Report on Factors Affecting U.S. House Prices

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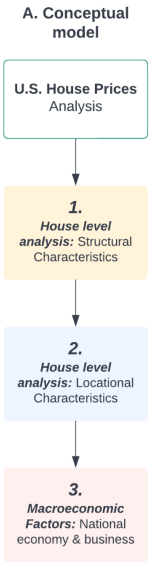
1. Introduction

Housing markets in the U.S., just like in other countries, are very well researched. Since, housing plays a major role as an investment in the world, there has been a number of research studies conducted that focuses on understanding the factors that may affect the price of houses. Certainly, characteristics such as the size and type of the house, their proximity to a desired area, amenities it provides, etc. have a decisive role on the price at the individual house level. But in recent years, rapid economic development has resulted in increasing demand for residential housing. This leads us to also investigate the behavior of house prices resulting due to the influence of macroeconomic factors in the real estate market.



2. Methodology

Our interest in analyzing the factors which may influence the U.S. residential housing prices over the decade, requires us to step back and consider all possible sectors which can contribute towards it. For this, a MECE (Mutually Exclusive Collectively Exhaustive) framework was used and a conceptual model was implemented in order to break down the overall problem statement and generalize it as shown in Fig. 2.1. *Conceptual model of U.S. House Prices*.

3. House Level Analysis

In order to build the conceptual model, first the house level analysis was taken into consideration. While homes and homebuyers are heterogeneous, there are certain definable characteristics and attributes to residential properties that contribute to the overall appeal and market value that a given property elicits. This is also called the hedonic approach which considers the relationship between the house price & the quality characteristics of a house i.e., size, type, location, amenities, etc. at a microeconomic level. These are some of the necessary attributes that are analyzed by homebuyers. The conceptual model further divides this level into structural characteristics (structure of the house) & locational characteristics (location & neighborhood of the house).

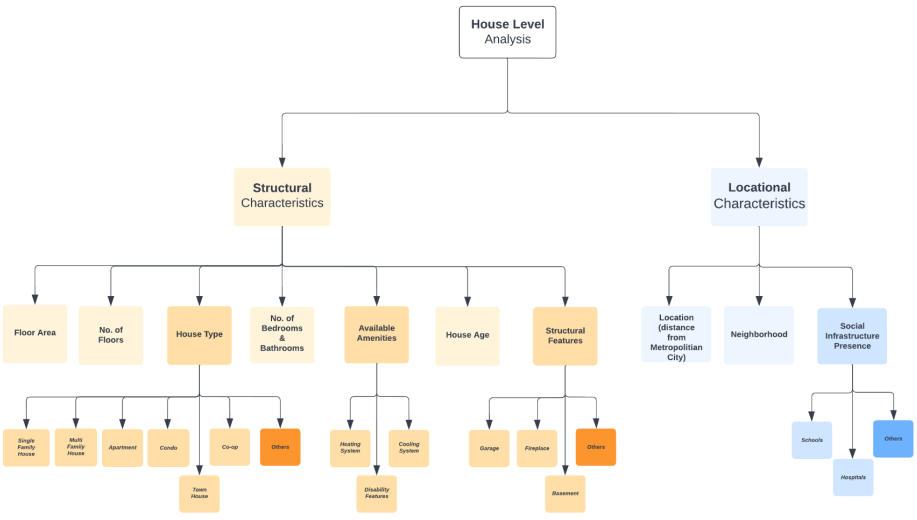


Fig. 3.1.1. Segmentation model of House Level Analysis

3.1. Structural Characteristics

1. **Number of Bedrooms & Number of Bathrooms**
   It is evident from Fig. 3.1.1. that as the number of bedrooms or number of bathrooms increase, the median price of the house also increases.

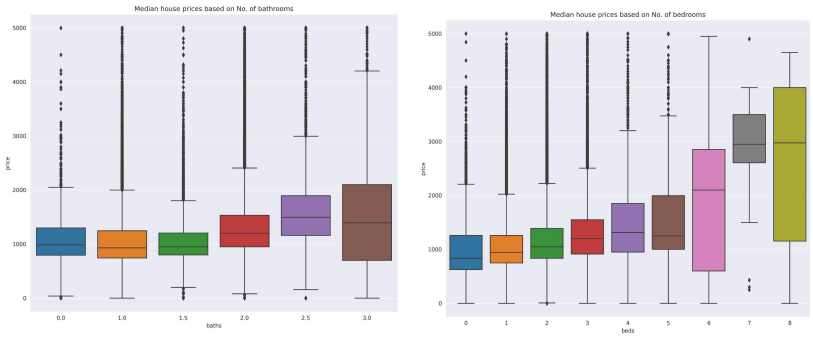


Fig. 3.1.1. Median house prices based on (a) Number of Bedrooms (b) Number of Bathrooms

2. **Area**
   As the area increases and the number of rooms (as well as bathrooms and other factors), the house price increases.

