

Housing Market Dynamics

Team 127 (Mira Antolovich, Kimberly A Pierce, Houtan Rasouli and Donatien Toni)

Introduction

The "Housing Market Dynamics" project aims to gain a deeper understanding of the trends and patterns of housing prices in the United States by analyzing several critical factors, including interest rates, inflation, income, population growth, and historical house price data. This project aims to create an accurate, accessible, and user-friendly dashboard to explore the housing market and provide prediction tools for anyone interested in real estate, housing policies, and investments. Our approach combines data from multiple sources and utilizes machine learning models to get valuable insight into the housing market; which will benefit various stakeholders, such as real estate agents and potential homebuyers, providing them with the proper tools to make informed decisions.

Problem Definition

The problem addressed by our project is the lack of a comprehensive, accurate, and accessible tool for casual users to understand the trends and patterns of housing prices in the United States. The current methods of predicting the housing market are often presented in complex reports that may be difficult for casual users to comprehend, and simpler methods may have limitations, such as relying on limited data sources that may contain errors.

While the U.S. government also predicts the housing market using numerous factors, the current methods are often presented in complex reports, making it difficult for casual users to understand. Moreover, the existing user-friendly methods have limitations, such as relying on limited data sources, which can contain errors.

Literature Survey

Machine Learning Predictions (Gupta et al., 2021) show that while machine learning provides useful predictions on housing market synchronization, uncertainty still affects accuracy. We will experiment to choose an appropriate machine learning model to reduce potential uncertainty.

Bubble-like housing boom–bust cycles (Huang, 2014) find that households' expectations significantly impact housing market predictions and should be considered when making decisions. We should test if consumer sentiment and expectations data can be used to predict future housing prices; however, this may not be replicable as 2014's market may not apply to current conditions.

A Survey on Visual Analysis Approaches for Financial Data (Ko et al., 2016) highlights the potential of visual analysis in finance to improve decision-making and the need for further research. However, the usefulness of visual analysis depends on user skill and experience. To alleviate this, we should continually review the user interface through surveys to make it accessible to all users.

Fundamental Drivers of House Prices in Advanced Economies (Geng, 2018) shows which factors drive housing costs between 20 countries. It also highlights the differences between supply and demand factors regarding housing costs. We can use this to further expand on the US data specifically and potentially utilize the price-to-rent (PTR) ratio for our analysis.

Volatility in Home Sales and Prices: Supply or Demand (Anenberg, et al., 2022) indicates supply factors tend to have a larger role in fluctuations in home prices. This study was done primarily in response to COVID-19 fluctuations, so it may only help describe any changes in a time series analysis for more recent years due to the pandemic. We can apply this theory to our predictions during the affected years.

The 1920s Real Estate Boom and Great Depression (White, 2014) is a study on the 1920s real estate market and the effects it may have had on the Great Depression. This could be useful for a historical viewpoint on the housing market or show a 100-year change in pricing, but it may not be useful for our project, depending on the time frame.

Housing Prices and Inflation (Bernstein et al., 2021) explore the factors that drive home values, including demand, building costs, and housing supply. It also explains the impact of rising home prices on the CPI (Consumer Price Index). However, it focuses on the pandemic, which introduces uncertainty to economic data and could impact the historical relationship between housing prices and the CPI.

Data Analysis for Time Series (Nielsen, 2019) provides a framework for exploring time series data sets and applying commonly used data exploration techniques to time series data. This topic is vital for our project as we deal with time series data. However, the book followed a general overview of time series analysis and did not dive into specific prediction techniques for housing market data.

Housing Market Forecasting and Analysis in California (Atachian, Karapetyan, & Petrosian, 2022) propose using the Holt-Winters Exponential Smoothing method and Geographic Information Systems in tandem to forecast price changes in the real estate market. However, these methods' ability to handle seasonal data variations must be assessed.

Housing market dynamics and the future of housing prices. Journal of Housing Economics (DiPasquale & Wheaton, 1996) reviews the housing market dynamics, supply and demand, economic cycles, government policies, and their potential implications for future housing prices. It concludes that the housing market's future is uncertain but likely to remain an essential part of the economy, with population growth, technology, and housing bubbles having an impact. This gives us further insights into our project data.

A Hierarchical Factor Analysis of U.S. Housing Market Dynamics (Moench & Ng, 2015) uses a hierarchical factor analysis to investigate the dynamics of the U.S. housing market. The authors use historical monthly housing market data to construct the model, which can identify and measure the underlying factors driving the housing market. The model architecture is a good reference for our project.

U.S Housing Market Conditions - Comprehensive Housing Market Analyses (CHMA) (Browne & Kane, 2020) provides a regional and local overview of the U.S. housing market, including supply, demand, affordability, and market conditions, using data from the Census Bureau and other sources. This paper allowed us to get a deeper understanding of how the U.S. government views the current housing market.

Methodology

The project offers superior capabilities compared to the current state-of-the-art technology available for free due to its accuracy and availability. As per an initial user-survey, of those who identify as casual users, 50% of them were unable to find an interactive tool that helped predict the housing market while 30% had never looked for such a tool. You can find the results of the initial user survey in Appendix 1.

