A Tale Of Two Crises

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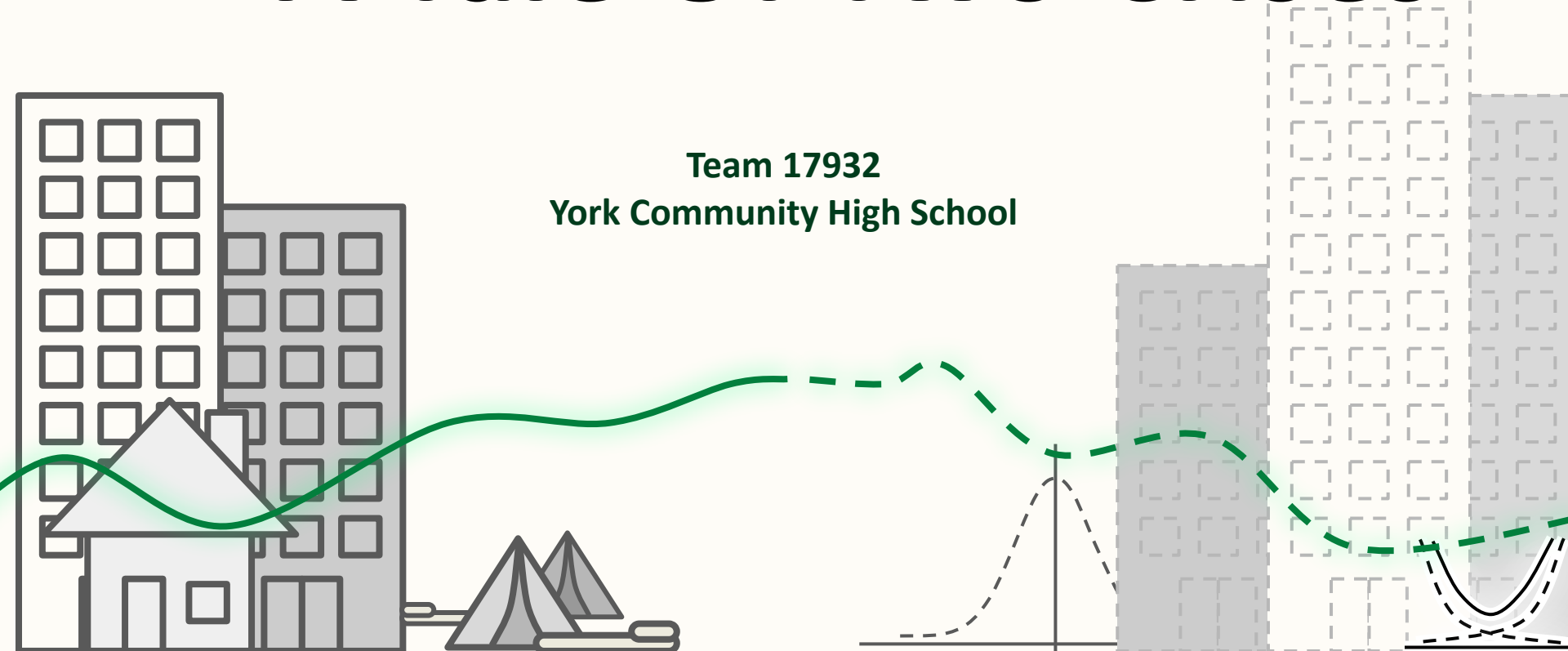
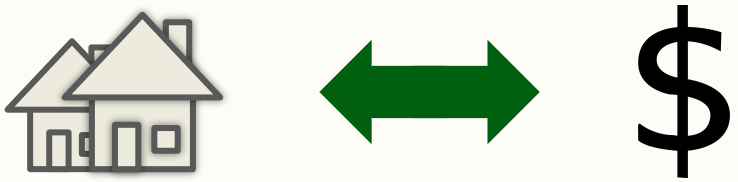
York Community High School



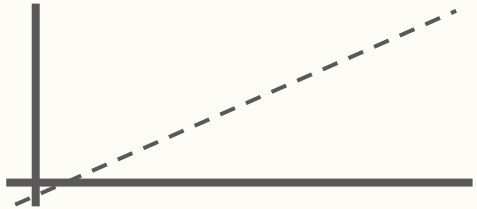
Global Assumptions

- Historical homelessness and housing data are predictive of future trends

- Homelessness and housing are directly related to the economy

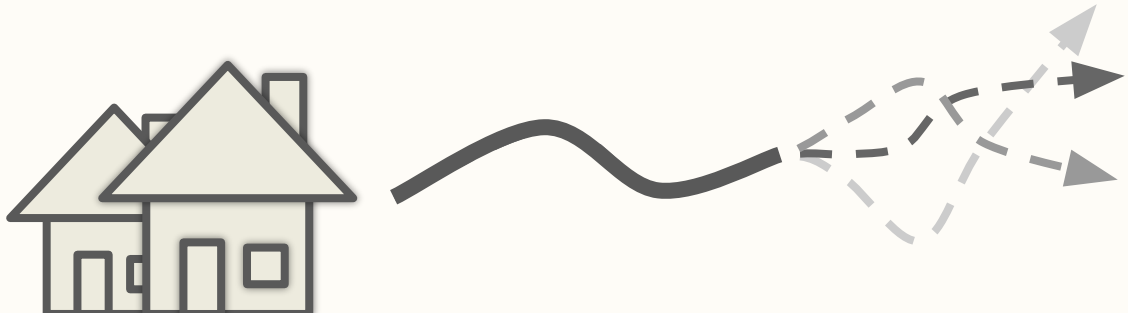


- The housing market will not reach its theoretical limit during our time period



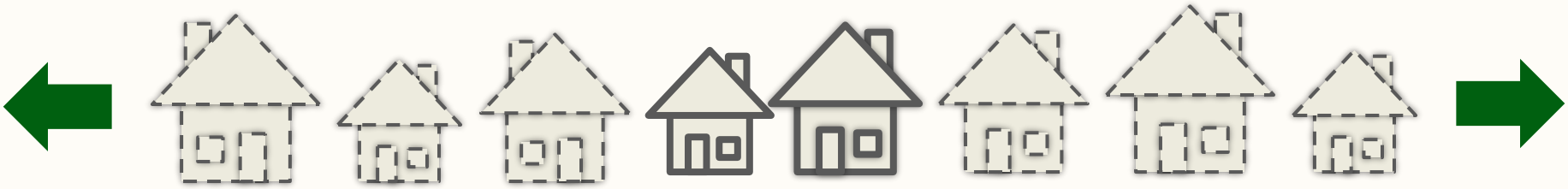
Question 1 — It Was the Best of Times…

Create a model that **predicts changes in the housing supply** in Seattle, Washington and Albuquerque, New Mexico in the next **10, 20, and 50 years**. Indicate your **level of confidence** in your predictions.



