Exploratory Data Analysis of U.S. Housing Trends

Thesis Project

Merve Pakcan

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INTRODUCTION

PROBLEM

Rising housing costs and urban challenges force people to reconsider where and how they live.

GOAL

Apply data analytics to uncover housing trends and guide sustainable urban choices.

RESEARCH QUESTIONS

1. What drives homes to sell above their expected value in competitive urban markets?
2. Do cities with stronger housing demand show distinct pricing patterns or clusters?
3. How do housing market dynamics influence price behavior across different regions?

HYPOTHESIS

Will be explained in next slide

SUSTAINABLE DEVELOPMENT GOALS

DATA DESCRIPTION

10500 ROWS & 12 COLUMNS

The data is obtained from Zillow Research, a public platform that provides comprehensive, **regularly updated datasets** on the U.S. housing market.

Zillow

Covers the period from **March 2018 to February 2025.**

Merging Datasets(7)

- Median_sale_price.csv
- Percent_of_homes_sold_above_list.csv
- Zori_median_rent.csv
- Market_heat.csv
- Affordability_years_to_save.csv
- Mean_sale_to_list_ratio.csv
- New_con_median_sale_price.csv

Challenges in Data Gathering

Bucharest data- Not received because of data privacy from real estate

Variables

- RegionID
- RegionName
- RegionType
- StateName
- Date
- Median Sale Price
- Pct Sold Above List
- Median Rent
- Market Heat Index
- YearsToSave
- SaleToListRatio
- NewCon Median Sale Price

HYPOTHESIS TESTING

GOAL

HYPOTHESIS 1

Cities with stronger market signals(Sale-to-List Ratio and New Construction Sale Price) tend to cluster around higher sale prices.

Key action 1 Correlation analysis

Key action 2 K-means clustering

HYPOTHESIS 2

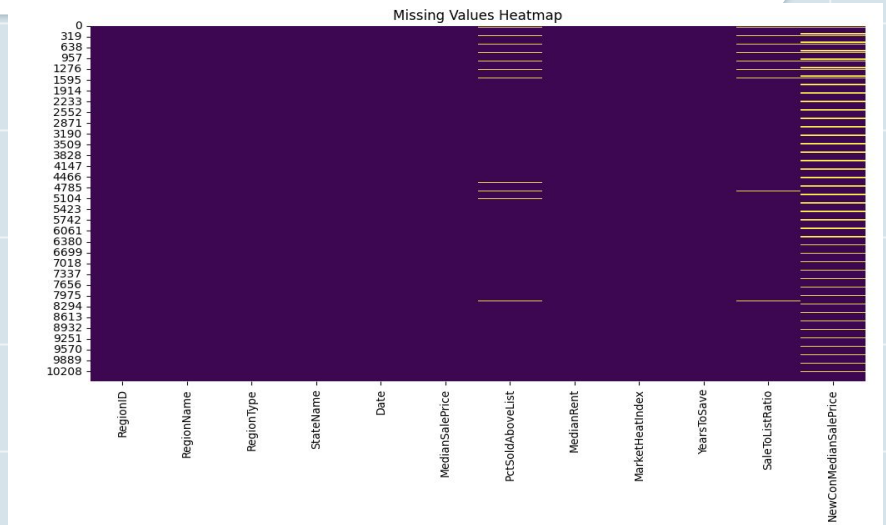
Cities with a higher Market Heat Index are more likely to sell homes above the list price.

