Case Study of Top 10 Metropolitans of USA: Relation of Macroeconomic Indicators (Inflation, Interest Rates, and Income) & Housing Affordability

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1 INTRODUCTION

As a result of globalization and interconnected economies, we are witnessing an enormous outflow of skilled workers from developing countries towards developed economies like Germany and USA. Usually, the ground realities of developed economies are not transparent from the home countries of expats, hence it becomes difficult for the skilled workers to make informed decisions while relocating to developed countries. The author particularly wants to analyze housing affordability over the last 10 years in the top 10 Metropolitans of the US. Housing affordability is the most important thing during relocation for expat skilled workers because rental prices constitute a disproportionate chunk of their disposable incomes as compared to other expenses like food, etc. Moreover, the condition of the housing market can be seen as a proxy measure to measure the health of an economy if analyzed side by side with Macroeconomic indicators. This study will provide an outlook on the US economy for people interested in moving there.

2 DATA SOURCES

For analysis, we used the output of our data pipeline, i.e., a CSV file containing merged Housing and Macroeconomic time-series data for the last 10 years for the top 10 Largest Metropolitans of the USA.

2.1 Data Structure

The CSV output of our pipeline is a well-structured table in a time series format with monthly timestamps. It contains continuous features (e.g., CPI, Disposable Income etc), and categorical features (e.g., Region), and temporal features (Date). The sample output of our data (Fig. 1) is shown below. We can see that our data is in

DATE	Region	SF Home Prices	All Home Prices	SF Rental Prices	All Rental Prices	SF Rental Demand	All Rental Demand	Heat Index	CPI	Inflation	30Y Fixed Rate	15Y Fixed Rate	Income
2015-01-01	United States	183832.254851	184918.050518	1253.339325	1208.652197	95.4	50.8	50.4	233.707	-0.1	3.7	3.0	13797.7
2015-02-01	United States	184623.569981	185714.707627	1259.779349	1214.197215	127.8	83.4	52.0	234.722	-0.0	3.7	3.0	13848.0
2015-03-01	United States	185430.820473	186524.115022	1268.343734	1220.153703	151.4	104.8	52.6	236.119	-0.1	3.8	3.0	13811.3
2015-04-01	United States	186317.956037	187409.136805	1278.430726	1225.102763	158.5	105.6	52.8	236.599	-0.2	3.7	2.9	13842.0
2015-05-01	United States	187294.071588	188385.459545	1287.859367	1229.581922	158.5	105.6	52.3	237.805	-0.0	3.8	3.1	13865.6

Fig. 1. Samples From Final Data

a long format, i.e., first we will have 10 years of data for United States Average Case then we will have 10 years of data for the 1st metropolitan and so on. We have 14 features in total including 7 for Housing data (columns 3-9) and 5 for Macroeconomic data (columns 10-14).

The Housing data feature names starting with keyword 'SF' represent the 'Single Family Category' homes and the feature names starting with keyword 'All' represent the 'All Category' homes, e.g., SF Rental Demand represents the Demand for the Single Family Homes. Hence, we have two subcategories (SF and All) for each housing data feature except the Heat Index which represents the Heat Index of the complete housing market.

Macroeconomic Indicators include the following.

Consumer Price Index(Inflation): The Consumer Price Index (CPI) measures the average change over time in the prices paid by consumers for goods and services, if YoY change in CPI is positive its inflation if negative it is deflation.

30/15Y Fixed Mortgage Rate (Interest Rate): This is a type of Interest Rate only eligible for Housing finance and it has a fixed per annum interest % for the whole tenure of loan, e.g., either 30 years or 15 years.

Disposable Income: It is the amount of income after paying taxes, if it is increasing it means tax burden is relatively going down.

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2.2 Data License

According to the terms of use of both datasets i.e., Housing data[Zillow 2024] and Macroeconomic data[FRED 2024], we are entitled to use the data for academic purposes as student researchers. Moreover, we ensured the proper attribution to both data sources transparently. We have no plan to use this data for any purpose deviating from the initially stated reason.

3 ANALYSIS

3.1 Exploratory Data Analysis

We utilized EDA methods to detect seasonal or long-term trends for Housing features vis-à-vis each Macroeconomic feature. These trends between different variables can help us confirm the Correlation Analysis that we would perform later, for example, if the Correlation Analysis between CPI and Home Prices suggest a very strong positive correlation then it means the time-series trend lines should also be very similar for both variables over the years.

