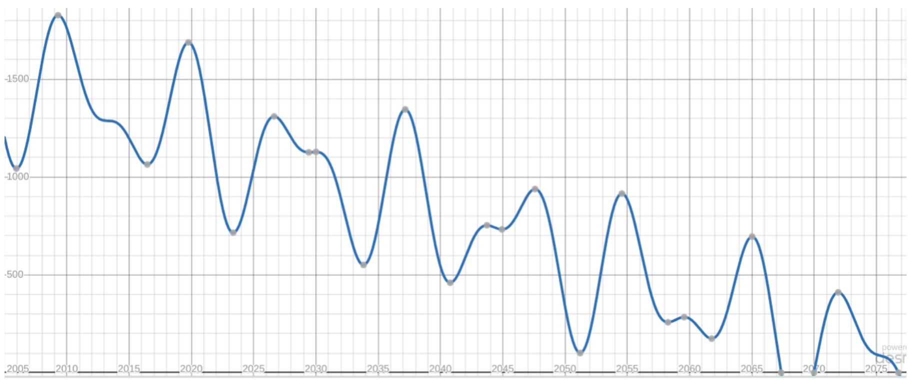

Figure 9: Sinusoidal Model of Albuquerque's Homeless Population Extended to 2080 [8]

Eqn: $y = 5306\, sin(0.00405x + 415.7) + 291.8\, sin(0.6977x - 559.1) + 187.6\, sin(1.107x + 303.7)$

where x = the year and y = the estimated population of Albuquerque

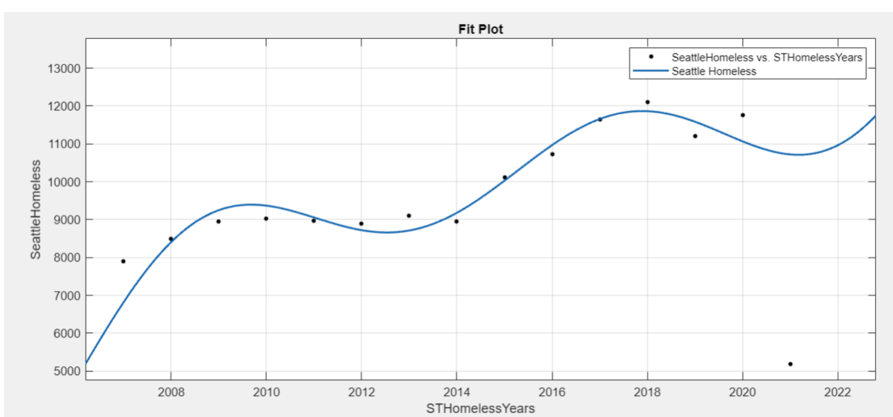

Figure 10: Sinusoidal Model of Seattle's Homeless Population Derived in MATLAB [7]

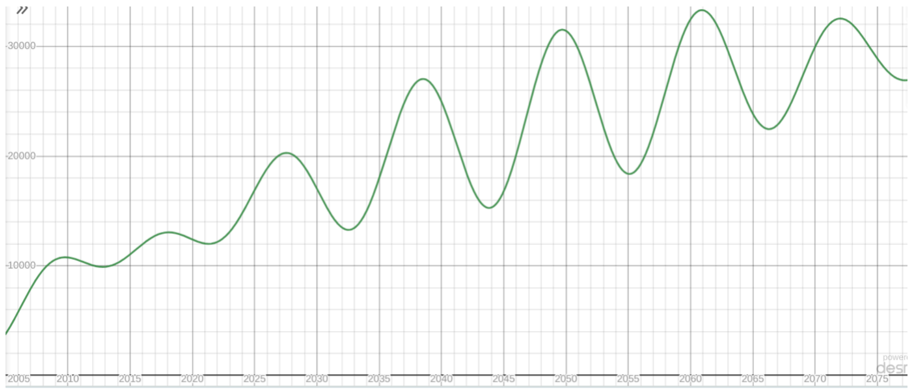

Figure 11: Sinusoidal Model of Seattle's Homeless Population Extended to 2080 [8]