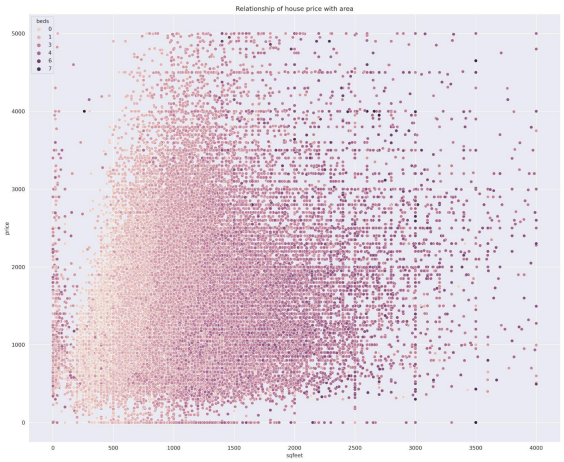


Fig. 3.1.2. Effect of area on house prices

3. **Available amenities & structural features**

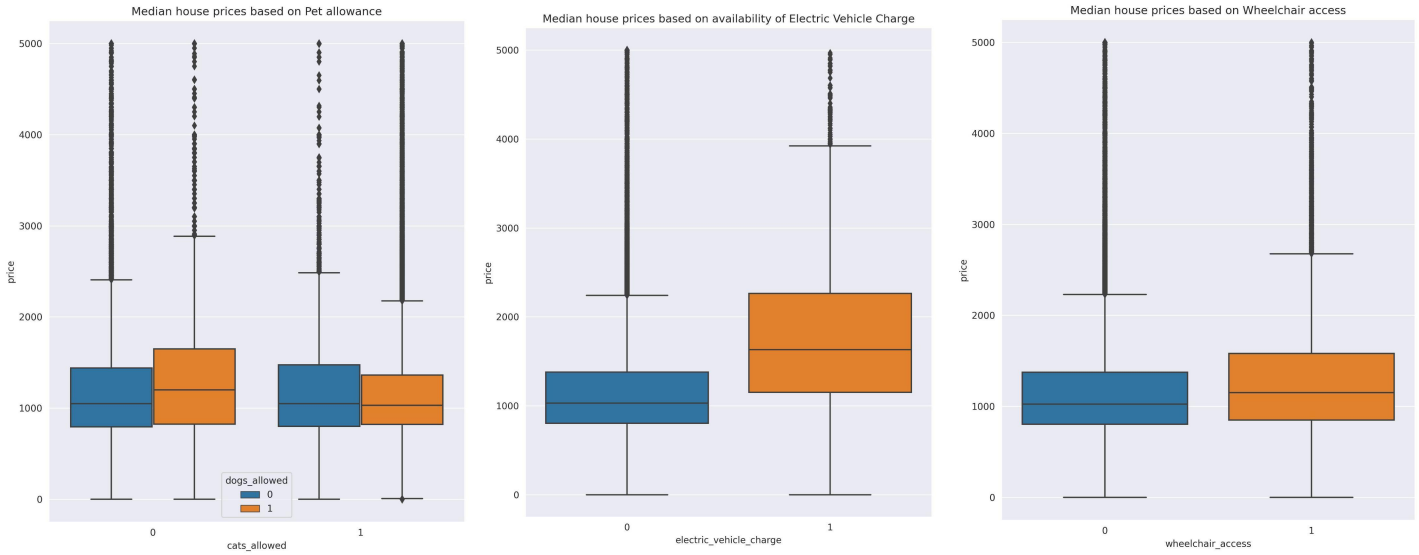


Fig.3.1.3. Median home price based on (a) Pet allowance (b) Electric vehicle charge (c) Wheelchair access

In Fig. 3.1.3. We can see how the availability of all the possible amenities and structural features can increase the median house price. For example, in fig. 3.1.3. (c) houses with availability of wheelchair access have slightly higher median prices. We should also note, in fig. 3.1.3. (a) houses where cats are not allowed but dogs are allowed have the highest median house price. While the place where cats are allowed have a very slight change irrespective if the dogs are allowed or not.