In addition to the user-survey findings, our project offers several features that further set it apart. Firstly, the project combines data from multiple sources, including historical house price data, population growth, income, inflation, and interest rates, to provide a more comprehensive view of the housing market trends and patterns. Secondly, the project utilizes advanced machine learning models to analyze the data and generate accurate predictions about the housing market. Finally, the project aims to create an accessible and user-friendly dashboard that provides valuable insights into the housing market for a diverse range of stakeholders, including real estate agents, investors, and potential homebuyers.

Dashboard

The dashboard has three pages, each serving a specific purpose. The predictions page presents the user with the current data of the US housing market, including the current values as of 2022, the average US housing market, and predictions based on city and state selected from 2000 to the end of 2024.

The second page contains detailed explanations for the significant factors affecting the housing market. Additionally, it offers comprehensive statistics for the selected metro region between 2000 and 2023. This information is designed to help users gain a better understanding of what affects the housing market and the metro's statistics.

The final page allows users to see the paper and poster we created for this project, as well as more in-depth information for the model and data retrieval. It provides simplified yet detailed information about the predictive model, data preparation, and the data retrieval methods used in the model's development. This page helps users gain a deeper understanding of the project's technical aspects. You can view the dashboard in Appendix 2 or in our project's [GitHub](#). Past wireframes can be viewed in Appendix 3 and 4.

The user-friendly data presentation makes the housing market more accessible to a broader range of people. The multitudes of user surveys and user tests for the dashboard has improved our dashboard,

making it more accessible to a comprehensive range of people, and they enable users to make more informed decisions based on a better understanding of the data. By leveraging these tools, casual users can have a more transparent view of the housing market.

Model

Our first innovation was to select appropriate data and create a unique model for the housing market. Through our approach, we leveraged publicly available data sources. The model is especially valuable for users who may not have access to more complex models. By utilizing the correct data, we have developed a model that accurately describes the various components of the market dynamics.

As for the model, we first identified several statistical significance factors. Refer to Appendix 5 for a complete list of data sets. The data is organized by metro from 2000 to 2023. Once we selected the data sources for building the predictive model for house prices, we began cleaning and preparing the data for analysis.

Next, we conducted exploratory data analysis (EDA) to comprehend the trends and patterns in the data. This involved creating visualizations, such as time series plots, autocorrelation plots, and seasonal decomposition plots, shown in Appendix 6 and 7. By analyzing these visualizations, we gained valuable insights into the data, such as:

| Learning | Description |
|--------------------------------|---|
| Overall trends | We can see whether the median house prices have increased or decreased over time, as well as any general patterns in the data. |
| Seasonality | We can see if the median house prices follow a consistent seasonal pattern, such as being higher in the summer months and lower in the winter months. |
| Variation across cities/states | We can see how the median house prices vary across different cities and states in the United States. |
| Outliers | We can see whether there are values that are significantly different from the rest of the data and may indicate errors or anomalies. |
| Missing values | We can see whether there are any gaps in the data, indicating missing values or incomplete data. |

From these findings, we began to generate hypotheses about the data and devised a plan for further investigation.

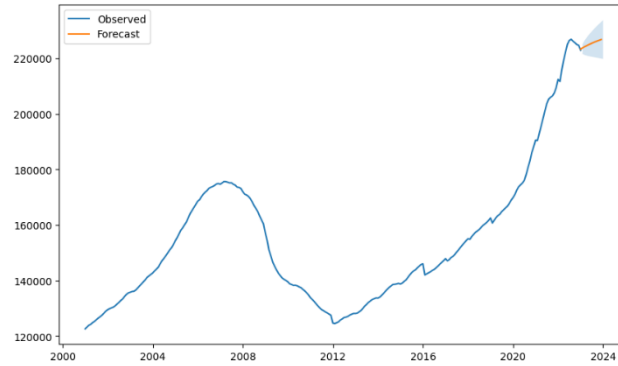
(S)ARIMA

We are utilizing the Seasonal Autoregressive Integrated Moving Average (SARIMA) model, which accounts for the seasonality observed in our monthly house price data. We use visual analysis and statistical tests, such as the Akaike and Bayesian information criteria, to determine the most appropriate SARIMA model by examining model parameters, including differencing, and moving averages. In Appendix 8, we visually represent the housing market trends over time.

We utilized the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test to examine our dataset and determine whether the time series is trend-stationary or difference-stationary. Appendix 9 presents the results of the KPSS test. The result provides compelling evidence against the null hypothesis of non-stationarity. Moreover, the p-value of the test is 0.1, which is greater than the significance level of 0.05. Hence, we cannot reject the null hypothesis at the 5% significance level, but we can reject it at the 10% level.

After confirming we did not need to transform the data, we identified the appropriate model parameters for our SARIMA model. These parameters are (p, d, q) x (P, D, Q, s), where p, d, and q correspond to the non-seasonal component, while P, D, and Q relate to the seasonal component, and s represents the length of the seasonal cycle. We can utilize statistical methods such as Akaike Information Criterion (AIC) or Bayesian Information Criterion (BIC) to select these parameters. These metrics balance the trade-off between the fit and model complexity, with lower values indicating a better fit.