Eqn:

$$y = 29570\,sin(0.01626x + 388.6) + 3544\,sin(0.5078x - 178.4) + 3854\,sin(0.5991x + 476.4)$$

where x = the year and y = the estimated population of Seattle

2.04 Interpreting the Models

The graphs and equations above can be used to estimate the homeless population of Albuquerque and Seattle in the coming years. According to Figures 8 and 9 and the equation, we can estimate the population of Albuquerque as 555 in 10 years, 751 in 20 years, and 159 in 50 years. The graph estimates the homeless population of Albuquerque to be 779 in 2024, which means the decrease in population from 2024 will be 224 in 2034, 28 in 2044, and 620 in 2074. Figure 10 and Figure 11 estimate the population of homeless in Seattle to be 15,024 in 2034, 15,336 in 2044, and 30,564 in 2074. The estimated homeless population of Seattle is 14,778, which means the increase in homeless from 2024 will be 246 in 2034, 558 in 2044, and 15,786 in 2074.

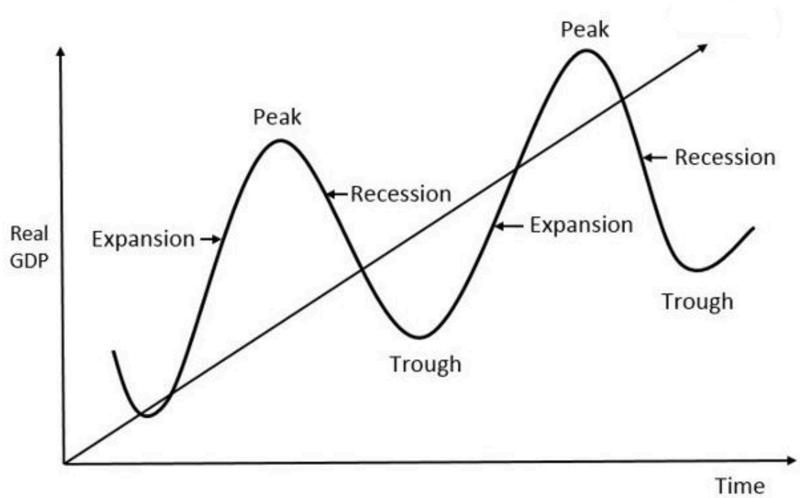

Figure 12: Fluctuations in the Business Cycle [GoHighBrow]

2.04.1 Evaluating the Results

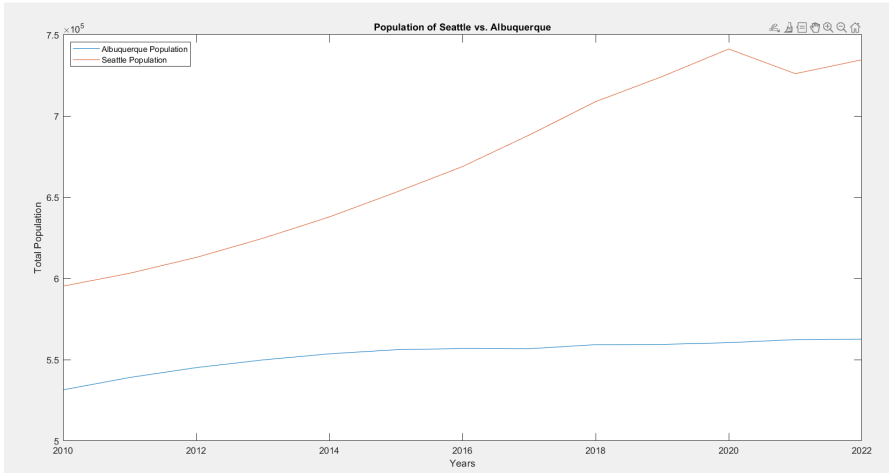

Figure 13: Population of Seattle (Red) and Albuquerque (Blue) Over Time [7]