Key action 1 Correlation analysis

Key action 2 K-means clustering

DATA CLEANING & PREPROCESSING

```
Shape: (10500, 12)

 Column Types:
 RegionID                          int64
RegionName                        object
RegionType                        object
StateName                         object
Date                      datetime64[ns]
MedianSalePrice                  float64
PctSoldAboveList                 float64
MedianRent                       float64
MarketHeatIndex                  float64
YearsToSave                      float64
SaleToListRatio                  float64
NewConMedianSalePrice            float64
dtype: object

 Missing values per column:
 NewConMedianSalePrice    1718
PctSoldAboveList           301
SaleToListRatio            291
MedianRent                 191
StateName                   84
dtype: int64
```



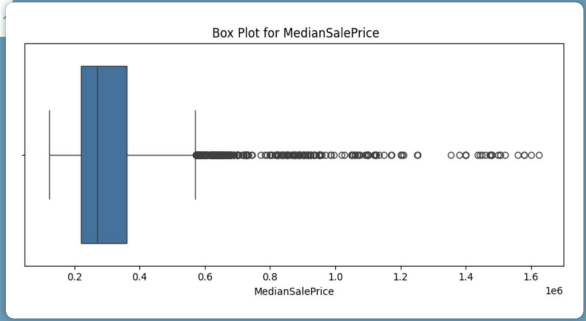

```
Rows before drop: 10500
Rows after drop (excluding only key variables): 9893

Duplicate Rows: 0
```

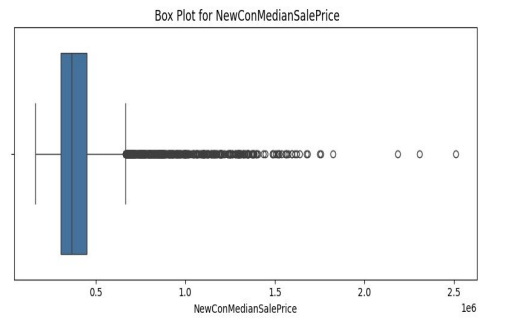
Data Types
Not dropped missing in Newcon