Local Assumptions

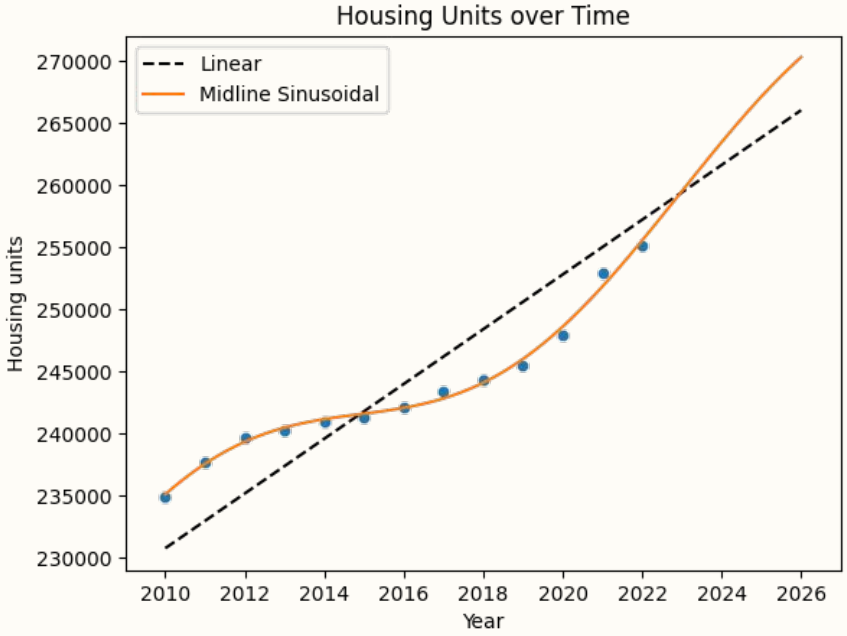
- Usable space is not a significant constraint for housing availability



- Average longevity of housing will remain unchanged

Our approach: Midline Sinusoidal Regression

Economic activity generally follows the business cycle, which has two main features:[1]



1 - https://srbadvisors.com/bull-and-bear-market-cycles/

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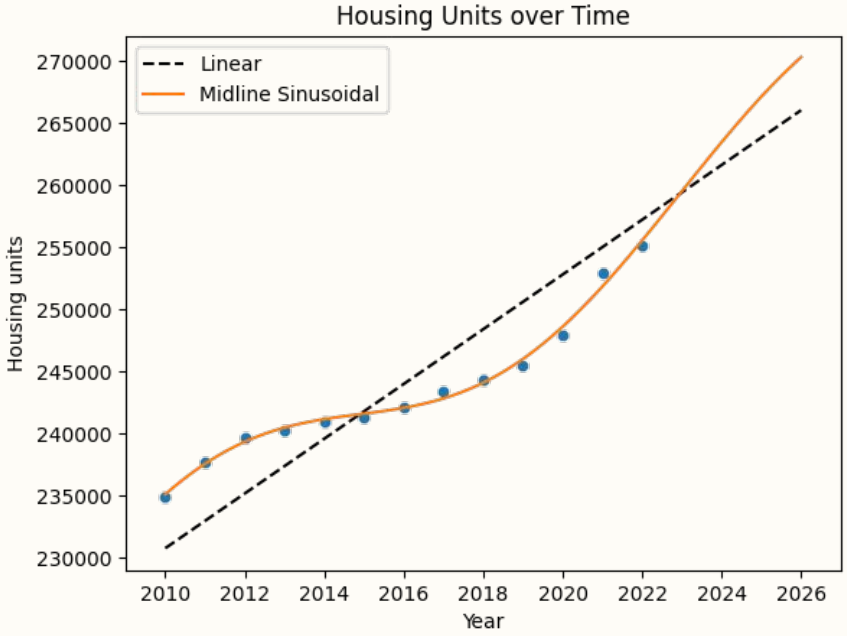
- An overall linear increase

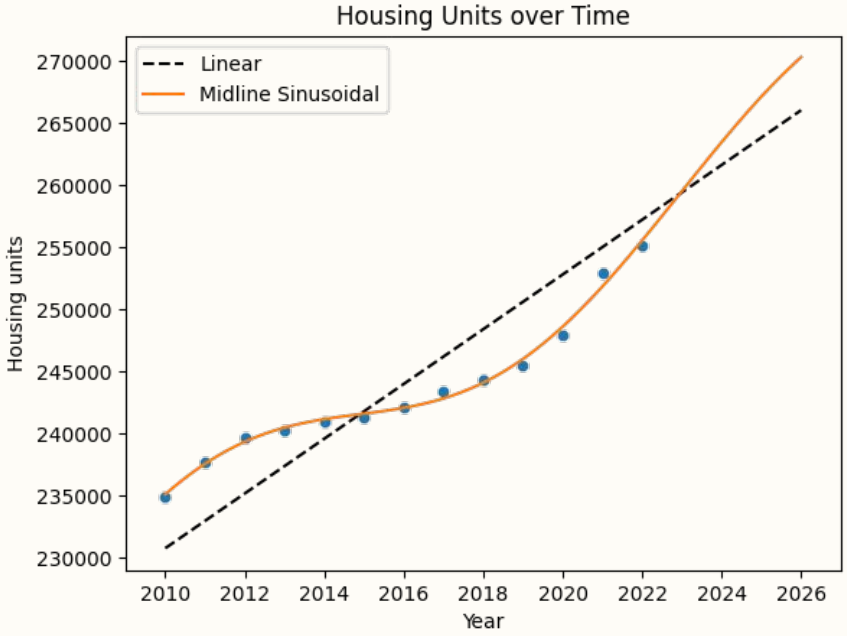


1 - https://srbadvisors.com/bull-and-bear-market-cycles/

Our approach: Midline Sinusoidal Regression

Economic activity generally follows the business cycle, which has two main features:[1]

- An overall linear increase
- Periodic deviations



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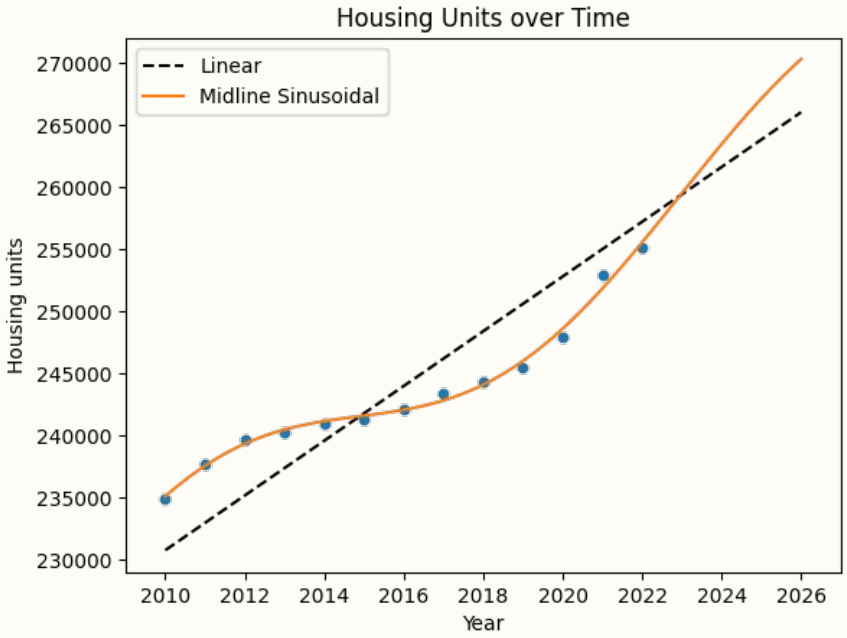
Our approach: Midline Sinusoidal Regression

Economic activity generally follows the business cycle, which has two main features:[1]

- An overall linear increase
- Periodic deviations

A midline sinusoidal regression models both **without unnecessary complexity**.