Once the optimal model is selected based on its validation data performance, it can be utilized to produce forecasts for the upcoming year's house prices in the chosen metro city. Additionally, prediction intervals can be calculated to measure the uncertainty surrounding the predictions. Our script was executed on Azure ML Studio, and we still need to improve our model parameters and cluster configurations for better accuracy and performance. In our initial testing, the following predictions were generated:

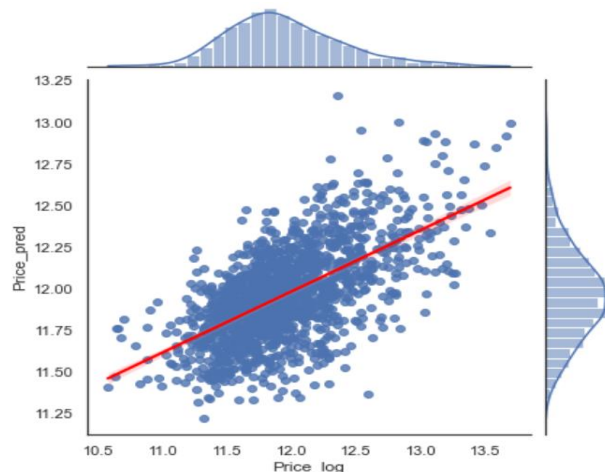


Multiple Regression Analysis

Multiple regression analysis (MRA) is a statistical technique proven to be a powerful tool for analyzing the relationship between a dependent variable and two or more independent variables. This technique has been widely used to identify the factors that influence the dependent variable and to predict its value based on the importance of the independent variables. We used the equation: $Y = XB + E$.

| Variable | Description |
|----------|--|
| Y | Dependent variable observation vector |
| X | Independent variables observation matrix |
| B | Coefficients vector |
| E | Random error vector |

Our project used MRA to examine the dynamics of the market by analyzing the relationship between numerous factors that affect the price of housing. These factors include GDP growth, mortgage rates, employment, population growth, income, crime rate, and more. Based on our analysis, our model is based on income, employment, and population growth after rigorous data screening and availability. Then, the data was analyzed to determine the strength and direction of the relationship between the variables and generate a prediction model. We found a strong relationship between income, unemployment, and housing price, where the model can predict how these factors affect the housing market.



To evaluate the accuracy of our forecasts, we computed several error metrics. These can be found in Appendix 10. The metrics we used to evaluate the model are R-squared and Mean Squared Error (MSE). R-squared is a statistical measure of how close the data are to the fitted regression line, while MSE assesses the average squared difference between the observed and predicted values. These metrics provided a valuable insight into the model's accuracy and ability to predict housing prices. These performance metrics indicate that the SARIMA model is not perfectly accurate, however, the model is capturing some of the underlying trends and patterns in the data. It is important to note that these metrics

are relative to the scale of the data, and we continue working on our model accuracy and finding the best parameters for better performance. You can find the residual diagnostics chart in Appendix 11.

Experiments & Evaluation

To ensure that our dashboard met the needs of casual users, we conducted an initial user survey with 10 participants who self-identified as casual users through Google surveys. This survey allowed us to better understand their perspective, including their understanding of the US housing report, whether they searched for prediction tools and were able to find them, and most importantly, whether they would use a tool like ours. By conducting this survey, we obtained valuable insights into the preferences and expectations of our target audience. This information enabled us to refine our project design and ensured that it met the general needs of casual users. You can see the results of the survey in Appendix 1.

Based on the feedback from the first user survey, we simplified the dashboard significantly to make it more user-friendly. We then conducted a second user survey using modified wireframes of the potential dashboard through Google survey found in Appendix 12 where we received positive feedback from users of all experience levels found the metro selection, predictions, and historical data to be useful. You can find the results of this survey in Appendix 13.

The final round of testing we completed on our dashboard was a user survey and usability tests to understand if our dashboard was effective. The useability test script can be found in Appendix 14. The useability tests were run on two different people, which can be found in Appendix 15 and 16. Within these surveys, it was clear that the functionality of the dashboard was relatively smooth, though the user interactivity could have used some work. The data could also be presented in a more user-friendly manner; however, the Google survey showed that the final dashboard was able to display the information that users of all experience levels needed. Overall, 75% of users found that the dashboard was “fairly easy” or “very easy” to understand, while over 65% of users found the dashboard “fairly easy” or “very easy” to use. The results of the final survey can be seen in Appendix 17.

Conclusion & Discussion

The goal of the Housing Market Dynamics project was to identify the factors that impact the housing market and develop a dashboard that provides accurate predictions and is easy to use. Our research revealed that income levels, employment rates, and population growth are significant factors that affect the housing market; these factors all lead to fluctuations in demand and prices. The most notable achievement was the creation of a dashboard that empowers homeowners and investors to understand the factors that influence the value of their homes and make informed decisions about buying and selling. The results of the final survey showed that 75% of people found the dashboard easy to understand, while 65% found the dashboard easy to use. The user surveys showed gaps where we could have further improved the dashboard, but the overall functionality seemed to be functional for casual users.

Furthermore, the model provides essential insights into the driving factors of the US housing market, with great interest to investors and homeowners. It can also serve as a basis for future research on the economic impact of the housing market. [By utilizing and studying the error metrics (such as R^2 and MSE) and comparing their values, we were able to assess the efficacy of our SARIMA and Multiple Regression models in capturing the patterns and trends in our data and gauging the dependent variables. While our models demonstrated a decent degree of accuracy, we acknowledge that there remains room for improvement.].