3.1.1 Methodology

For EDA, we utilized double-axis line plots to detect long-term trends for 3 Housing features (Home/Rental Prices & Rental Demand) vis-à-vis each Macroeconomic feature. We observed that both subcategories of Housing data, i.e., (SF & All) Home/Rental Prices & Demand reflect a similar long-term relationship with Macroeconomic indicators hence we will only discuss the analysis done for all category homes housing features.

In each line plot (Fig. 2, Fig. 3, Fig. 4) the right y-axis (red) represents a Macroeconomic Indicator while the left y-axis (blue) represents a Housing feature. There is a legend given inside each plot which color codes each region differently and each color represents a Region's behavior for the underlying Housing feature and the thick red line represents the underlying Macroeconomic indicator's trend over the years.

3.1.2 Results & Interpretations

Almost all the 11 Regions have a similar upward long-term trend for all housing features except the Rental Demand. Specifically, five regions including USA Average Case (blue), Los Angeles (green), New York (orange), Washington (pink), Miami (beige green) have very high values of Rental Prices ranging from 1500 USD to 3000 USD as compared to other 7 regions where Rental Prices range between around 1000 USD and 1500 USD since last 10 years. It shows that the rental prices in these 4 regions (NY, LA, WT, Miami) have almost doubled while the other 7 regions saw around 50% increase in the Rental Prices in the last 10 years.

Similarly, when talking about Home Prices, these 3 regions (NY, LA, WT) have had a price range from 400k USD to 900k USD as compared to the other 8 regions where prices ranged between around 200K USD and 400k USD. The Home Prices have roughly doubled for all the regions no matter if the magnitude of prices was higher or lower 10 years back, suggesting an equivalent effect of Macroeconomic & other exogenous factors on all the regions.

Moreover, the Rental Demand data is very noisy and the trend from 2022 onward seems to decline non-linearly without showing any similarity to any Macroeconomic indicator's trend. Hence we decided not to include visuals of its comparison with Income and Interest Rates. Our choice of neglecting its visuals was endorsed by our Correlation analysis as most regions showed a weak or no correlation between Macroeconomic indicators and Rental Demand.

An economy behaves atypically to exogenous shocks, e.g., pandemics. That is why we have some atypical behavior of macroeconomic indicators, e.g., Income and Interest Rates during 2019-2022. During the pandemic, due to the mobility restrictions, people were not able to spend their incomes, which resulted in a lack of demand for goods and services including money. As a result the prices and Interest Rates came down so people were left with more money at the end of month that is why the disposable incomes soared in that time frame.

CPI vs 3 Housing Market Features (Fig. 2): There is a clear similar trend between CPI and Home/Rental Prices over the last 10 years suggesting a strong positive correlation. Moreover, the Rental Demand seems to be decreasing in correspondence with the increasing CPI/Inflation over the years which suggests a natural response as increased CPI/Inflation suggests that now people have less purchasing power hence the demand for goods and services goes down including demand for rental homes. We can ignore Rental Demand data before 2021 as it was artificially created for the sake of completeness but from 2021 onward (real data) we have a weak negative correlation between CPI and Rental Demand.

Income vs 3 Housing Market Features (Fig. 3): If we neglect the COVID-19 Pandemic period (2020-2022) we can clearly see that there is a similar upward trend of both Income and Home/Rental Prices over the last 10 years suggesting a strong positive correlation. Also the relative gap between the income line and the Home/Rental Prices has maintained that relative difference over the years, i.e., no matter if Home/Rental Prices have been increasing there is a concurrent increase in the Disposable Income suggesting that most people have been able to cope up with increasing housing prices. We can say that the increase in Income levels have been offset by the increasing Housing Prices hence the increased income was not able to generate more demand for Rental Homes that is why we can see declining Rental Demand in long run.