As shown by the results in the graph, the rate of homelessness in Albuquerque is predicted to decrease, while in Seattle, it increases. We chose to use a sum of sines distribution for our data points as we predicted homelessness rates would behave in a matter similar to the business cycle, with its lows corresponding to economic peaks. Again, the results must be interpreted in context, as one must consider the varying circumstances of each city. As Seattle's population is predicted to increase, based on the data provided by MathWorks, it makes sense that the homeless population should increase together with the population, while Albuquerque's is predicted to remain relatively constant. If Albuquerque is predicted to increase its supply of housing while keeping their population growing at a slower rate than Seattle, their homeless population should benefit from these changes, thanks to its much smaller population density and smaller number of residences. In addition to this, climate change has had a much larger effect on Seattle than on Albuquerque, which amplifies the homeless problem – one would find higher homeless populations in warmer climates. [16] In Seattle, temperatures have risen by roughly 3 degrees over the century [16], while in Albuquerque, the temperatures have remained relatively constant [17]. Lastly, the job market for Seattle and Albuquerque must be considered.

2.04.2 Strengths and Weaknesses

Our prediction model demonstrates the general trend of homelessness based on the overall well-being of the city, whether its living conditions are likely to rise in coming years or decrease as the populations increase. With Albuquerque's low population density and high capacity for growth due to its proximity to Texas, a rising tech hub, its economic and social status is likely to rise. Seattle, on the other hand, has already been listed as one of the most dense cities in the US, with a greater population growth rate. However, the models are probably affected by national events such as the 2008 recession and more importantly, the COVID-19 pandemic, where city governments scrambled to house homeless individuals in order to limit the spread of the virus, explaining the sudden drops which likely offset the data.

2.05 Additional Factors

2.05.1 Unemployment

A leading factor in the reason for homelessness is unemployment. As discussed above, COVID-19 played a large factor in the increase in unemployment, and then the increase in homelessness. Prior to COVID-19, 46% of the homelessness in Los Angeles County was caused by unemployment or other financial reasons, this statistic can be applied to many other major U.S. cities [18].

Although homelessness can be caused by unemployment, the state of homelessness can also cause a barrier to employment, making one's situation even worse. There are many barriers to employment including mental and physical health challenges that can be caused, or worsened by homelessness. For example, depression, schizophrenia, and bipolar disorder was between 25% and 30% amongst the homeless population in 2019. The lack of vocational training as well can make many homeless people unable to find jobs they are qualified for. Finding a job while facing these conditions creates a major barrier to employment as many employers would not want workers with health disorders or those who lack training [18].

2.05.2 Climate Change

Change in climate not only makes more extreme, hard to live in conditions for homeless people, but actually has a large impact and influence on homelessness in America. With an increase in greenhouse gas emission and global warming, heat related illnesses present themselves in individuals. For example, in California 13% of heat-related hospitalizations between 2017 and 2021 were from the homeless population, even though they only make up less than half a percent of the state's population. Homeless individuals are more susceptible to chronic respiratory conditions and the rise of poor air quality has made their conditions even worse [19].

The more prominent issue of climate change for homeless individuals is natural disasters. After a natural disaster, residents are left with very few resources, many have insurance plans and other ways to support themselves, but many do not. In 2023, 66 major disasters took place, about 3.1 million people were displaced in just one year. Most were out of their homes for less than a month but some were displaced for over six months, and some never returned home [20]. .In addition, many cannot afford repairs to damage caused by more mild natural disasters. For example, many cannot afford flood insurance and do not qualify for disaster loans [19]. When a house floods, it may not ruin the foundation of the home but will lower its selling value and the owners or renters cannot afford to fix the house's damages due to their lack of insurance and income. In addition, damage that is done to a house may not make the house unlivable but can decrease comfort and safety but is, most of the time, very expensive, and for some, the expenses are too high and they will remain living in the uncomfortable and unsafe conditions.