However, we acknowledge that the project has limitations. It relies on historical data and primarily focuses on the US real estate market, making it challenging to extrapolate the results to other countries or predict future trends accurately. If we were to continue working on this project, we would expand our analysis to include the impact of government policies on the housing market and environmental factors such as climate change.

We are pleased with the progress we have achieved through the Housing Market Dynamics project while acknowledging that there is more work required to ensure that the dashboard remains relevant and

valuable for our users. Throughout the project, each team member contributed equally and was dedicated to its success.

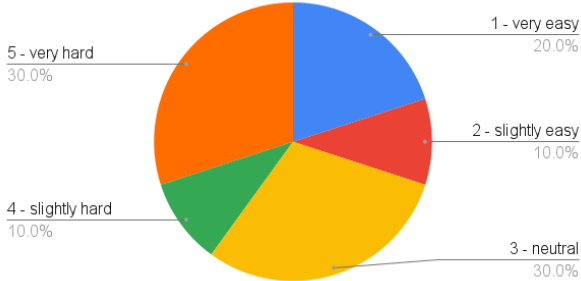
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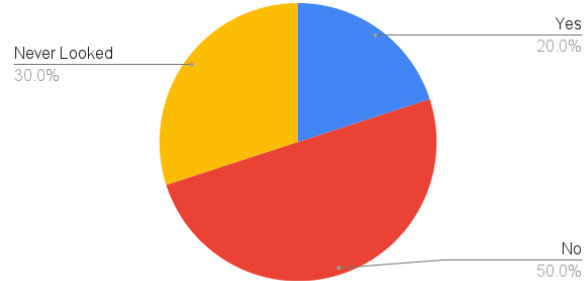
Appendix

Appendix 1

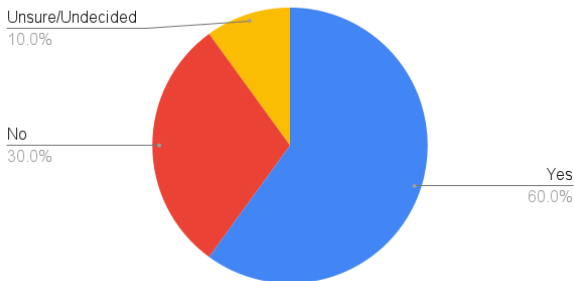
On a scale of 1 to 5, how easy or difficult is it for you to understand the US housing market report?



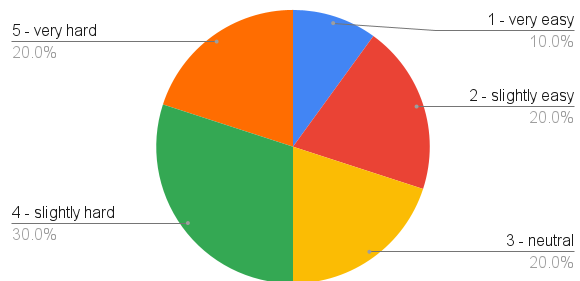
Have you ever found an interactive tool that predicts the housing market?



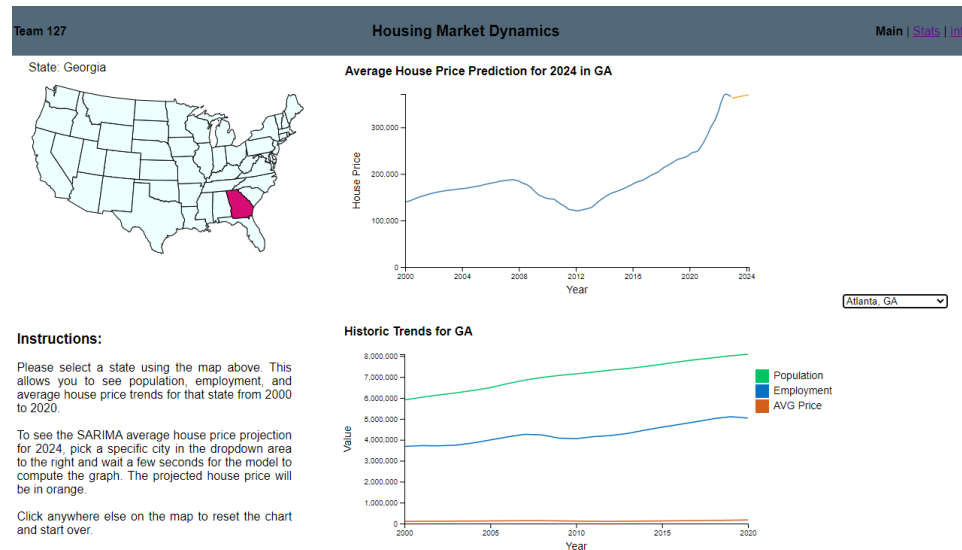
Would you use a tool that displayed a prediction of the housing market?



On a scale of 1 to 5, how easy or difficult is it for you to understand the current housing market?



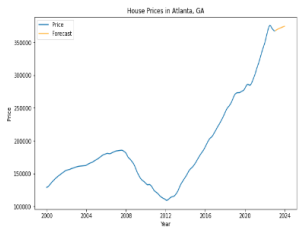
Appendix 2



Analysis Types and Further Information

[SARIMA](#) | [Trends](#) | [Multiple Regression](#)

SARIMA and the Prediction Graph



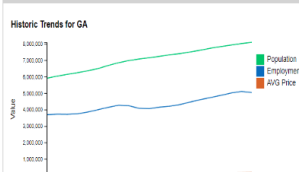
What is SARIMA? ARIMA or autoregressive integrated moving average is a forecasting method for univariate time series data. SARIMA is an extension of the ARIMA method that supports time series data with a seasonal component. On the main page, our prediction graph using a SARIMA model displays the historic average house price for metros from 2000 through our predicted values for 2024.