1 - https://srbadvisors.com/bull-and-bear-market-cycles/

Model Setup

Name	Description	Units
t	Time after 2010	Years
m	Midline slope	Houses per Year
β	Midline initial value	Houses
α	Sinusoidal amplitude	Houses per Year
ω	Sinusoidal frequency	$Years^{-1}$
φ	Sinusoidal phase shift	Dimensionless

General modeling function

$$f(t) = mt + \alpha \sin(\omega t + \phi) + \beta$$

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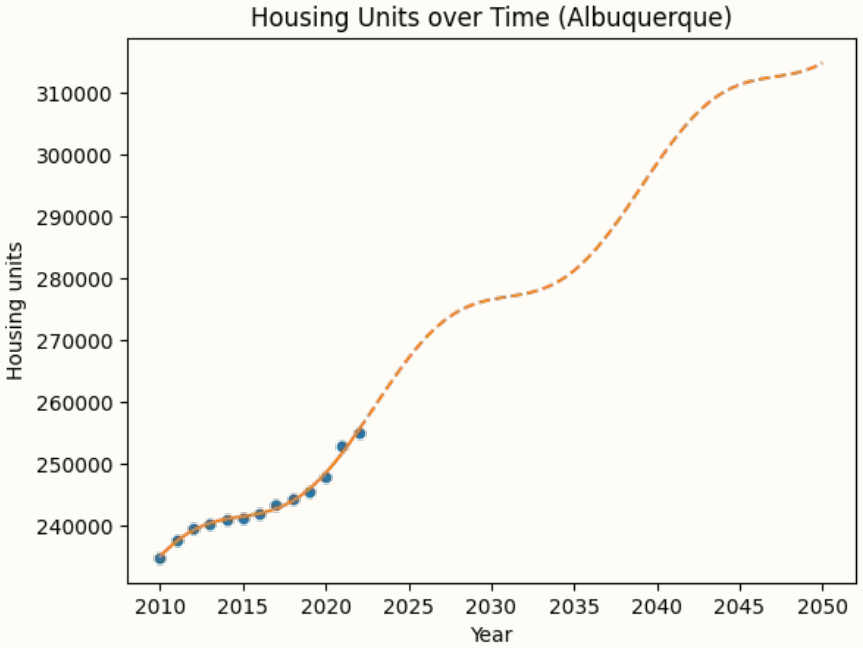
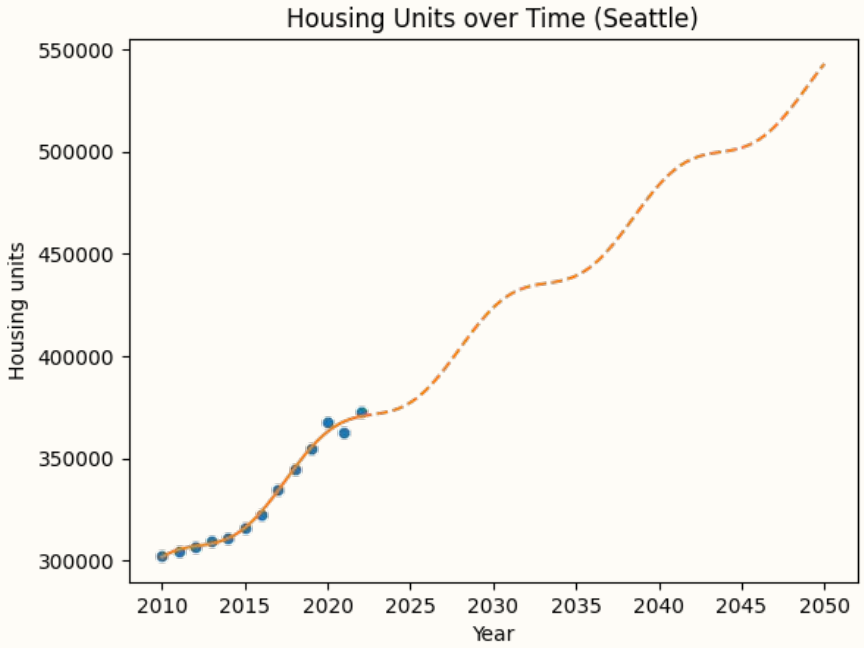
Albuquerque	$f_A(t) = 2205.8t + 4604.53\sin(0.3901t + 1.232) + 230758$
Seattle	$f_S(t) = 6108.7t + 8251.45\sin(0.5986t + 1.807) + 293665$

Model visualization





Predictions

Years after 2024	Albuquerque	Seattle
10 years	279,500 houses	424,400 houses
20 years	310,000 houses	496,900 houses
50 years	345,400 houses	684,300 houses

- Total housing units in Albuquerque will **increase by 35%** over the next 50 years
- Total housing units in Seattle will **increase by 98%** over the next 50 years

Error Analysis

Albuquerque percent error

$f_A(12) \approx 254{,}793$

Actual 255,178

0.15% error

Seattle percent error

$f_S(12) \approx 374{,}430$

Actual 372,436

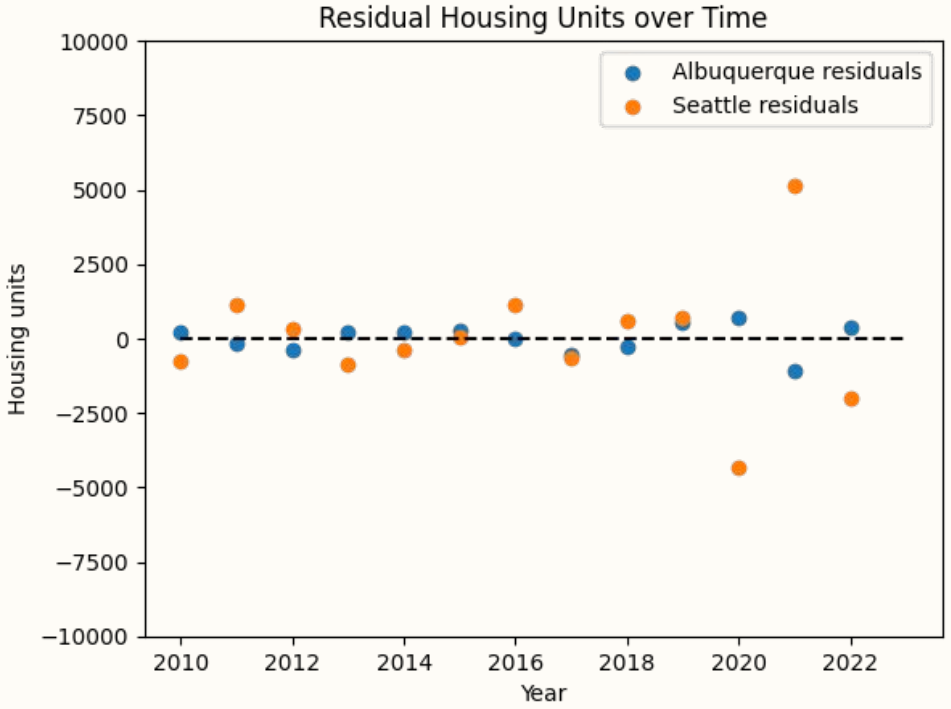
0.54% error

We are confident in our predictions due to low percent error and a high R^2 value of **0.9936** and **0.9928** for Seattle and Albuquerque respectively

Strengths

- Periodic model, accurate predictions in the near future

- Mostly homoscedastic residual plot with minimal discernable patterns[2]