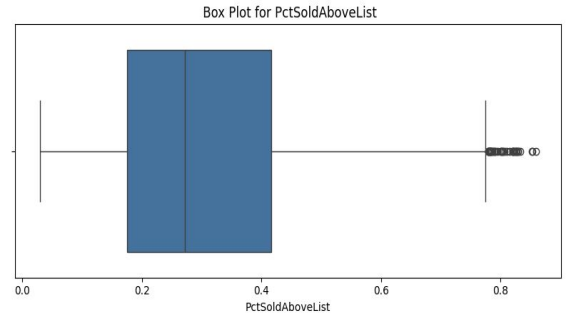
Missing Values
No duplicate

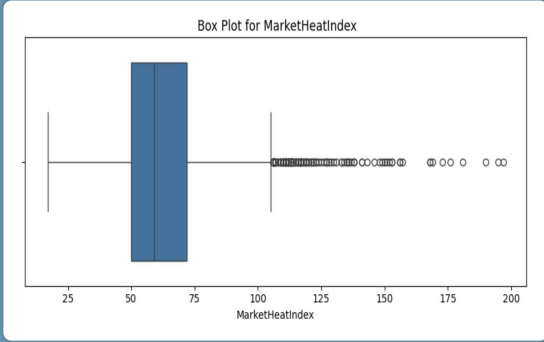
10500 ROWS —> 9893 ROWS

Outliers



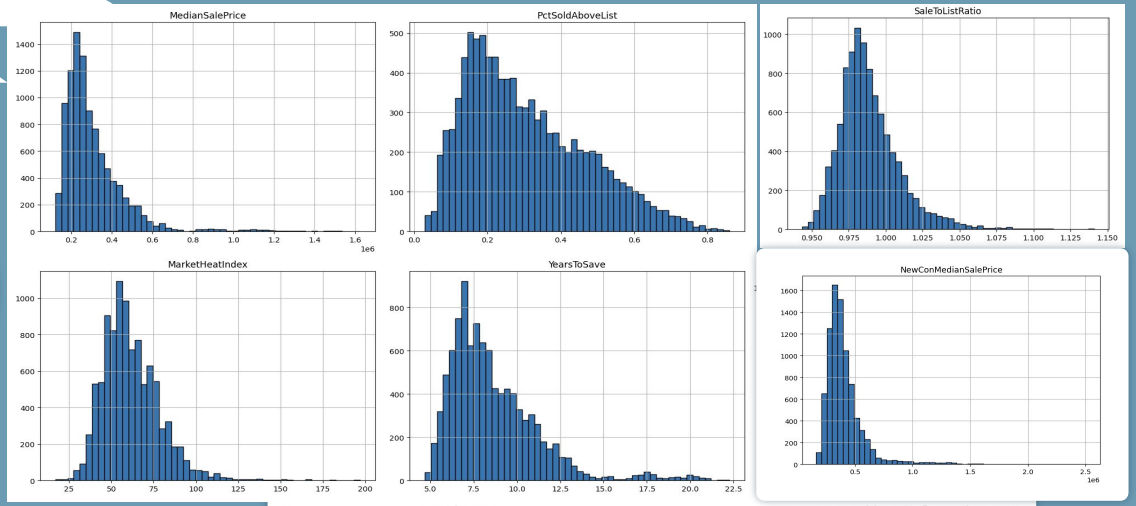






Not dropped outliers, it is meaningful

EXPLORATORY DATA ANALYSIS



Histograms

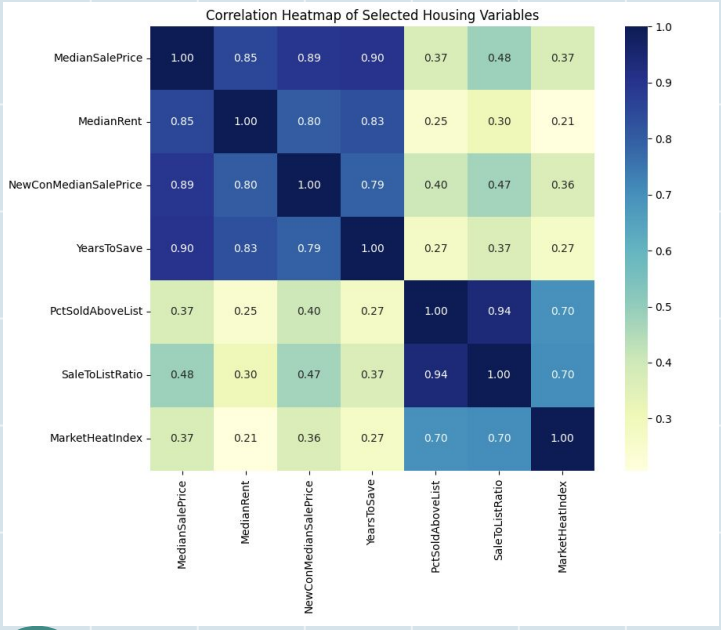
Descriptive Statistics

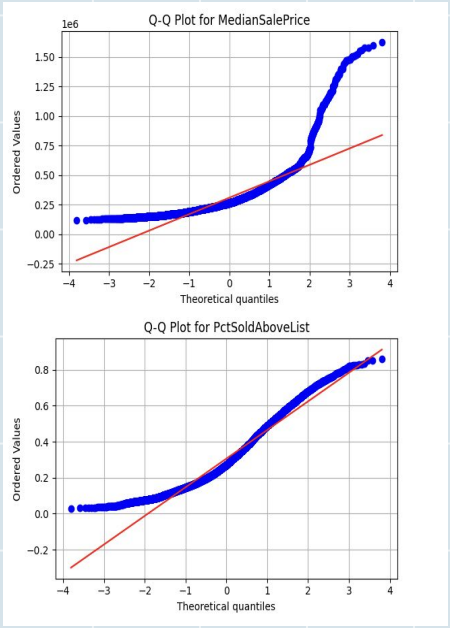
	RegionID	Date	MedianSalePrice
count	9893.000000	9893	9.893000e+03
mean	406601.992621	2021-10-16 19:09:28.038006528	3.096715e+05
min	394312.000000	2018-03-31 00:00:00	1.219750e+05
25%	394531.000000	2020-01-31 00:00:00	2.131770e+05
50%	394792.000000	2021-10-31 00:00:00	2.650000e+05
75%	395005.000000	2023-07-31 00:00:00	3.599000e+05
max	753912.000000	2025-02-28 00:00:00	1.625000e+06
std	64112.991749	NaN	1.627796e+05