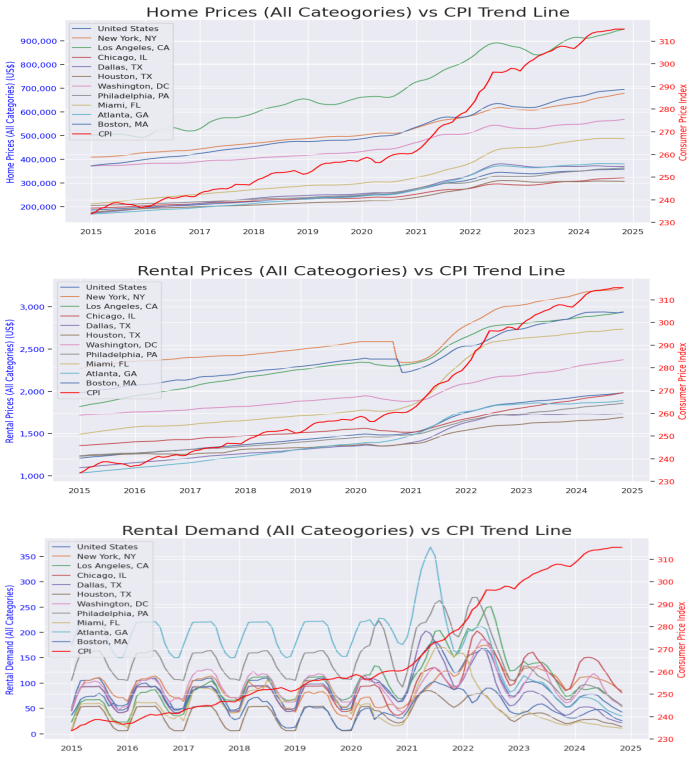


Fig. 2. CPI vs Housing Market Features

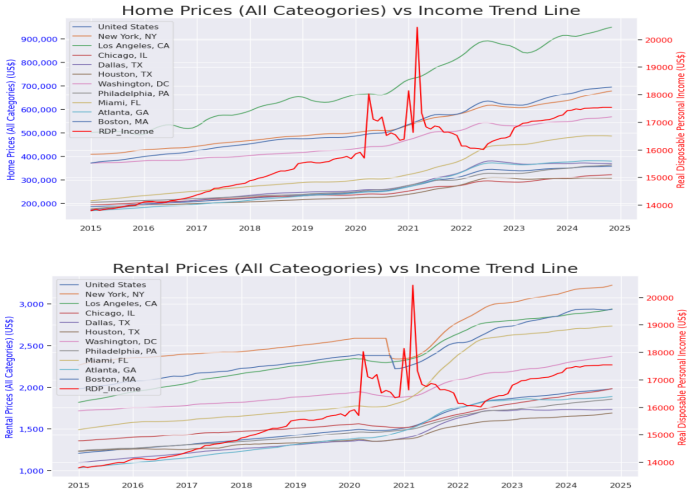


Fig. 3. Disposable Income vs Housing Market Features

Interest Rates vs 3 Housing Market Features (Fig. 4): If we again neglect the COVID period between roughly 2019 and 2022 we can

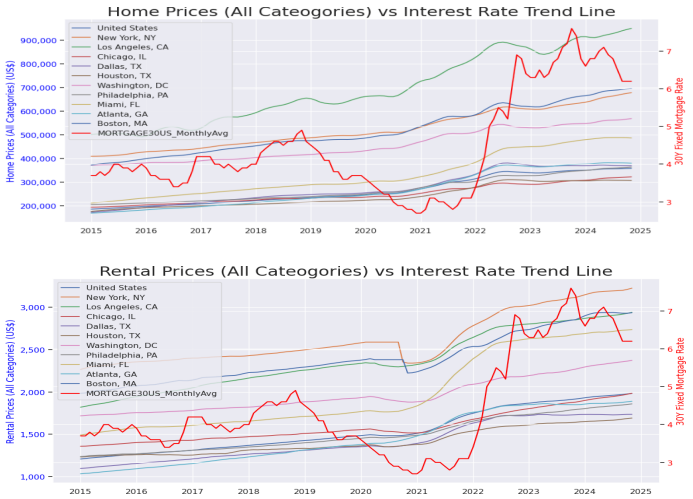


Fig. 4. 30Y Fixed Mortgage Rate vs Housing Market Features

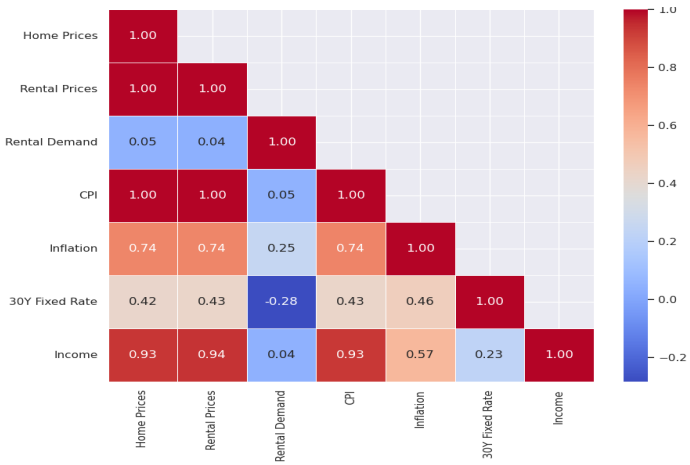


Fig. 5. Correlation Matrix: USA Average Case

see that there is a similar upward trend in the long run between Home/Rental Prices, moreover, I assume there is a non-linear relationship between the Housing Prices and Interest Rates over the last 10 years suggesting a weak but positive correlation between them. The effect of Interest Rates was also atypical because despite the increasing Interest Rates the Rental Demand have been decreasing.