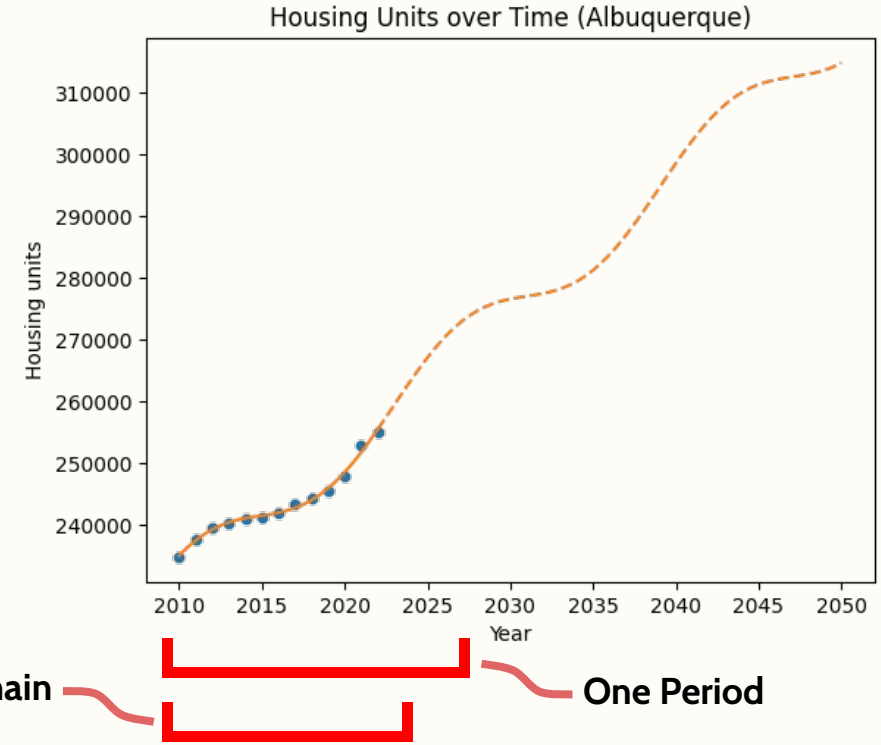


2 - https://www.statisticssolutions.com/free-resources/directory-of-statistical-analyses/homoscedasticity/

Areas of Improvement

- We ignore land restrictions, which leads to inaccurate predictions in the long run

- Model was created with a timeframe of provided data close to or shorter than that of a full cycle (12 years), $F_A(t)$ period ≈ 16 years, $F_S(t)$ ≈ 10.5 years[3]



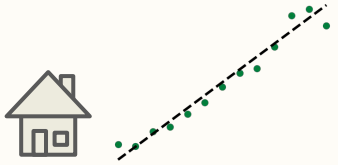
3 - https://www.datarobot.com/blog/how-much-data-is-needed-to-train-a-good-model/

Question 2 — It Was the Worst of Times…

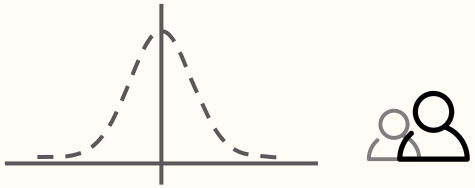
For the chosen regions in Q1, **predict changes in the homeless population** in the next **10, 20, and 50 years**.

Question 2 - Local Assumptions

- Population, income, and housing price are fundamentally linearly



- Yearly income follows a normal distribution with its mean being the yearly median income



- Maximum income cutoff for homelessness is defined as the median housing unit price divided by 30[4]

- The 2021 data was invalid due to a lack of data collection of unsheltered homeless population[5]

4 - https://www.rocketmortgage.com/learn/average-mortgage-length
5 - https://www.npr.org/2021/01/18/957379320/for-many-areas-count-of-homeless-population-is-canceled-or-delayed

Question 2 - Variables

Name	Description	Units
N	Predicted homeless population	Homeless people
p	Population	People
I	Median Income	Dollars
h	Median house price	Dollars
s	Standard Deviation of Income	Dollars
t	Time since 2010	Years

Question 2 - Our Approach

Compute Normal CDF with:

- The benchmark ($h(t)$ divided by 30) as the upper bound
- No lower bound
- The predicted income I as the median
- The predicted standard deviation $s(t)$

We then multiply this proportion by $p(t)$ to estimate homeless population

$$N(t) = p(t) \cdot \Phi\left(\frac{\frac{h(t)}{30} - I(t)}{s(t)}\right)$$

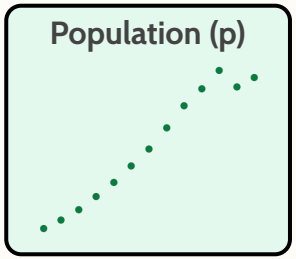
$$\Phi(x) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{x} \exp\left(\frac{u^2}{2}\right) du$$

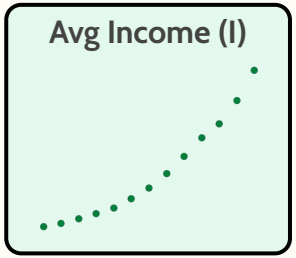
Question 2 - Computation of standard deviation

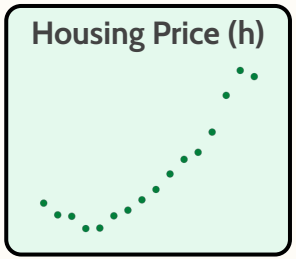
- For $p(t)$, $I(t)$, and $h(t)$, we computed simple linear regressions for each for both cities.

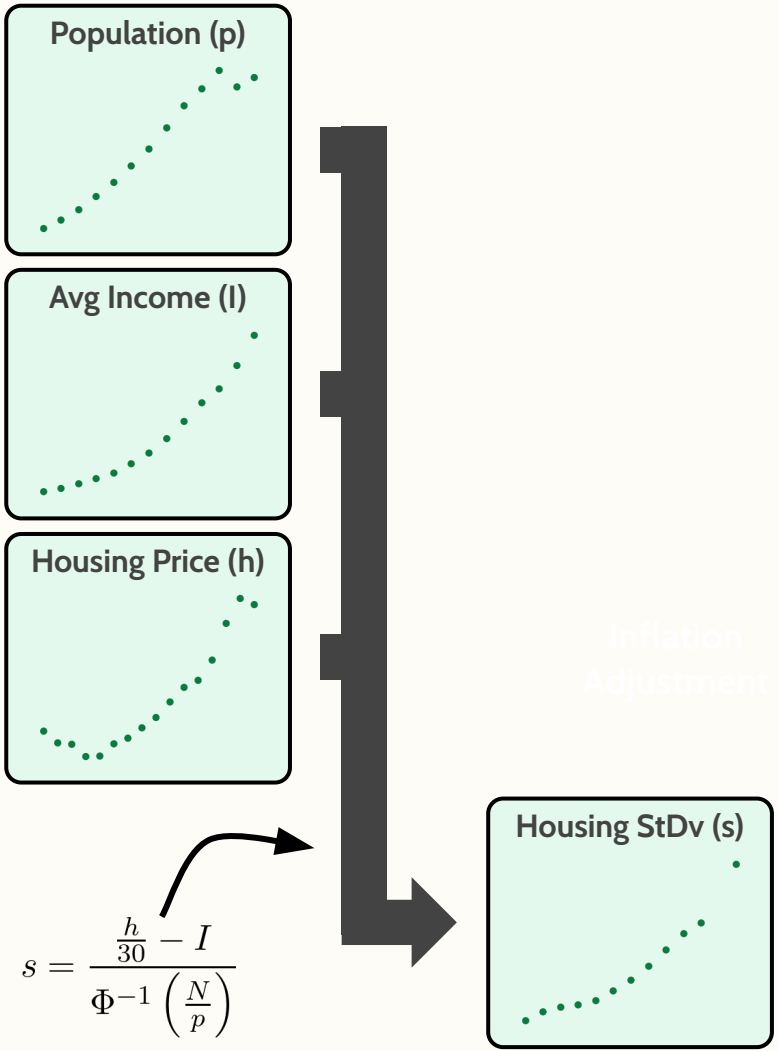
- For $s(t)$, we used $\text{invNorm}(h(t)/30, I(t), s(t)) = N(t)/p(t)$ and $N(t)$ is the actual recorded amount of homeless people. We executed this process for each data point, then made a linear regression function for standard deviation over time.