2.05.3 Substance Abuse

Substance abuse becomes an issue for many individuals who face homelessness at some point in their lives and can make many situations worse. For example, substance use is another factor in unemployment as it is a barrier to employment. Employers do not want workers who use substances as substance users have difficulty maintaining employment. People with substance use disorders are also more likely to have lower-level jobs providing less income than those who do not have substance use disorders. In 2019, 16% of homelessness in Los Angeles County was caused by substance use [18].

2.06 Potential Solutions

2.06.1 Federal Housing Assistance

By providing federal housing aid for low-income households, governments can mitigate the homeless rate in their respective cities. While Section 8 housing choice vouchers and rent control policies increase the affordability of housing for low-income individuals, they disincentivize current tenants from seeking alternative housing options in fear of higher rental prices and fail to provide a consistent supply of housing for the homeless [20].

2.06.2 Mixed-Use Housing

Instead of compartmentalizing city buildings for certain uses, it is conducive to incorporate residential and commercial aspects into one property. In other words, using properties for multiple purposes can optimize sustainable development (i.e. renting the floor above a restaurant for living space). While mixed-use housing can lead to noise pollution, it optimizes more flexibility for living spaces in the city [22].

2.06.3 Standards of Living

By making access to public goods more equitable, such as public transportation, infrastructure, and health, governments can improve standards of living for both the homeless and low-income individuals. Particularly, through the likes of public housing funds, eligible individuals can receive grants that subsidize basic resources. However, since the federal government has invested less capital in public housing since the mid-1990s, housing units have fallen by over 200,000 units and continue to dwindle without federal funding [21].

3 Q3: Rising from This Abyss

3.01 Addressing the Problem

Our model is designed to solve the problem of homelessness in Seattle and Albuquerque, mainly by addressing the shortages in the housing market and the human capital among the homeless. The supply of housing is forecasted to increase, though it requires government involvement to improve at a faster rate. However, this would still be susceptible to further economic crises and natural disasters, making it equally important to increase the human capital of the homeless. The main detriments to homeless people include drug addiction, mental illness, and physical disability, which significantly decrease their value in the workforce, and their socioeconomic situation is comparable to that of a game of musical chairs, except this player has a sprained ankle [24]. Thus, giving the homeless an equal chance in the workforce is vital to their integration into society.

3.02 Our Model

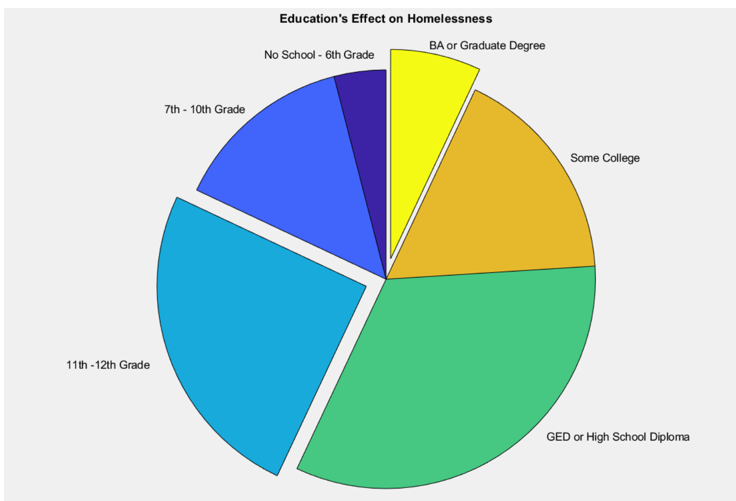

Figure 14: Model Reflecting the Correlation Between Education and Homelessness [24]

To combat homelessness, our model proposes to subsidize construction, relax zoning laws on properties, and implement innovative housing technologies to maximize efficiency. This eases the stress on the housing market, which precludes many people from acquiring a stable home or being secure about their rent, and thus mitigates future homeless rates. The model further proposes to increase the human capital of the homeless to keep them on equal footing with the rest of the workforce. An increase in education for the homeless not only helps solve their problem of poverty but also contributes to the output of the city. Thus, governments should focus on clearing debilitating conditions that affect the homeless through rehabilitation for drug addiction and mental illness, and then invest in training to help them enter the workforce. This second step goes hand-in-hand with the first step, as a sense of security in location is vital for improving health; furthermore, it serves as a long-term oriented solution to the homelessness problem, as they should be provided with an educational platform to develop their skill sets.