Why did we choose to use SARIMA? Through our analysis of the data, we found that there was a seasonal aspect to monthly house pricing. In addition to this, SARIMA is typically an easy to understand and interpret model, making it more useful for casual users than a complicated model.

How did we interpret significance of the model? Using error metrics like MSE, MAE, and RMSE we found that the SARIMA model is not perfectly accurate but the model captured underlying trends and patterns within the data.

[MSE](#) | [MAE](#) | [RMSE](#)

Housing Market Trends



What are Trends? In analytics, Trends are long-term upward or downward changes in the average measured value. For our model on the main page, we showed the trends in regards to Employment, Population, and Average Price per state for each year from 2000-2020.

Why might it be useful to display Trends? Housing prices can be heavily influenced by multiple factors, so showing the factors that have the most weight in regards to Trends can help a user better understand why our model predicts certain future prices.

How did you determine these factors were the most influential? A regression analysis was performed with respect to house pricing and our results below indicated the most influential factors in house prices.



Sources and Surveys

[Data Used](#) | [Literature Survey](#)

Data

SARIMA: *Housing Price Data by US Metros 2000-2022* from Zillow [Housing Data](#)

Regression: *A combination of data from the Bureau of Economic Analysis and Zillow* [Employment](#) [GDP](#) [Income](#) [Population](#) [Home Prices](#)

Literature Survey

Anenberg, Elliot, and Daniel Ringo (2022). "Volatility in Home Sales and Prices: Supply or Demand?" Finance and Economics Discussion Series 2022-041. Washington: Board of Governors of the Federal Reserve System, <https://doi.org/10.17016/FEDS.2022.041>

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Appendix 3

Overview

MENU BAR

Info | Paper

SELECTION CRITERIA

Location:
(state) or (metro)

Year(s):
(year) 2003 2007 (year)

Statistic (US Map):
(statistic) Sorted by importance

Info about the statistic, blah blah blah. effect on housing market. 3 sentence summary. [Changes based on statistic selected].

Apply

US [DATA] OVERVIEW ([Year]-[Year])

State/Metro Specific Value

HEAT MAP - ZOOMABLE - HOVER/CLICK FOR DATA POPUP

COLOR MEANING

[LOCATION] DATA OVERVIEW ([Year]-[Year]) | [LOCATION] PREDICTION OVERVIEW

The Global Decline of Manufacturing

PROPER GRAPH OF DATA IN THAT AREA

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Disclaimer: We do not guarantee accuracy of predictions. This is not financial advice.

Overview

MENU BAR

Info | Paper

STATISTICS

CPI | Migration | Crime Rate | CPI | Migration | Crime Rate | CPI | Migration | Crime Rate | CPI | Migration | Crime Rate

Term

Consumer Price Index (CPI)

An index that measures the monthly change in prices paid by U.S. consumers.

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Term

FINAL PDF POSTER

ANALYSIS TYPES & FURTHER INFORMATION

[Data Used](#) | [Model](#) | [Clustering](#) | [Data Used](#) | [Model](#) | [Clustering](#) | [Data Used](#) | [Model](#)

Data

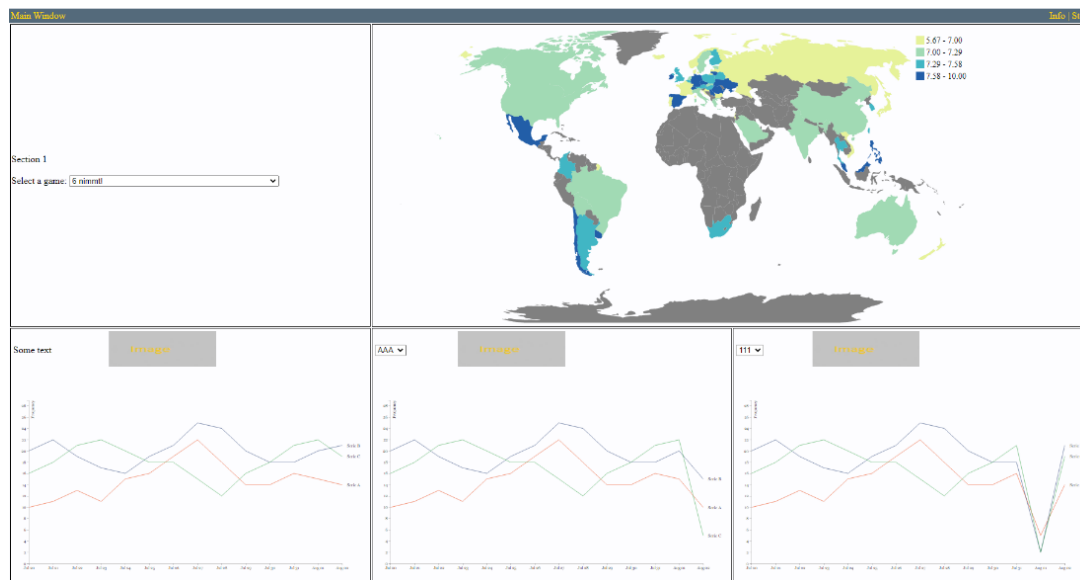
Housing Data: Zillow (<https://www.zillow.com/research/data/>), Zillow (<https://www.zillow.com/research/data/>), Zillow (<https://www.zillow.com/research/data/>), Zillow (<https://www.zillow.com/research/data/>).