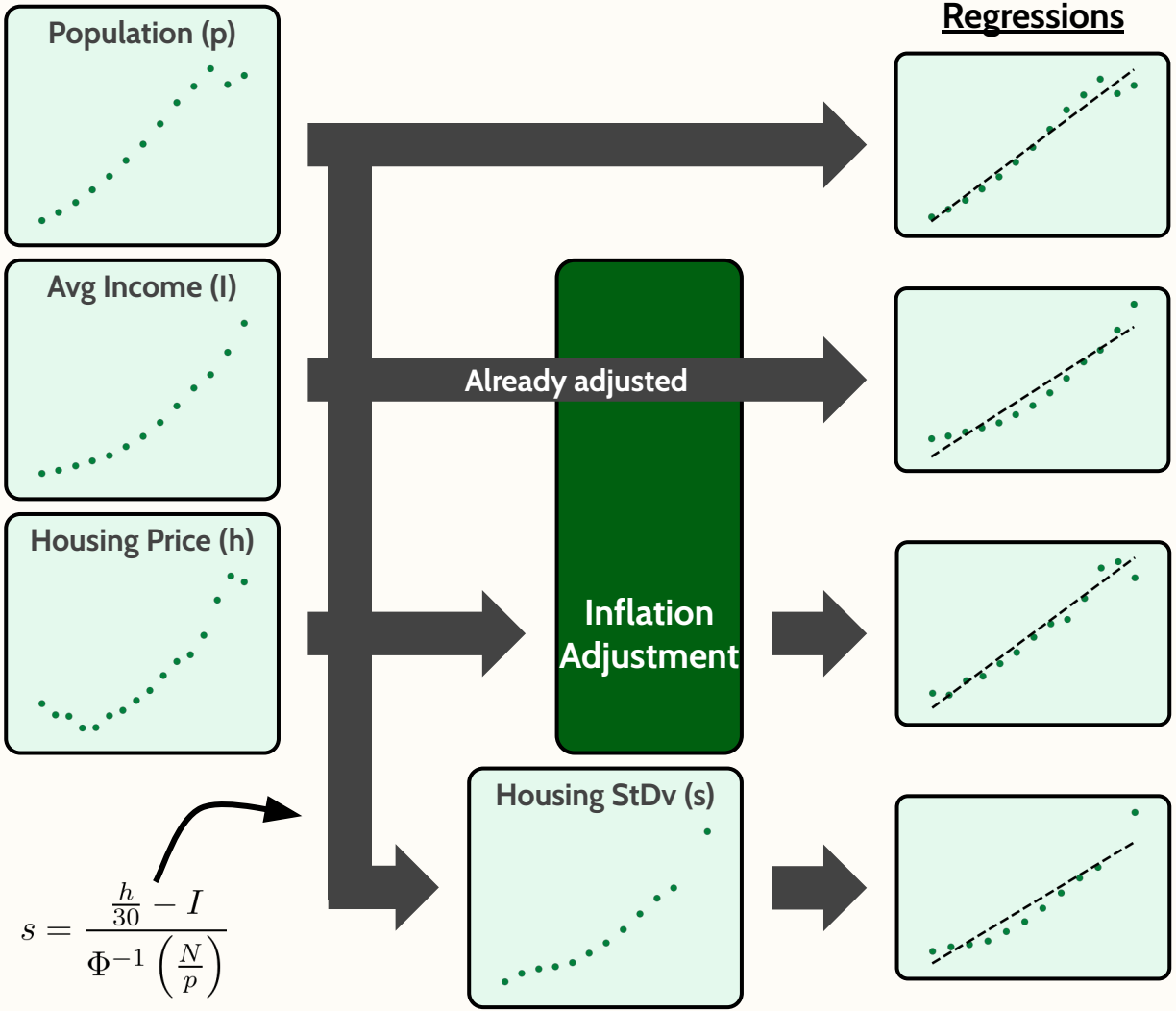
$$s = \frac{\frac{h}{30} - I}{\Phi^{-1}\left(\frac{N}{p}\right)}$$