3.03 Interpreting the Models

3.03.1 Strengths And Weaknesses

As the pie chart indicates, most of the homeless have had some education, but education is not directly correlated with homelessness. The effectiveness and value of high school and college education have decreased over time, with many cities allocating money to public high school programs in troubled areas and seeing little results. Thus, although the students may graduate or continue up to 11th grade, they do not receive the full benefits of education. It is thus important that the model's training includes a reformation of the individual's values to optimize productivity. The model also requires a significant effort from local governments, as it requires them to decrease their revenues by granting subsidies while also increasing their expenditures on public education by citizens, which may require public initiatives or funding.

3.04 Community Incentives

3.04.1 Public Health

Homelessness plays a large role in the health of many individuals, making public health an incentive to reduce homelessness in America. Children who have experienced homelessness at any point in their lives are more likely to experience serious health conditions, developmental delays, and abuse. In addition, those who experience homelessness die almost 30 years earlier than the average American. Health problems increase the chances of becoming homeless, as healthcare is very expensive and creates a large financial issue for many Americans [25]. Currently, homeless individuals are stuck in a never-ending cycle when it comes to healthcare. Access to housing would increase the likelihood of getting a job and eventually increase income, leading to increased access to healthcare and doctors.

3.04.2 Socioeconomic Growth

A reason to increase housing in America and reduce homelessness would be the incentive for greater human capital. If more housing was provided for homeless individuals, they would have better chances of getting access to a job. Barriers to employment are present for many homeless people, but as more people enter the workforce, America's human capital will increase. Increasing human capital stimulates economic growth, innovation, and productivity [26]. As more individuals enter the workforce, they will be able to earn higher wages and support education. As more individuals get an education, human capital will outweigh homelessness, provide higher education, and create benefits nationwide.

3.04.3 Human Development

The Human Development Index (HDI) measures the average achievements in aspects of human development, such as health, education, and standard of living. If new housing were to be developed more individuals would have access to homes and jobs, which would improve the HDI [27].

3.05 Sustainable Solutions

3.05.1 Subsidized Housing

Subsidized housing would increase the supply of housing in the U.S. which would help many individuals facing homelessness. By subsidizing the costs of building houses and related infrastructure for contractors, the availability of housing would increase. As this supply increases, housing becomes more affordable, and it would also reduce the number of vacant units since their price is lowered to the market equilibrium.

3.05.2 Housing Innovation

There are many new innovative ways to create new housing. 3D-printed houses, which use cement base material to create buildings layer-by-layer, are effectively increasing in popularity [28]. Similarly, in-fill housing is when houses are reutilized and refurbished on vacant lots or interspersed between buildings [29]. In-fill housing also creates many benefits for the homeowner/renter, as they are more walkable and have convenient access to public transportation [30]. Volumetric construction, or stacking premade modules to form a complete building, is another quick and quality option for housing development. Volumetric construction is also better for the environment because it incorporates material waste into its construction. Although there is limited flexibility after design, the affordable short-term costs make volumetric construction a viable option for housing development [31].

3.05.3 Land-Use Planning and Infrastructure

One of the biggest issues in regard to the housing shortage in America is the availability of land, or lack thereof. It is difficult to find land within an urban area to create more housing. California has attempted to solve this issue by turning golf courses into low-income housing spaces. The Rancho Park Golf Course in West Los Angeles was estimated to fit about 15,000 units, which could house about 50,000 people on 200 acres. Most urban golf courses are about 120 acres, and in L.A. alone, 2300 acres of land are occupied by golf courses. As of 2020, L.A. housing prices were on average 7.3 times higher than a Californian's median income. Unfortunately, many people do not want housing to be built on their golf courses, even if they support the idea of affordable housing [32].