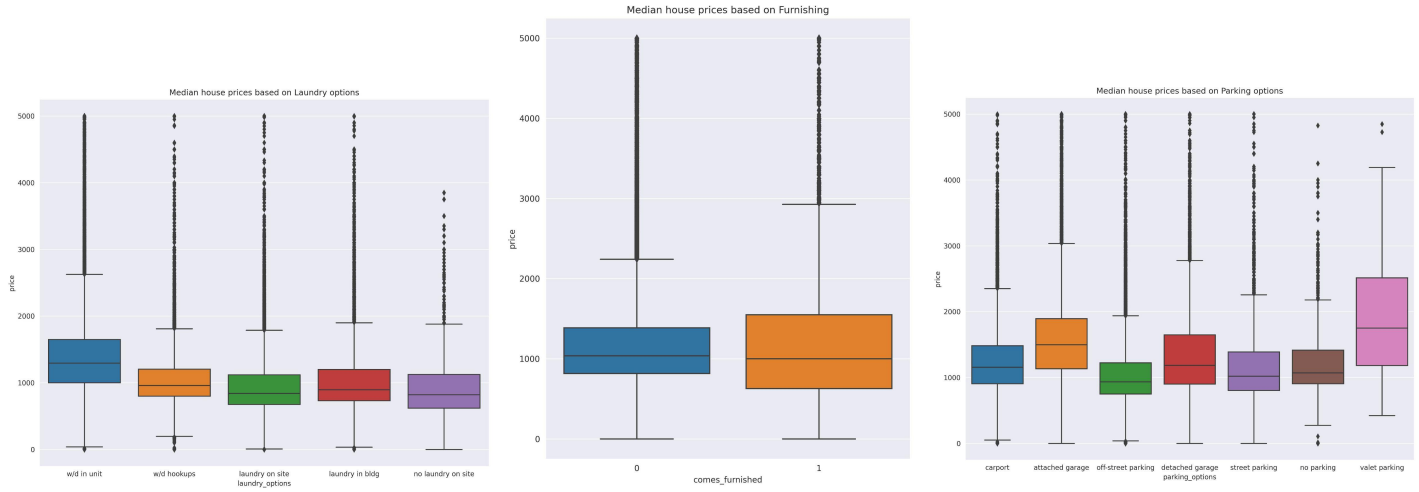


Fig. 3.1.3. Median house prices based on (d) Laundry options (e) Furnishing options (f) Parking options