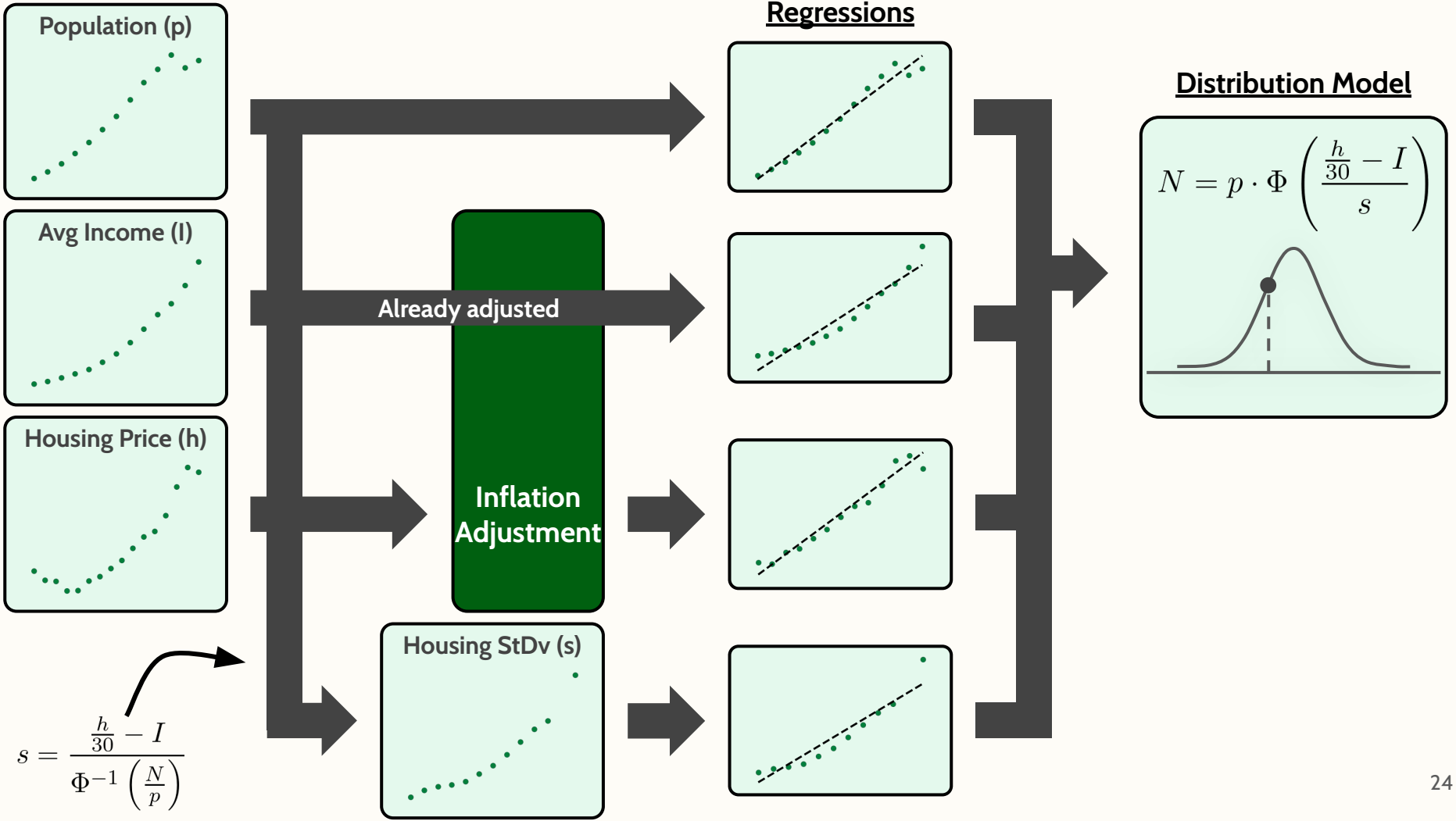

Population (p)

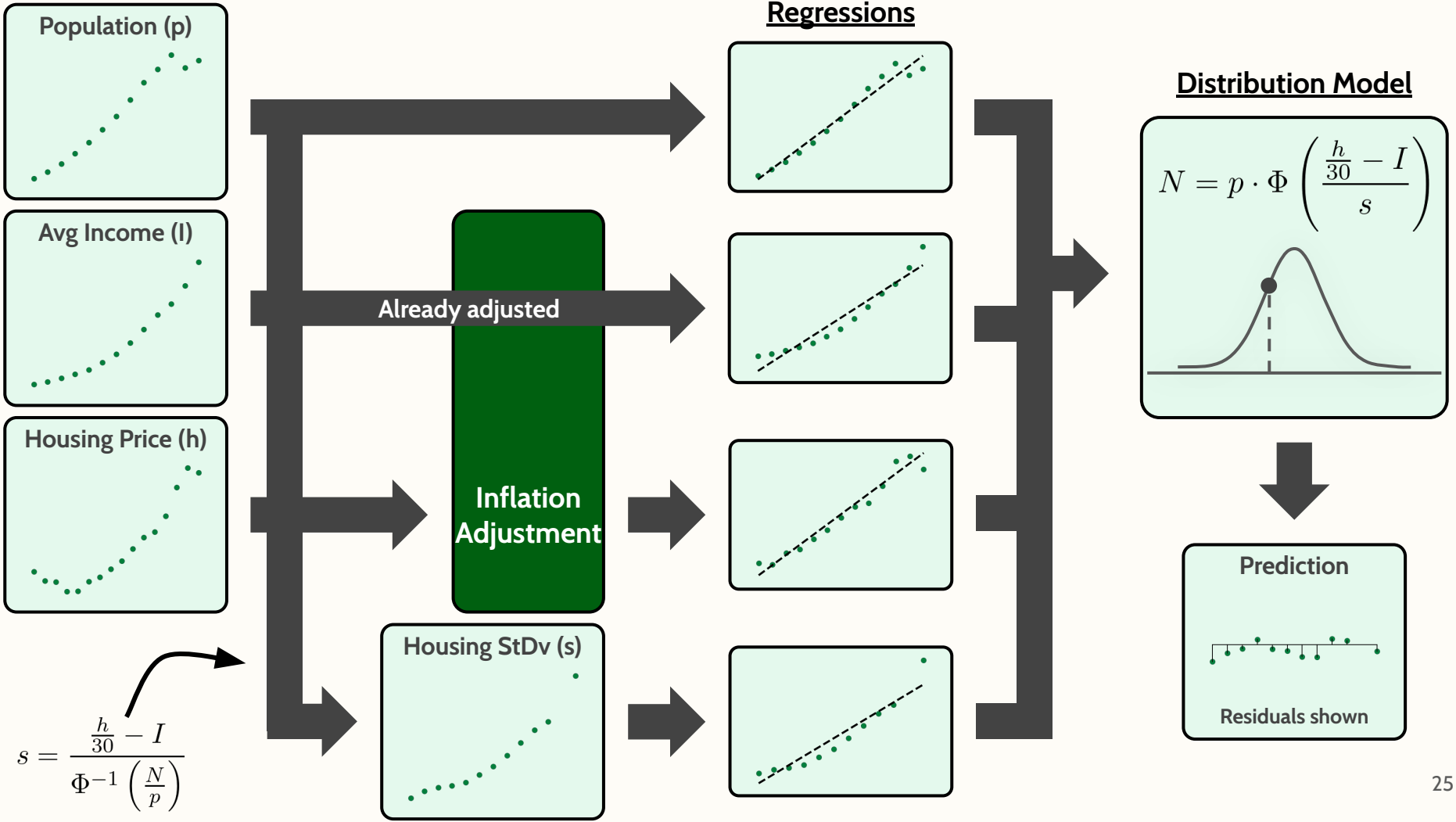

Avg Income (I)


Housing Price (h)


Population (p)
Avg Income (I)
Housing Price (h)
Inflation Adjustment
Housing StDv (s)
$s = \frac{\frac{h}{30} - I}{\Phi^{-1}\left(\frac{N}{p}\right)}$


Regressions
Population (p)
Avg Income (I)
Housing Price (h)
Already adjusted
Inflation Adjustment
Housing StDv (s)
$s = \frac{\frac{h}{30} - I}{\Phi^{-1}\left(\frac{N}{p}\right)}$


Population (p)
Avg Income (I)
Housing Price (h)
Housing StDv (s)
Already adjusted
Inflation Adjustment
Regressions
Distribution Model
$N = p \cdot \Phi\left(\frac{\frac{h}{30} - I}{s}\right)$
$s = \frac{\frac{h}{30} - I}{\Phi^{-1}\left(\frac{N}{p}\right)}$


Population (p)
Avg Income (I)
Housing Price (h)
Already adjusted
Inflation Adjustment
Housing StDv (s)
Regressions
Distribution Model
$N = p \cdot \Phi\left(\frac{\frac{h}{30} - I}{s}\right)$
Prediction
Residuals shown
$s = \frac{\frac{h}{30} - I}{\Phi^{-1}\left(\frac{N}{p}\right)}$

Question 2 - Results

Years since 2024	Albuquerque	Seattle
10 years	1,800 Homeless people	17,500 Homeless People
20 years	2,000 Homeless People	21,000 Homeless People
50 years	2,500 Homeless People	31,000 Homeless People

- Albuquerque has a predicted **increase of 96%**
- Seattle has a predicted **increase of 132%**