3.2 Correlation Analysis

Correlation Analysis helps to understand the strength and direction of relationship between two numerical features. Hence, all of our features being numerical in nature, we used Correlation Analysis to better understand the relationship between these features.

3.2.1 Methodology

As we have data for 11 Regions i.e., USA Average Case and 10 largest metroplitans of USA we will generate and discuss 11 correlation matrices. The subsets of the Housing Data, e.g., Single Family Home Prices, All Category Home Prices behaved very similar against Macroeconomic indicators hence we will only discuss the correlation matrices for housing data for only All Category Homes. We will see if Macroeconomic Indicators can explain the long term trend of Home/Rental Prices and Rental Demand.

We used the US Average Case Matrix as comparison benchmark and during the analysis, we observed that some metropolitans behaved very similarly to the USA Average Case while some behaved exceptionally different. Based on this observation we divided metropolitans into two distinct clusters based on the similarity of their correlation matrices i.e., metroplitans with correaltion matrices very similar to US Average Case belong to cluster 1 and other belong to cluster 2.

Based on EDA, we observed that our features might have non-linear relationships and there were some outliers as well for the Macroeconomic indicators because of COVID-19 Pandemic, hence we used the Spearman Correlation method because it measures the monotonic relationship between two variables, which means it checks if one variable consistently increases or decreases as the other does, regardless of whether the relationship is linear or non-linear and it is also robust against outliers.

We finally decided to generate and discuss the correlation matrices only for the features including Home Prices, Rental Prices, Rental Demand, CPI, Inflation, 30Y Mortgage Rate, and Income because they had significant correlations. We also masked the upper triangle (redundant values) of the correlation matrix to make it visually simple & interpretable, as we know that the upper triangle represents the mirrored view of the lower triangle.

3.2.2 Results & Interpretations

Correlation Matrix: USA Average Case: First we will discuss a visually clear & big correlation matrix for the US Average case (fig. 5) so that we can later easily interpret the trends in other correlation matrices of different metropolitans given in smaller visuals due to limited page limit.

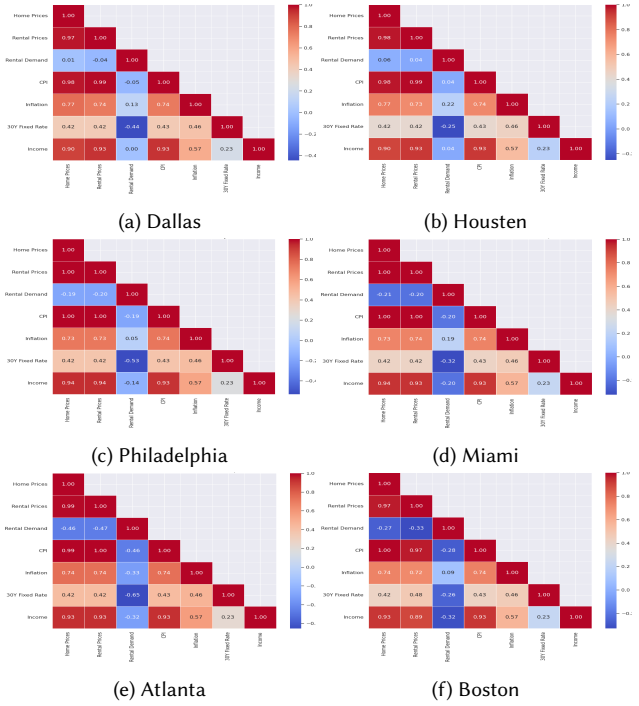
Except for Rental Demand and 30Y Fixed Rates all variables are suggesting strong positive correlations. There is a strong positive correlation between Home & Rental Prices with Income with a magnitude of 0.93 and 0.94 respectively. Moreover, Home & Rental Prices show a perfect correlation of 1.0 with the Consumer Price Index and a strong correlation with Inflation of around 0.74. There is a moderate positive correlation (0.42) between Mortgage Rates and Home Prices. This suggests that as mortgage rates increase, home prices also tend to rise. This may seem counterintuitive because higher rates make borrowing more expensive. However, this could reflect delayed adjustments in home prices, shared economic factors (e.g., inflation), or supply constraints that keep home prices elevated even as borrowing costs rise.