4. House Type

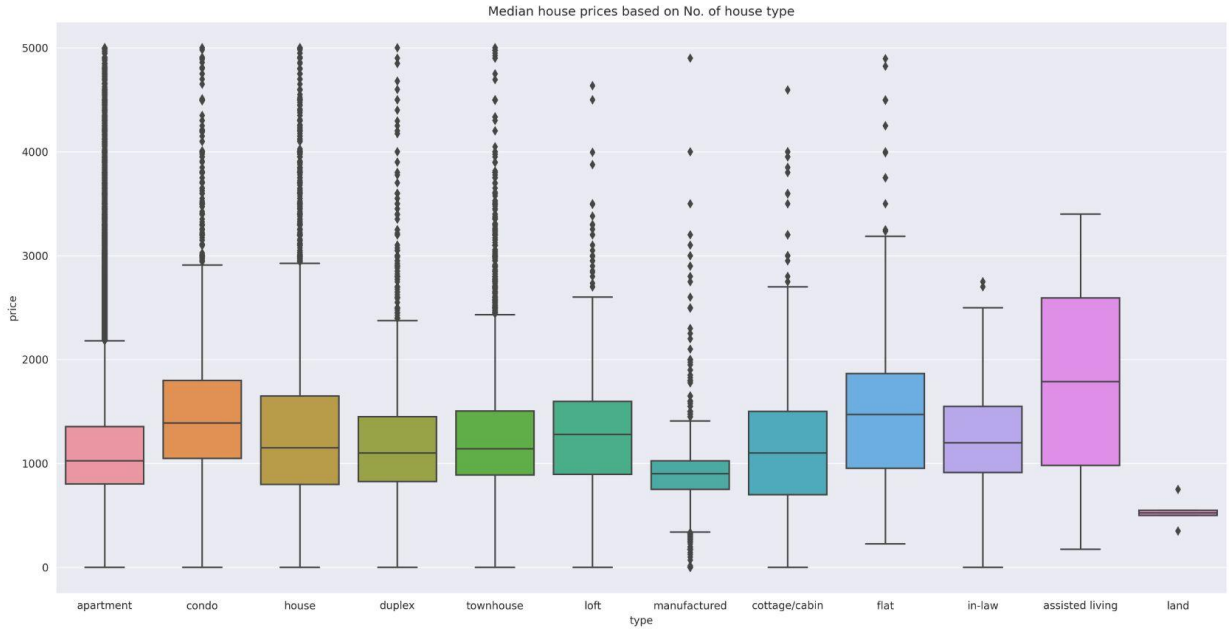


Fig. 3.1.4. Median House price based on house type

From fig. 3.1.4., we can conclude that manufactured homes have the lowest median house price, while assisted living houses have the highest.

4. Macroeconomic Factors

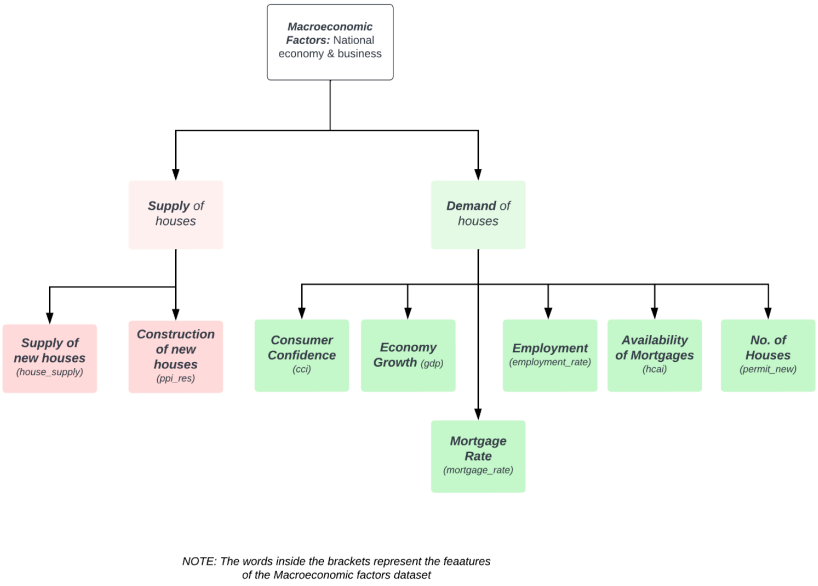


Fig. 4.0. Segmentation model of Macroeconomic factors

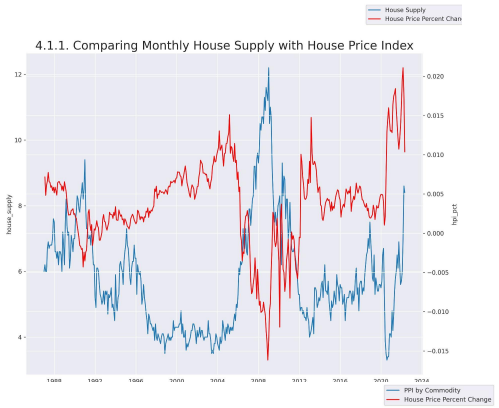
In order to perform a technical analysis of macroeconomic factors, a dataset (*link*) was created using the individual time series found on FRED. The trend of economy, demand and supply of houses are considered as possible explanatory variables. With periods of rising demand and limited supply, rising house prices, rising rents & increased risks of homelessness can be seen. Similarly, rising supply, but limited or constant demand can reduce house prices. The technical analysis of the macroeconomic factors are as follows:

4.1. SUPPLY

A shortage of supply pushes up the prices & excess supply will cause the prices to fall.