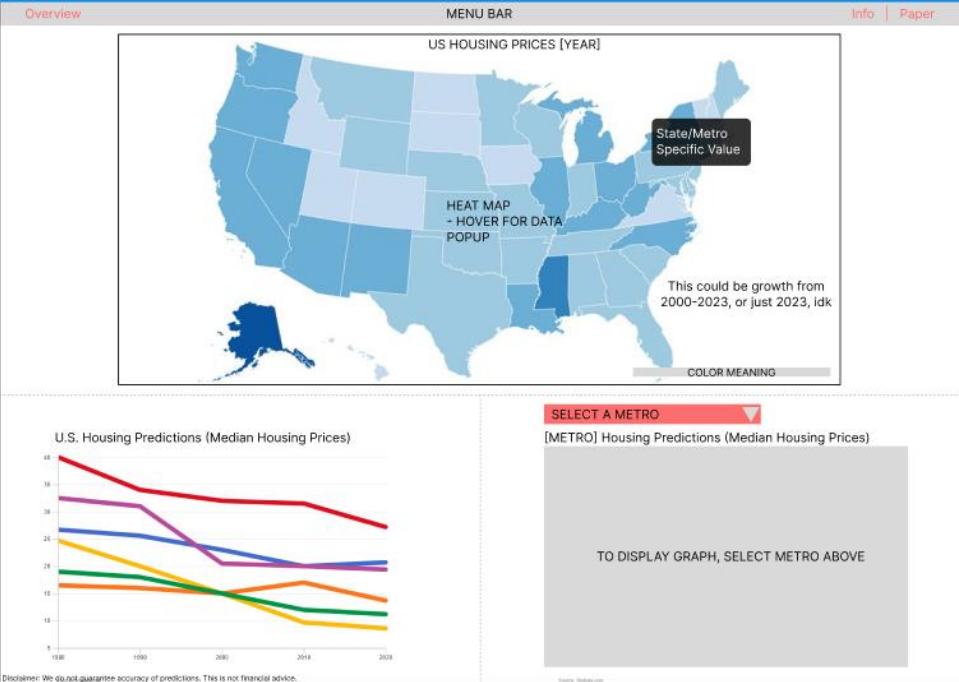
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Housing Data: Zillow (<https://www.zillow.com/research/data/>), Zillow (<https://www.zillow.com/research/data/>), Zillow (<https://www.zillow.com/research/data/>), Zillow (<https://www.zillow.com/research/data/>).



Appendix 4





| STATISTICS | |
|---|---|
| CPI Migration Crime Rate CPI Migration Crime Rate CPI Migration Crime Rate CPI Migration Crime Rate | |
| SELECT A METRO | |
| Historical Data | <p>What is [TERM]? Lorem ipsum dolor sit amet, consectetur adipiscing elit. Nulla vulputate erat viverra justo rhoncus viverra. Phasellus ut sapien vitae odio interdum commodo. Vestibulum nec ante vel lacus elementum elementum. Mauris tincidunt imperdiet sodales. Sed accumsan tristique dui, sed tempor diam ultrices at. Aenean nec pellentesque metus, vel congue urna.</p> <p>How is it calculated? Lorem ipsum dolor sit amet, consectetur adipiscing elit. Nulla vulputate erat viverra justo rhoncus viverra. Phasellus ut sapien vitae odio interdum commodo.</p> <p>What is it's impact on the housing market? Lorem ipsum dolor sit amet, consectetur adipiscing elit. Nulla vulputate erat viverra justo rhoncus viverra. Phasellus ut sapien vitae odio interdum commodo.</p> |
| Historical Data | <p>What is [TERM]? Lorem ipsum dolor sit amet, consectetur adipiscing elit. Nulla vulputate erat viverra justo rhoncus viverra. Phasellus ut sapien vitae odio interdum commodo. Vestibulum nec ante vel lacus elementum elementum. Mauris tincidunt imperdiet sodales. Sed accumsan tristique dui, sed tempor diam ultrices at. Aenean nec pellentesque metus, vel congue urna.</p> <p>How is it calculated? Lorem ipsum dolor sit amet, consectetur adipiscing elit. Nulla vulputate erat viverra justo rhoncus viverra. Phasellus ut sapien vitae odio interdum commodo.</p> <p>What is it's impact on the housing market? Lorem ipsum dolor sit amet, consectetur adipiscing elit. Nulla vulputate erat viverra justo rhoncus viverra. Phasellus ut sapien vitae odio interdum commodo.</p> |
| Historical Data | <p>What is [TERM]? Lorem ipsum dolor sit amet, consectetur adipiscing elit. Nulla vulputate erat viverra justo rhoncus viverra. Phasellus ut sapien vitae odio interdum commodo. Vestibulum nec ante vel lacus elementum elementum. Mauris tincidunt imperdiet sodales. Sed accumsan tristique dui, sed tempor diam ultrices at. Aenean nec pellentesque metus, vel congue urna.</p> <p>How is it calculated? Lorem ipsum dolor sit amet, consectetur adipiscing elit. Nulla vulputate erat viverra justo rhoncus viverra. Phasellus ut sapien vitae odio interdum commodo.</p> <p>What is it's impact on the housing market? Lorem ipsum dolor sit amet, consectetur adipiscing elit. Nulla vulputate erat viverra justo rhoncus viverra. Phasellus ut sapien vitae odio interdum commodo.</p> |