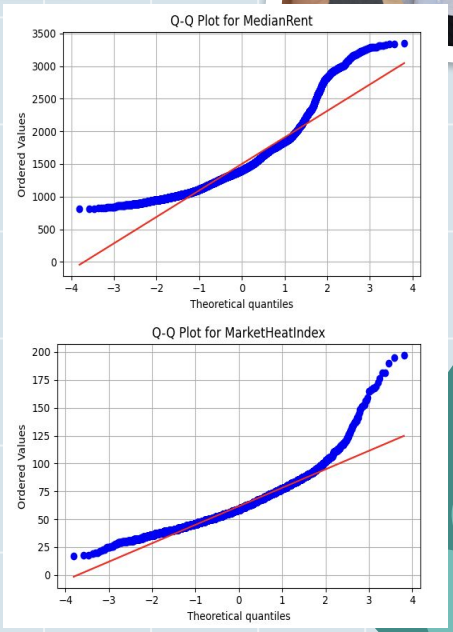
	PctSoldAboveList	MedianRent	MarketHeatIndex	YearsToSave
count	9893.000000	9893.000000	9893.000000	9893.000000
mean	0.306217	1500.371539	61.627211	8.631004
min	0.029102	806.913837	17.000000	4.670567
25%	0.175565	1208.192870	50.000000	6.822396
50%	0.271981	1402.893622	59.000000	7.959976
75%	0.416761	1715.942181	71.000000	9.836859
max	0.859512	3347.407630	197.000000	22.269278
std	0.163279	429.354211	17.170322	2.625767

	SaleToListRatio	NewConMedianSalePrice
count	9893.000000	8.481000e+03
mean	0.988815	4.059965e+05
min	0.943317	1.620000e+05
25%	0.975242	3.062750e+05
50%	0.985311	3.650000e+05
75%	0.998708	4.499900e+05
max	1.140964	2.510000e+06
std	0.020732	1.759764e+05