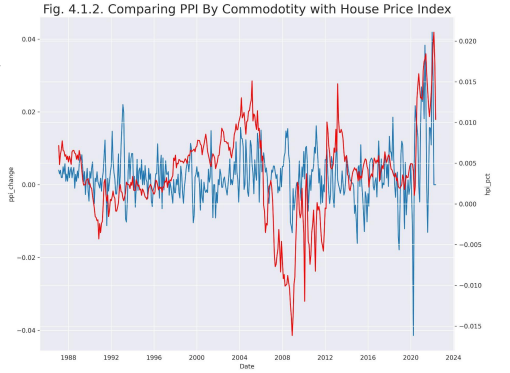
A. House Supply

As we can see in Fig 4.1.1., an increase of house supply lowers the house price. We can note, in 2020, the supply of houses reduced tremendously due to COVID-19. This led to the sudden increase in the house prices as the demand for homes increased. Another example would be the housing bubble in 2007-2008. The supply of the house kept increasing until the market crashed, and the prices of the houses decreased. This was a big hit to investors with real estate assets, when the value of the houses reduced.*o*

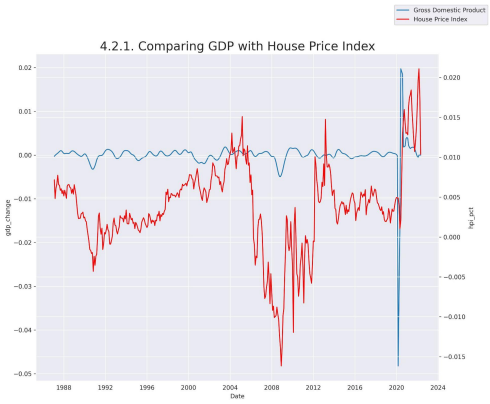


B. Producer Price Index by Commodity

Here, in fig. 4.1.2., we can see how the construction costs reduced tremendously during COVID-19, while the value of houses increased.



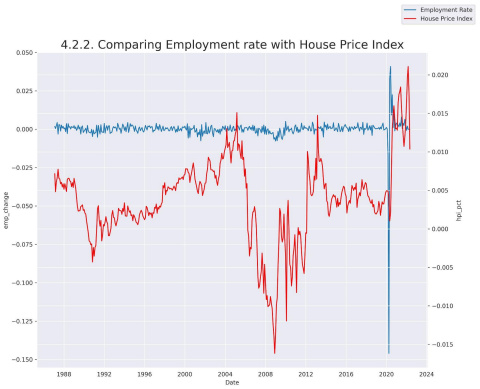
4.2. DEMAND



Demand in houses with constant or reduction in supply, leads to increase in the value of houses. This increases the house prices.

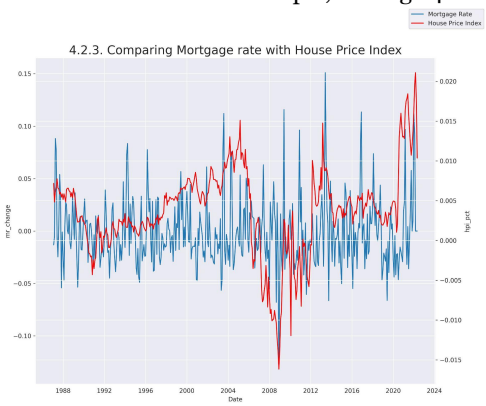
A. Economic Growth

Demand for housing is dependent upon income. With increase in economic growth & rising incomes, people will be able to spend more on houses, which in turn would increase the demand and increase house prices. We can see in fig. 4.2.1., how the financial crisis in 2007-08 reduced the overall GDP of the U.S. resulting in a decrease in demand for houses and hence reduction in prices. As for COVID-19, there was a tremendous reduction in GDP due to unemployment, but the GDP exceeded its pre-COVID level in the third quarter of 2021 due to various reasons such as remote working, fast recovery of the stock market, etc. gaining back the value of houses as well.



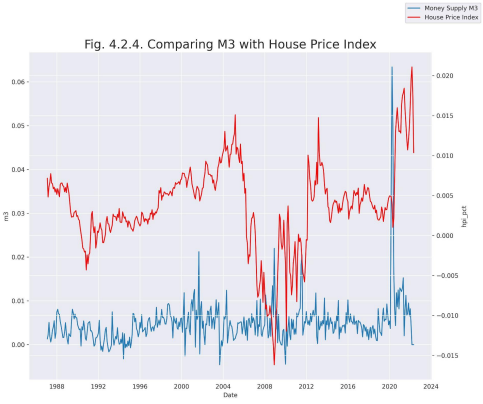
B. Employment Rate

Related to economic growth, as the employment rate increases in a country, the demand for houses also increases as people can consider purchasing a house. Reduction in employment rate discourages people from even entering the property market. For example, in Fig. 4.2.2., during COVID-19, employment rate reduced significantly, leading to reduction in house prices as well.