3.05.4 Reduced Zoning Rules

Zoning rules have many undesirable effects, including overcrowding in low-income neighborhoods and a lack of suitable housing within these areas. While these high-density, low-income neighborhoods consist primarily of large apartment complexes, high-income areas are generally characterized by single-family houses on spacious lots, thus driving up costs of land and resources in areas that cannot accommodate a greater population [2]. In fact, as of 2019, 81% of residential land in Seattle had been zoned for detached single-family homes [33]. This high percentage excludes multi-family homes that could support others who cannot afford a single-family home.

The reduction of zoning rules would create more opportunities for individuals to have affordable housing. Many urban areas have zoning rules that allow only single-family housing to be built. Revamping these restrictions would allow more multi-family homes to be built, which would create more affordable housing for many. For example, California, Oregon, and Maine have already passed laws ending single-family zoning, and they are now allowing the construction of more than one home per parcel of land which many people will help boost the supply of rental units [33].

4 Conclusion

As the limited spacing in cities puts a restriction on the housing supply, we used a logistic regression model to best predict future housing supply. The trend in homeless populations, however, varied much more across different cities. Due to the effects of the business cycle, both cities' homeless populations could be estimated through a sinusoidal model – the relative leveling-out of Albuquerque's total population led to an overall decrease in the homeless population while Seattle's rapidly increasing population led to an overall increase in the homeless population. We also concluded that the most pressing problem contributing to the housing crisis is the lack of equal opportunity as a result of factors, such as socioeconomic status, disability, and mental illness. This lack of opportunity contributes to the increase in homelessness among those with lower levels of education. As a solution, subsidized housing, housing innovation, infrastructure and land-use planning, and reduced zoning rules would maximize the amount of housing available in large cities, thereby giving the homeless population greater access to opportunities afforded to those with stable housing.