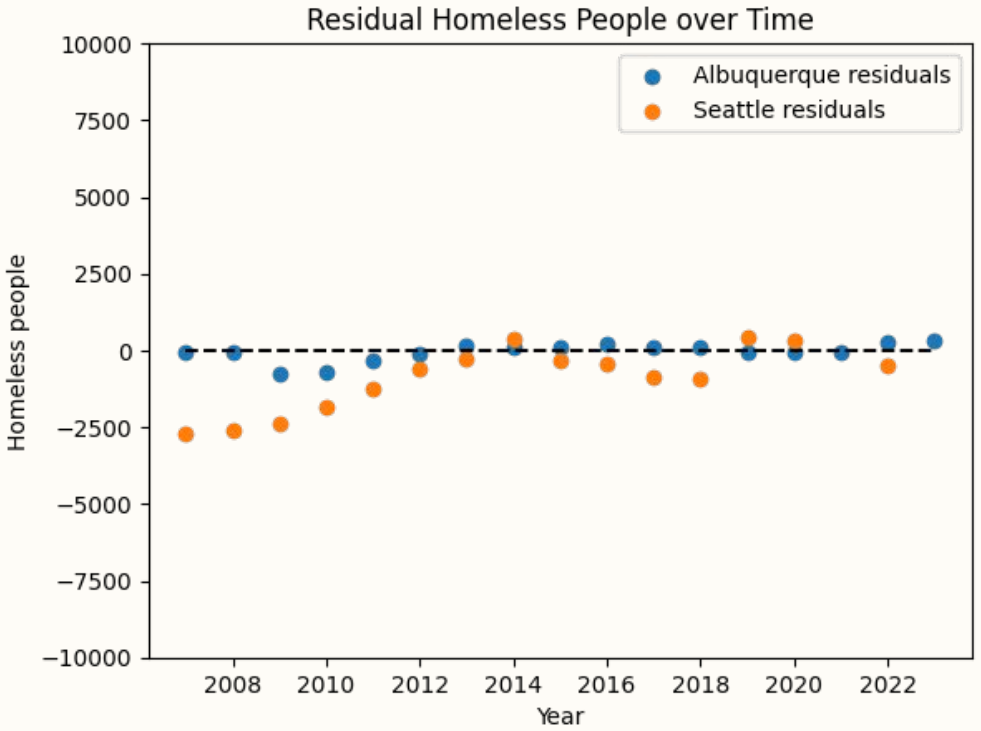
Question 2 - Error Analysis

Albuquerque

Predicted: 1,535 homeless people
Actual: 1,567 homeless people
% error: **2.04%**

Seattle

Predicted: 12,895 homeless people
Actual: 13,368 homeless people
% error: **3.54%**



Question 2 - Strengths

- Our model draws from multiple data sources[6]

- High R^2 on a majority of our linear regressions

Function	R^2
p(t), Albuquerque	0.8324
p(t), Seattle	0.9659
I(t), Seattle	0.9286
h(t), Albuquerque	0.8179
h(t), Seattle	0.9651
s(t), Seattle	0.9088

6- https://medium.com/@bijit211987/what-matters-more-data-size-or-model-size-31cb004d7209

Question 2 - Areas of Improvement

- Some regressions had a low R^2 value

- Income is log-normally distributed, not normally distributed[7]

Function	R^2
$I(t)$, Albuquerque	0.7816
$s(t)$, Albuquerque	0.6855

- All of our regressions necessitated the same asymptotic growth rate

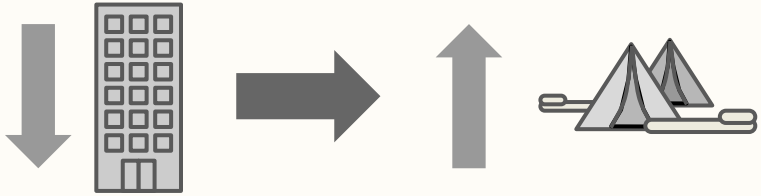
7 - https://www.aier.org/article/income-distribution-and-inequality/

Question 3 — Rising from this Abyss

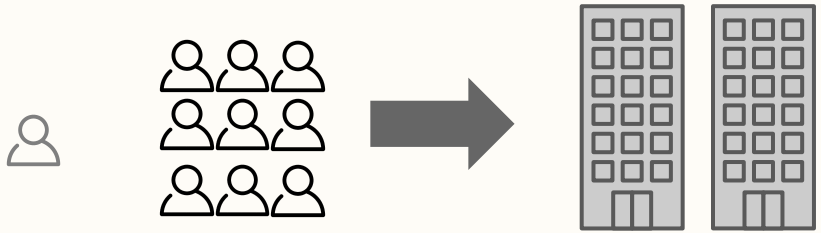
Considering your results from the first two questions for at least one of the cities, create a model that would **help a city determine a long-term plan to address homelessness**. How adaptable is your model to **unforeseen circumstances** like natural disasters, economic recessions, or increased migrant populations?

Question 3 - Local assumptions

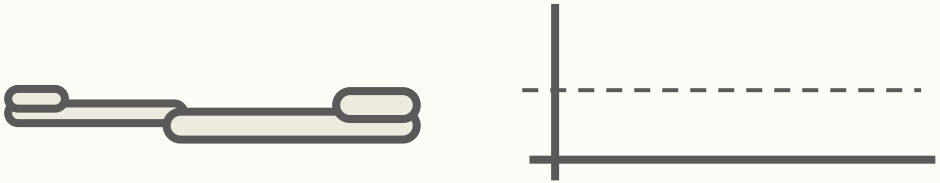
- A decrease in transitional housing causes an increase in homelessness in Seattle



- 90% of the homeless population will be willing and able to reside in transitional housing



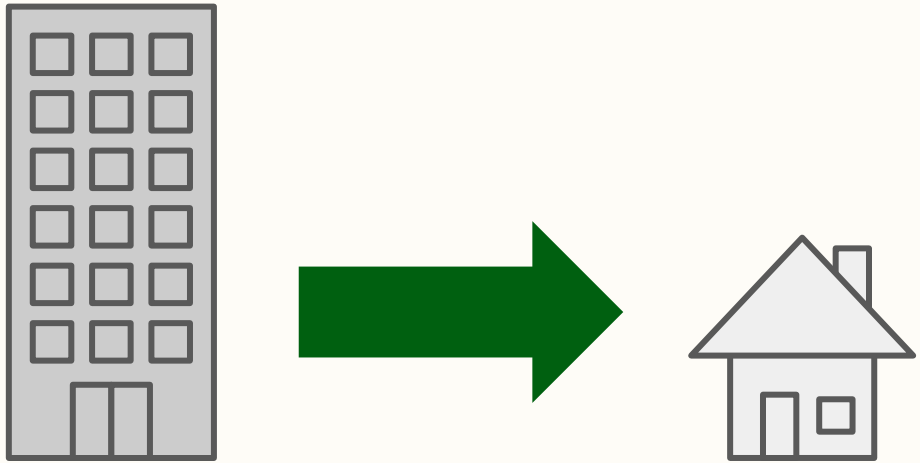
- The number of sheltered homeless people remains constant at the current capacity



Question 3 - What is transitional housing?

- Transitional housing is **temporary** residence for unhoused individuals

- Usually, a resident will stay for a few months while they find **stable employment** **and housing** - the transitional housing may also provide services to expedite these processes.