Overview

MENU BAR

Info | Paper

FINAL PDF POSTER

ANALYSIS TYPES & FURTHER INFORMATION

Data Used | Model | Clustering | Data Used | Model | Clustering | Data Used | Model

Data

Housing Data: Zillow (<https://www.zillow.com/research/data/>), Zillow (<https://www.zillow.com/research/data/>), Zillow (<https://www.zillow.com/research/data/>), Zillow (<https://www.zillow.com/research/data/>),

Housing Data: Zillow (<https://www.zillow.com/research/data/>), Zillow (<https://www.zillow.com/research/data/>), Zillow (<https://www.zillow.com/research/data/>), Zillow (<https://www.zillow.com/research/data/>),

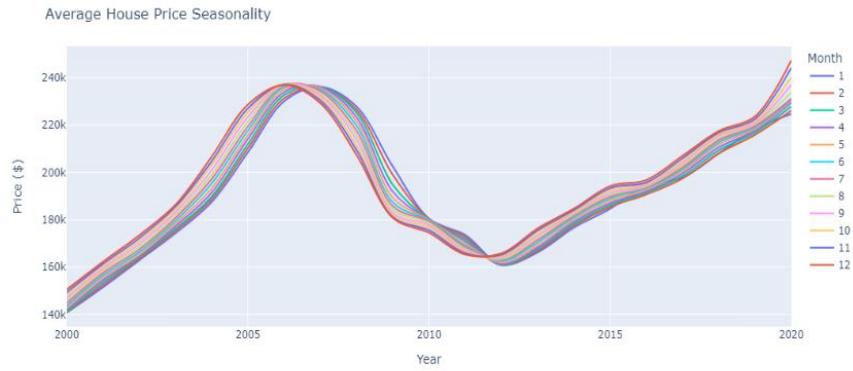
Housing Data: Zillow (<https://www.zillow.com/research/data/>), Zillow (<https://www.zillow.com/research/data/>), Zillow (<https://www.zillow.com/research/data/>), Zillow (<https://www.zillow.com/research/data/>),

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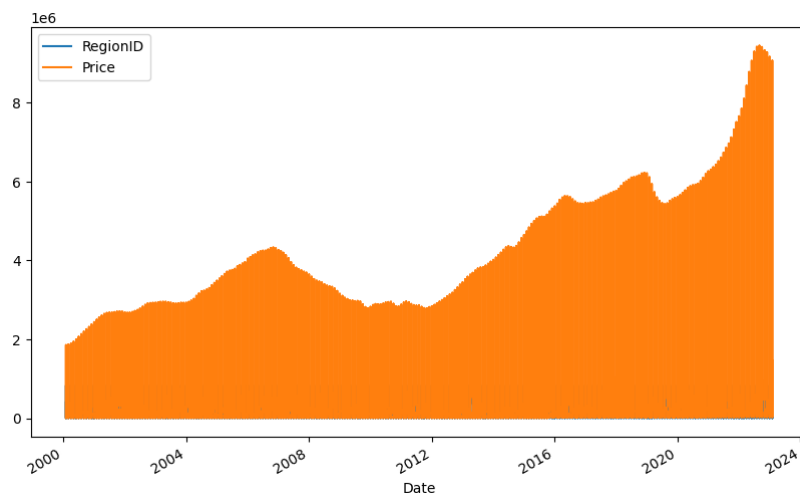
Appendix 5

| Factor | Description |
|----------------------------|--|
| Interest Rates | Influences the cost of borrowing for homebuyers, affecting their purchasing power and the overall affordability of housing. |
| CPI (Consumer Price Index) | Inflation affects the cost of housing and borrowing. |
| GDP | Economic growth can increase the demand for housing and encourage people to invest in real estate. |
| Employment | A strong employment market increases consumer confidence and encourages people to buy homes. |
| Population | Affects the number of people looking to buy homes |
| Income | Affects the ability of potential buyers to afford a home |
| Crime rate | High crime rate in an area, can lead to decreased demand for housing in that area |
| House Sales Volume | Reflects the number of residential properties bought and sold, providing insights into market activity and demand for housing. |