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6 Code Appendix

```
%Extracts data from MathWorks provided data for the second model for Albuquerque's and Seattle's estimated homeless populations

SeattleHomeless = table2array(Seattle(59:74, 6));

AlbuquerqueHomeless = table2array(Albuquerque(59:74, 6));

%Extracts data from MathWorks spreadsheet for the graph modeling the populations of the two cities

AlbuquerquePopulation = table2array(Albuquerque(36:48, 2));

SeattlePopulation = table2array(Seattle(36:48, 2));

%Extracts years for x-axes of graphs

AQPopulationYears = table2array(Albuquerque(36:48, 1));

AQHomelessYears = table2array(Albuquerque(59:74, 1));

STPopulationYears = table2array(Seattle(36:48, 1));

STHomelessYears = table2array(Seattle(59:74, 1));

%Plots Albuquerque's population versus Seattle's population

plot(AQPopulationYears, AlbuquerquePopulation);

hold on;

plot(STPopulationYears, SeattlePopulation);

hold off;

title("Population of Seattle vs. Albuquerque")

xlabel("Years");

ylabel("Total Population");

legend("Albuquerque Population", "Seattle Population");

%Plots Albuquerque's homeless population versus Seattle's homeless population

plot(AQHomelessYears, AlbuquerqueHomeless);

hold on;

plot(STHomelessYears, SeattleHomeless);

hold off;

title("Homeless Population of Seattle vs. Albuquerque")
```

```
xlabel("Years");

ylabel("Homeless Population");

legend("Albuquerque Homeless", "Seattle Homeless")


%Extracts years for x-axis of model 1

years = table2array(Albuquerque(1:13, 1));

yearsSince2010 = years-2010;

%Extracts data from MathWorks provided data for the first model for Albuquerque's and Seattle's estimated housing supply

AlbuquerqueTotalHousing = table2array(Albuquerque(1:13, 2));

AQTotalHousing = AlbuquerqueTotalHousing/(10^5);

SeattleTotalHousing = table2array(Seattle(1:13, 2));

STTotalHousing = SeattleTotalHousing/(10^5);


%Creates arrays for pie chart model of education level in relation to homeless percentages

EducationLevels = ["No School - 6th Grade", "7th - 10th Grade", "11th -12th Grade", "GED or High School Diploma", "Some College", "BA or Graduate Degree"];

Percentages = [4, 14, 25, 33, 17, 7];

%Creates pie chart

pie(Percentages, [0 0 1 0 0 1], EducationLevels);

title("Education's Effect on Homelessness");


%Curve-fitting code to estimate Seattle's homeless population

function [fitresult, gof] = createFit(STHomelessYears, SeattleHomeless)

%CREATEFIT(STHOMELESSYEARS,SEATTLEHOMELESS)

%  Create a fit.

%

%  Data for 'Seattle Homeless' fit:
```

```
%      X Input: STHomelessYears
%      Y Output: SeattleHomeless
%  Output:
%      fitresult : a fit object representing the fit.
%      gof : structure with goodness-of fit info.
%
%  See also FIT, CFIT, SFIT.
%  Auto-generated by MATLAB on 03-Mar-2024 19:52:55
%% Fit: 'Seattle Homeless'.
[xData, yData] = prepareCurveData( STHomelessYears, SeattleHomeless );
% Set up fittype and options.
ft = fittype( 'sin3' );
opts = fitoptions( 'Method', 'NonlinearLeastSquares' );
opts.Display = 'Off';
opts.Lower = [-Inf -Inf -Inf -Inf 0 -Inf -Inf 0 -Inf];
opts.Robust = 'Bisquare';
opts.StartPoint = [15561.7765593416 0.20943951023932 0.52901809409157 6534.01469947322 0.418879020478639 2.82305356937704 1378.21659853918 0.837758040957278 -2.96477681134155];
% Fit model to data.
[fitresult, gof] = fit( xData, yData, ft, opts );
% Plot fit with data.
figure( 'Name', 'Seattle Homeless' );
h = plot( fitresult, xData, yData );
legend( h, 'SeattleHomeless vs. STHomelessYears', 'Seattle Homeless', 'Location', 'NorthEast', 'Interpreter', 'none' );
% Label axes
xlabel( 'STHomelessYears', 'Interpreter', 'none' );
ylabel( 'SeattleHomeless', 'Interpreter', 'none' );
```

```
grid on

%Curve-fitting code to estimate Albuquerque's homeless population
function [fitresult, gof] = createFit(AQHomelessYears, AlbuquerqueHomeless)
%CREATEFIT(AQHOMELESSYEARS,ALBUQUERQUEHOMELESS)