There is a moderate positive correlation (0.43) between Mortgage Rates and Rental Prices. This means rental prices also tend to increase as mortgage rates rise. This could occur because higher mortgage rates make homeownership less affordable, pushing more people into renting and driving up rental prices. Additionally, rental prices might respond to broader economic trends (e.g., inflation or

wage growth), which could also affect mortgage rates.

There is a weak-to-moderate negative correlation between mortgage rates and Rental Demand. This indicates that as mortgage rates increase, rental demand tends to decrease. This is an atypical expectation: when mortgage rates are low, people are more likely to buy homes instead of renting, which reduces rental demand. Conversely, when mortgage rates rise, one might expect rental demand to increase, but the negative correlation could reflect other factors, such as the rental market already being saturated or renters facing affordability challenges.

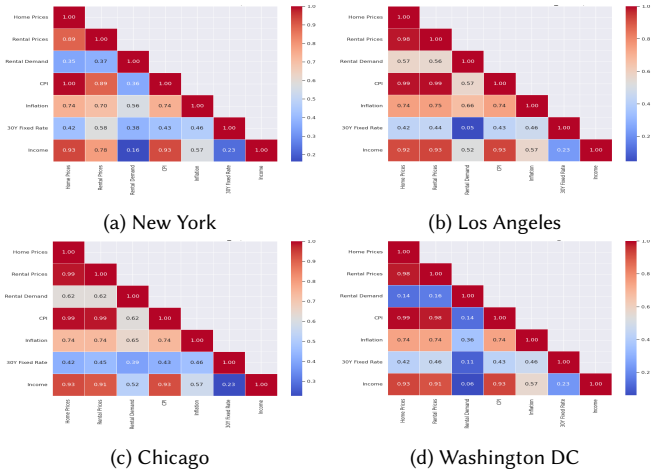
Correlation Matrices: Cluster 1: The correlation matrices (Fig. 6) of all the metropolitans in this cluster are very similar to the US Average case. This suggests that most of the cities in the USA exhibit similar economic trends and hence tend to show similar housing market trends as well. It suggests that if someone wants to move to these metropolitan then one should expect to experience an average US standard of living including housing market affordability.



(a) Dallas (b) Housten (c) Philadelphia (d) Miami (e) Atlanta (f) Boston

Fig. 6. Correlation Matrices: Cluster 1 Metropolitans

Correlation Matrices: Cluster 2: Opposite to other regions, for all these 4 regions in (Fig.7) the 30Y Fixed Rate is bluish and Los Angeles and Chicago seem to have a reasonably strong redish Rental Demand column. Other than this the correlation of other features aligns with the USA Average Case. A different correlation for Rental Demand & Interest Rates in cluster 2 suggests that these regions might be affected by some exogenous factors e.g., magnitude of their individual economies, Govt. policies or migration pressure etc.



(a) New York (b) Los Angeles (c) Chicago (d) Washington DC

Fig. 7. Correlation Matrices: Cluster 2 Metropolitans

4 CONCLUSION

Our EDA and Correlation Analysis suggest strong relationships between Macroeconomic Indicators and housing market trends, with positive correlations observed between Home Prices, Rental Prices, and indicators such as Income, CPI/Inflation but a negative correlation with rental demand. A consistent increase in Income levels alongside rising CPI/Inflation and Housing Prices over the last 10 years suggests that most people have been able to keep up with economic pressure. Based on this analysis, at least in the short-run, we can consider the USA not a promising but viable destination for relocation.

Although our analysis was able to help understand the Macroeconomic conditions of the USA and their relationship with Housing affordability there are still some limitations. First, correlation does not imply causation; while strong correlations were observed, the underlying causal mechanisms may be more complex and influenced by unmeasured variables, such as housing supply, government policies, or regional economic disparities. Second, the analysis is primarily based on aggregated data, which may obscure important variations at the local or regional level, especially in a diverse housing market like the United States. Additionally, the use of linear correlations may oversimplify relationships that could be non-linear or influenced by lag effects (e.g., delayed impact of interest rate changes on housing markets). The time period studied, while comprehensive, includes an anomalous phase during the COVID-19 pandemic, which introduced unique economic conditions that may not reflect typical market behavior.

Lastly, some key factors, such as employment rates, demographic shifts, or consumer sentiment, were not included in the analysis, which could provide a more holistic understanding of housing affordability. Addressing these limitations in future research could yield more nuanced and actionable insights.

References

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