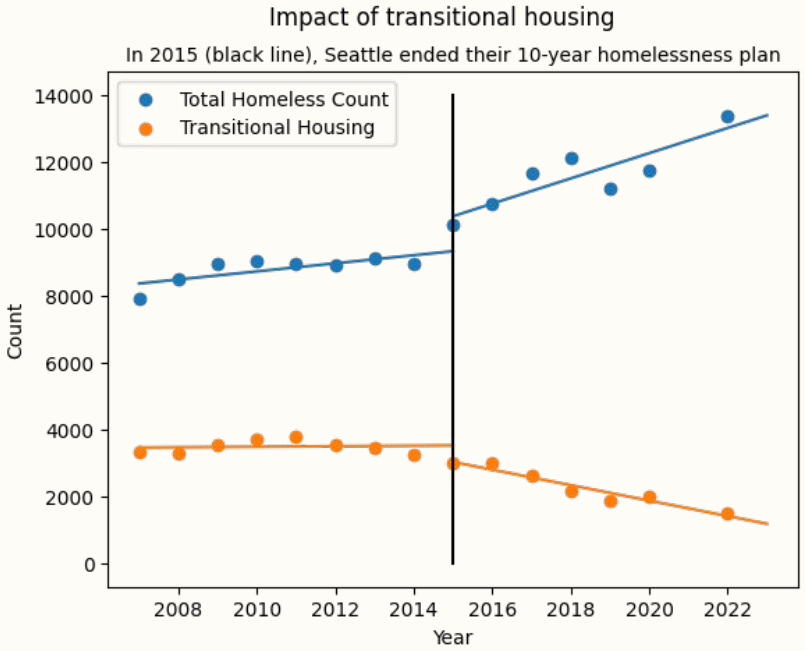


Question 3 - Why transitional housing?

- Long term solution

- Inverse correlation between transitional housing and total homeless count, as seen by Seattle's 10-year program ending[8]

- Inexpensive compared to other solutions



8 - http://www.cehkc.org/index.html

Question 3 - Variables

Name	Description	Units
C	Cost of the construction	Dollars
C_0	Cost of new housing construction per square foot	Dollars per ft^2
U	Amount of Unsheltered Homeless people	Number of people
S_T	Amount of sheltered homeless people	Number of people
T	Amount of necessary square feet of transitional housing	ft^2 per person
t	Years since 2010	Years
M	Maintenance Cost per year	Dollars per year

$$U(t) = N(p(t), I(t), h(t), s(t)) - S_t$$

Where S_t remains constant at 6040

Question 3 - Construction Costs Model

- 90% of Seattle's homeless population would opt to enter transitional housing
- 150 ft^2 (similar to one large bedroom) for each unit of transitional housing is an adequate amount of space for each person
- Costs approximately \$264/ft^2

Cost of construction: $C(t) = 0.9 \cdot C_0 \cdot T \cdot U(t)$

Question 3 - Construction Costs Results

To build enough transitional housing for all **current** unsheltered homeless -

$273,900,000

To build enough transitional housing to get all unsheltered homeless for the next

10 years: $408,400,000 **20 years: $533,200,000** **50 years: $889,600,000**

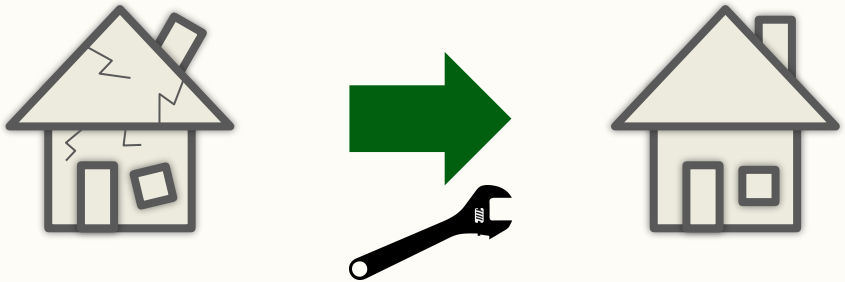
Can be split into 3 $300M projects over 50 years.

(All figures are in 2024 dollars)

Question 3 - Maintenance cost model

- We need to house 90% of the unsheltered people
- Maintenance cost $1.60/ft^2
- Approximately 150ft^2 of provided housing per person

Annual cost to maintain housing: $216/person[9]



9 - https://www.consultengsurvivor.com/the-cost-of-building-maintenance

Question 3 - Maintenance Costs

Maintenance Cost: $C(t) = 216 \cdot U(t)$

For maintenance of these facilities, Seattle would need to set aside…

10 years: **$2,475,360/year**

20 years: **$3,231,360/year**

50 years: **$5,391,360/year**

Question 3 - Adaptability to Unforeseen Circumstances

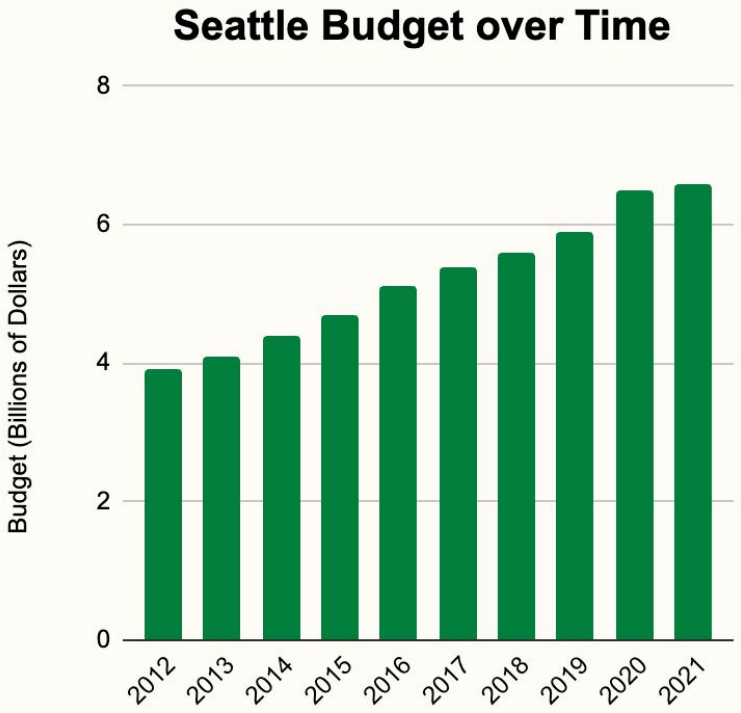
- Adaptable to economic recessions
- Adaptable to Severe weather
- Not adaptable to migration
- Not adaptable to natural disasters

Question 3 - Strengths

- We recognize Seattle's previous shortcomings in reducing transitional housing

- We effectively in create employment opportunities for Seattle's residents

- Our proposal is inexpensive and reusable, especially given Seattle's high annual budget of $7.1B[10]

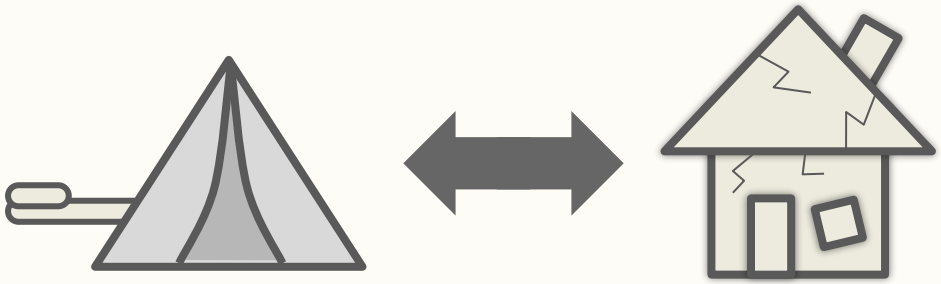


10 - https://openbudget.seattle.gov/#!/year/default

Question 3 - Areas for Improvement

- Our model fails to address issues with drug addiction and mental illness - these are major contributing factors in perpetuating the cycle of homelessness

- Our model fails to offer help to every homeless person, as a homeless person must have the opportunity to opt-into transitional housing



Conclusion

Through our model, we found that:

- Seattle and Albuquerque will both have an increase in housing, but Seattle has a much larger housing increase than Albuquerque

- Both cities have an increase in homeless population, but Seattle's will be greater

- Transitional housing is an inexpensive and effective way to combat homelessness

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