C. Mortgage Rate & Mortgage Availability

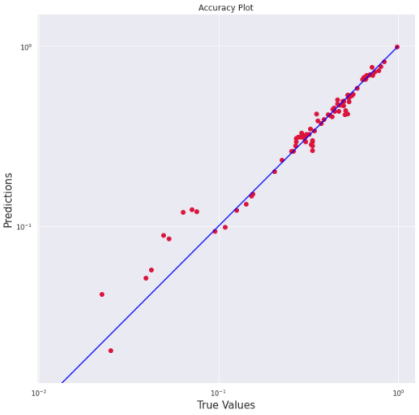
Mortgage rates affect the cost of monthly mortgage payments. A period of high rate will increase the cost of mortgage payments and will lower the demand to buy a house. Also, the ease of getting a mortgage meant that the demand for housing increased as more people were now able to buy. However, the lending criteria requiring a bigger deposit has tightened for various reasons, which reduces the availability of mortgages and hence the demand reduces.



D. Money Supply

What makes money supply of utmost importance is the fact that it regulates the growth of an economy. An increase in the money supply brings down the interest rates, which leads to a rise in investments by the people. A decrease in the money supply will have the opposite impact. In Fig. 4.2.4., we can note that during 2008, the money supply in the U.S. increased, whereas the house price has increased. Even during the early quarter of 2020, M3 increased significantly, hence, reducing the house price.

5. Data Modeling (link)



The above features were normalized and multivariate regression of various algorithms were performed, to find the model with the highest accuracy. Here, BayesianRidge & Linear Regression had the best score. So, we used BayesianRidge for further hyperparameter optimization. The optimization was performed using GridSearchCV and the best hyperparameters with the highest accuracy were obtained. Using the best hyperparameters, BayesianRidge algorithm was used to perform regression. The predictions vs True Values graph is shown. R Squared of this model is **0.97993**. RMSE is **0.0306.**

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RMSE:  0.030622590435954705
R squared:  0.9799314600892053
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Multivariate Regression using OLS was also performed and the summary of the model is as follows:

OLS Regression Results

Dep. Variable:	house_price_index	R-squared (uncentered):	0.997
Model:	OLS	Adj. R-squared (uncentered):	0.997
Method:	Least Squares	F-statistic:	5856.
Date:	Wed, 03 Aug 2022	Prob (F-statistic):	6.55e-232
Time:	03:55:32	Log-Likelihood:	459.94
No. Observations:	199	AIC:	-897.9
Df Residuals:	188	BIC:	-861.7
Df Model:	11		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
population	0.2579	0.029	8.885	0.000	0.201	0.315
house_supply	0.2772	0.020	13.796	0.000	0.238	0.317
gdp	0.1324	0.034	3.942	0.000	0.066	0.199
mortgage_rate	-0.1059	0.027	-3.936	0.000	-0.159	-0.053
employment_rate	-0.2349	0.037	-6.304	0.000	-0.308	-0.161
permit_new	0.1444	0.028	5.145	0.000	0.089	0.200
ppi_res	0.3119	0.050	6.209	0.000	0.213	0.411
m3	0.3027	0.053	5.665	0.000	0.197	0.408
cci	-0.0261	0.018	-1.480	0.141	-0.061	0.009
delinquency_rate	-0.2179	0.013	-17.305	0.000	-0.243	-0.193
hcai	0.2350	0.018	13.062	0.000	0.200	0.271

Omnibus:	21.819	Durbin-Watson:	2.155
Prob(Omnibus):	0.000	Jarque-Bera (JB):	28.284
Skew:	0.715	Prob(JB):	7.22e-07
Kurtosis:	4.170	Cond. No.	73.3

Notes:
[1] R^2 is computed without centering (uncentered) since the model does not contain a constant.
[2] Standard Errors assume that the covariance matrix of the errors is correctly specified.

Here, the model shows that CCI has no relationship with the target house_price_index since it fails to reject the null hypothesis (there's no relationship) i.e., p values > 0.005. Alternative hypothesis being '*some relationship exists*' is true for the rest of the features.
This model also shows that the 99.7% (r squares = 0.997) of the variability of the house price index can be explained by its independent features.

6. Conclusion

Through the use of statistical analysis, we were able to identify which factors influenced housing prices in the U.S. on a house level and as well as on a national level. The developed regression model helped us identify the driving forces of U.S. housing prices which were the most significant.