%  Create a fit.
%
%  Data for 'Albuquerque Homeless Model' fit:
%      X Input: AQHomelessYears
%      Y Output: AlbuquerqueHomeless
%  Output:
%      fitresult : a fit object representing the fit.
%      gof : structure with goodness-of fit info.
%
%  See also FIT, CFIT, SFIT.
%  Auto-generated by MATLAB on 03-Mar-2024 19:55:04
%% Fit: 'Albuquerque Homeless Model'.
[xData, yData] = prepareCurveData( AQHomelessYears, AlbuquerqueHomeless );
% Set up fittype and options.
ft = fittype( 'sin3' );
opts = fitoptions( 'Method', 'NonlinearLeastSquares' );
opts.Display = 'Off';
opts.Lower = [-Inf 0 -Inf -Inf 0 -Inf -Inf 0 -Inf];
opts.StartPoint = [2305.69711948835 0.20943951023932 0.628603748676673 1184.52669971783 0.418879020478639 2.7146728754169 102.307406328735 1.25663706143592 1.14695547040699];
% Fit model to data.
[fitresult, gof] = fit( xData, yData, ft, opts );
% Plot fit with data.
```

```
figure( 'Name', 'Albuquerque Homeless Model' );

h = plot( fitresult, xData, yData );

legend(  h,  'AlbuquerqueHomeless  vs.  AQHomelessYears',  'Albuquerque  Homeless
Model', 'Location', 'NorthEast', 'Interpreter', 'none' );

% Label axes

xlabel( 'AQHomelessYears', 'Interpreter', 'none' );

ylabel( 'AlbuquerqueHomeless', 'Interpreter', 'none' );

grid on


%Curve-fitting code to estimate Albuquerque's housing supply in coming years

function [fitresult, gof] = createFit(yearsSince2010, AQTotalHousing)

%CREATEFIT(YEARSSINCE2010,AQTOTALHOUSING)

%  Create a fit.

%

%  Data for 'New AQ Total Housing' fit:

%      X Input: yearsSince2010

%      Y Output: AQTotalHousing

%  Output:

%      fitresult : a fit object representing the fit.

%      gof : structure with goodness-of fit info.

%

%  See also FIT, CFIT, SFIT.

%  Auto-generated by MATLAB on 03-Mar-2024 20:02:21

%% Fit: 'New AQ Total Housing'.

[xData, yData] = prepareCurveData( yearsSince2010, AQTotalHousing );

% Set up fittype and options.

ft = fittype( '4/(1+exp(-(b*x)-c))', 'independent', 'x', 'dependent', 'y' );

opts = fitoptions( 'Method', 'NonlinearLeastSquares' );

opts.Display = 'Off';
```

```
opts.MaxFunEvals = 2000;

opts.MaxIter = 2000;

opts.StartPoint = [0.826629506618892 0.394534684233034];

% Fit model to data.

[fitresult, gof] = fit( xData, yData, ft, opts );

% Plot fit with data.

figure( 'Name', 'New AQ Total Housing' );

h = plot( fitresult, xData, yData );

legend( h, 'AQTotalHousing vs. yearsSince2010', 'New AQ Total Housing', 'Location', 'NorthEast', 'Interpreter', 'none' );

% Label axes

xlabel( 'yearsSince2010', 'Interpreter', 'none' );

ylabel( 'AQTotalHousing', 'Interpreter', 'none' );

grid on


%Curve-fitting code to estimate Seattle's housing supply in coming years

function [fitresult, gof] = createFit(yearsSince2010, STTotalHousing)

%CREATEFIT(YEARSSINCE2010,STTOTALHOUSING)

%  Create a fit.

%

%  Data for 'New ST Total Housing' fit:

%      X Input: yearsSince2010

%      Y Output: STTotalHousing

%  Output:

%      fitresult : a fit object representing the fit.

%      gof : structure with goodness-of fit info.

%

%  See also FIT, CFIT, SFIT.

%  Auto-generated by MATLAB on 03-Mar-2024 20:04:11
```

```
%% Fit: 'New ST Total Housing'.

[xData, yData] = prepareCurveData( yearsSince2010, STTotalHousing );

% Set up fittype and options.

ft = fittype( '5.5/(1+exp(-(b*x)-c))', 'independent', 'x', 'dependent', 'y' );

opts = fitoptions( 'Method', 'NonlinearLeastSquares' );

opts.Display = 'Off';

opts.StartPoint = [0.0646335910508684 0.436184955731448];

% Fit model to data.

[fitresult, gof] = fit( xData, yData, ft, opts );

% Plot fit with data.

figure( 'Name', 'New ST Total Housing' );

h = plot( fitresult, xData, yData );

legend( h, 'STTotalHousing vs. yearsSince2010', 'New ST Total Housing',
'Location', 'NorthEast', 'Interpreter', 'none' );

% Label axes

xlabel( 'yearsSince2010', 'Interpreter', 'none' );

ylabel( 'STTotalHousing', 'Interpreter', 'none' );

grid on
```