Correlation Matrix &Q-Q Plot

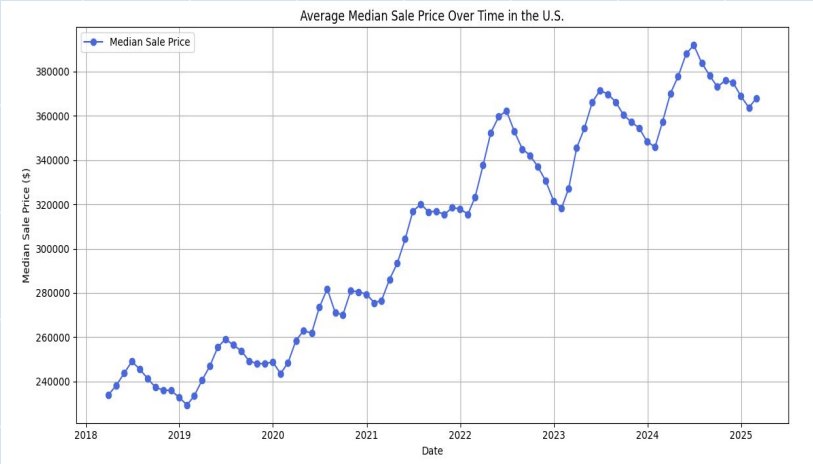




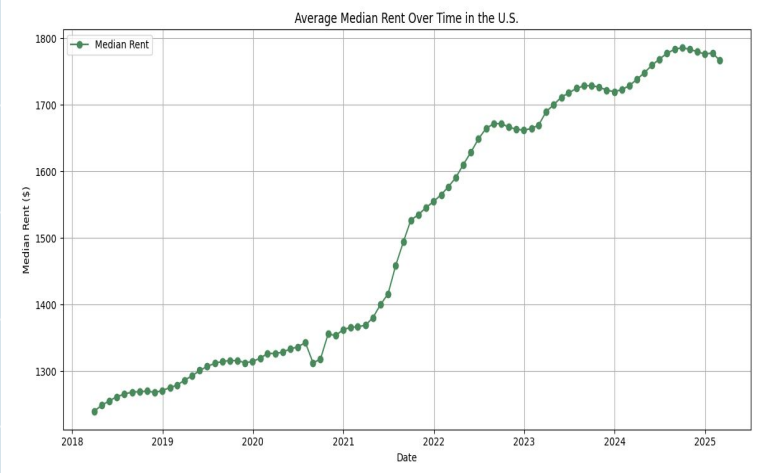


Most variables deviate from normality, as expected in housing data

TIME SERIES & PATTERN EXPLORATION



Average median sales over time



Average median rent over time

Sale prices and rents show a steady upward trend, with sharper increases during 2021–2022.

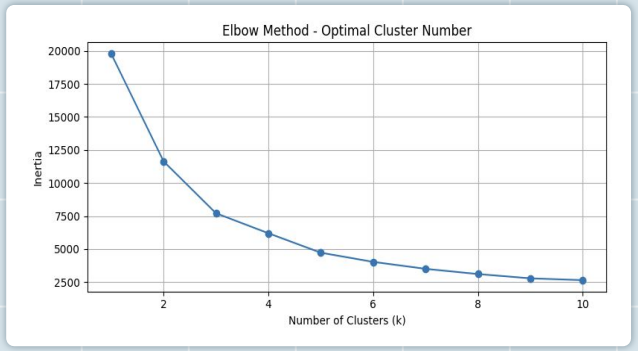
HYPOTHESIS 1

Cities with stronger market signals tend to cluster around higher sale prices.

```
Correlation between Median Sale Price and NewConMedianSalePrice:
Pearson r = 0.89 | p-value = 0.0000
```

New Construction Median Sale Price:

The median price of newly constructed homes that were sold in a given period.




```
Cluster Summary:
         MedianSalePrice  NewConMedianSalePrice
Cluster
0              241471.49              330942.49
1              436789.65              528787.91
2              925075.67             1183145.89
```

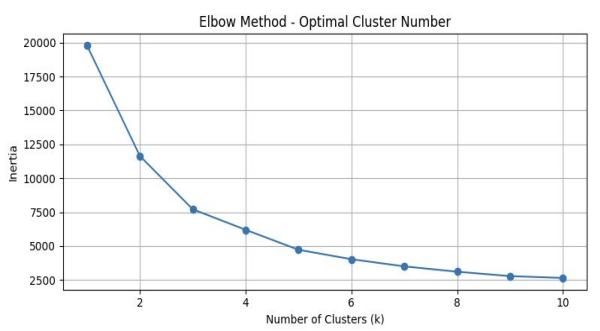
New home prices rise with overall market prices, and cities naturally group into low, mid, and high-priced clusters.

Additional Analysis

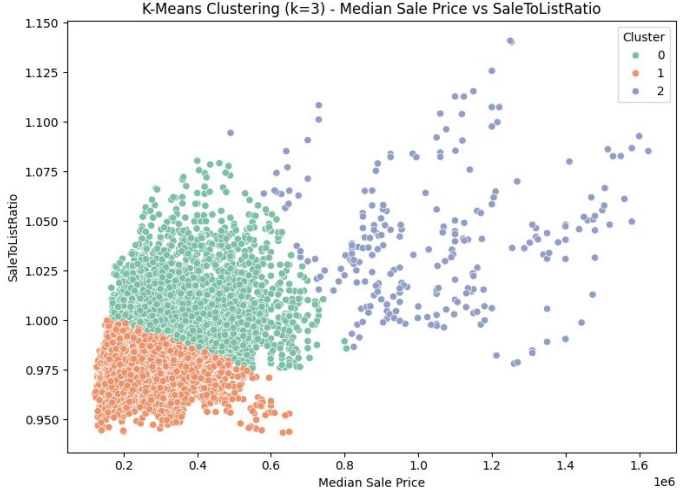
Mean Sale to List Ratio:

The average ratio between the final sale price and the original list price.

```
Correlation between Median Sale Price and SaleToListRatio:
Pearson r = 0.48 | p-value = 0.0000
```



- **Cluster 0:** High-priced, sell near list (≈1.00)
- **Cluster 1:** Mid-priced, sell above list (>1.00)
- **Cluster 2:** Low-priced, sell below list




```
Cluster Summary:
         MedianSalePrice  SaleToListRatio
Cluster
0              369528.39             1.01
1              248729.81             0.98
2             1040987.57             1.04
```

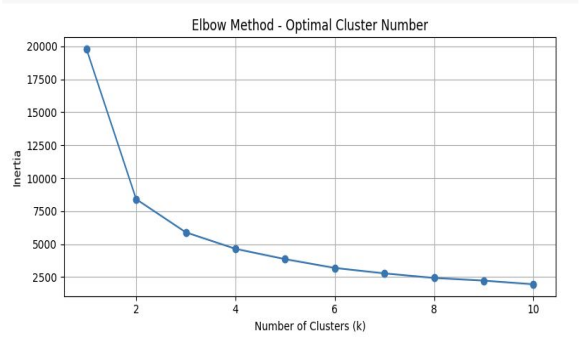
HYPOTHESIS 2

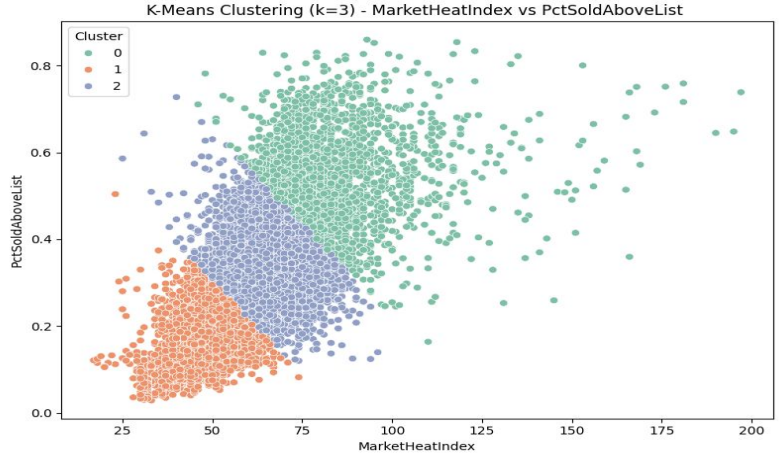
Cities with a higher Market Heat Index are more likely to sell homes above the list price.

For Market Heat Index and Percent Sold Above List:

```
Correlation between MarketHeatIndex and PctSoldAboveList:
Pearson r = 0.70 | p-value = 0.0000
```

More competitive markets tend to push prices above the list






```
Cluster Summary:
         MarketHeatIndex  PctSoldAboveList
Cluster
0                  84.56              0.54
1                  48.11              0.17
2                  64.46              0.34
```

INSIGHTS & CONCLUSION

What insights can we draw from all this?

General Comments

- Strong market signals align with higher housing prices.
- Competitive markets push prices above the list.
- Clear clustering patterns emerge across city price tiers.

EDA Challenges

- Missing data in some variables
- Non-normal distributions

Hypothesis Results

- H1 supported: Cities with stronger market signals cluster at higher prices.
- H2 supported: Market Heat Index positively correlates with homes selling above list.
- Clear clustering validated price segmentation.
- High r-values confirmed strong relationships between variables.

THANKS FOR LISTENING!

Do you have any questions?