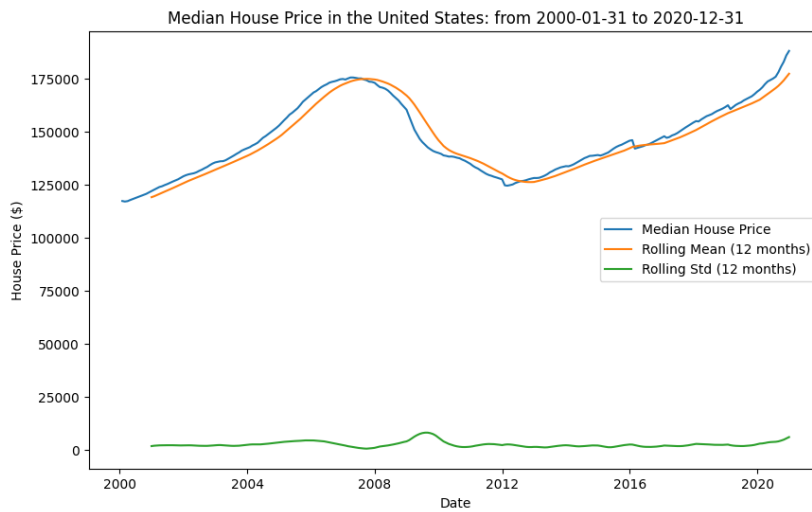
Appendix 6



Appendix 7



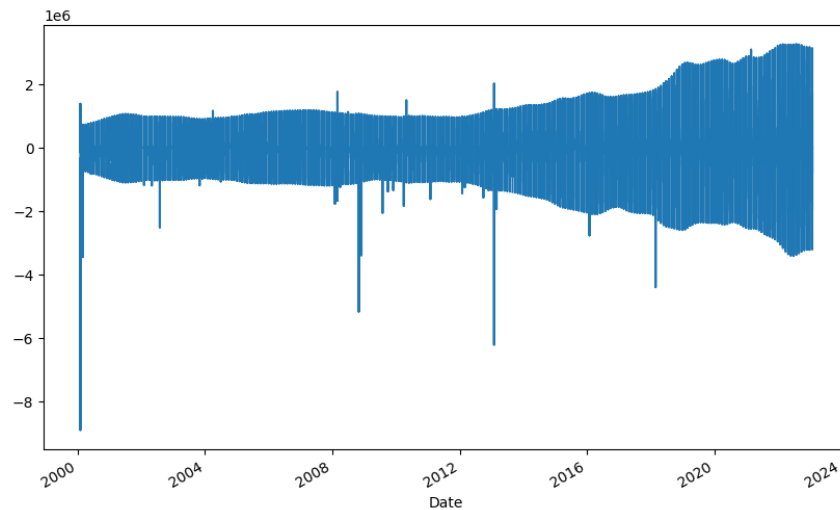
Appendix 8



Appendix 9

KPSS test statistic: 0.000823898395827289
p-value: 0.1

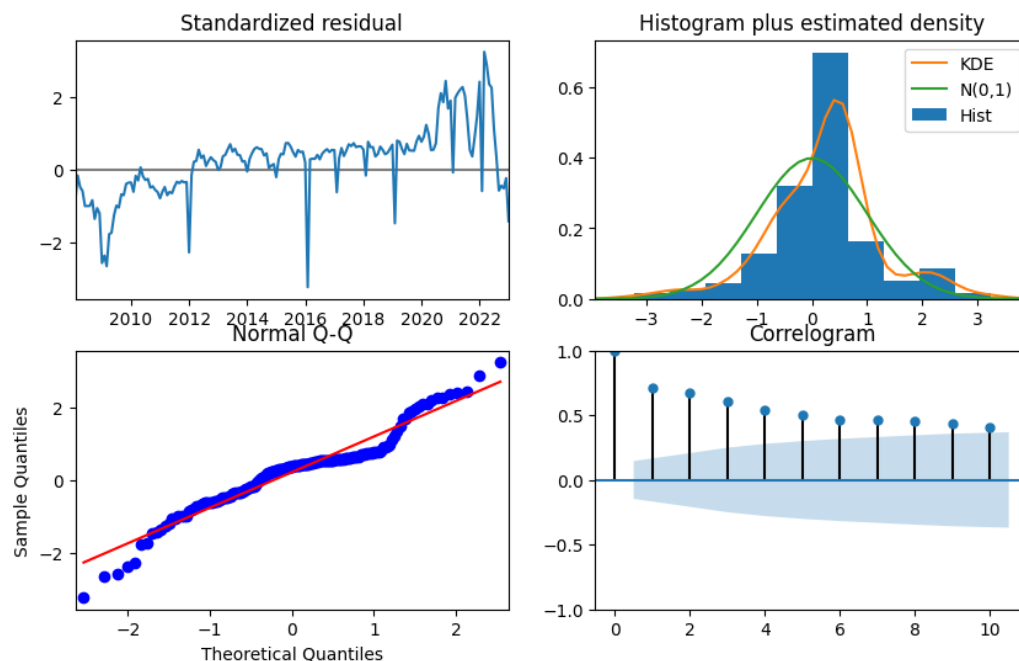
critical values: {'10%': 0.347, '5%': 0.463, '2.5%': 0.574, '1%': 0.739}



Appendix 10

The mean squared error (MSE) measures the average squared difference between the predicted and actual values. For our dataset, the MSE was 6,194,701.02. The mean absolute error (MAE) measures the average absolute difference between the predicted and actual values. In this case, the MAE was 2,245.92. The root mean squared error (RMSE) measures the square root of the average squared difference between the predicted and actual values. Based on the model, the RMSE is 2,488.92.

Appendix 11

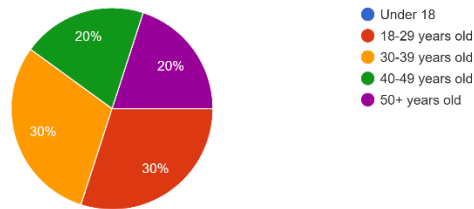


Appendix 12

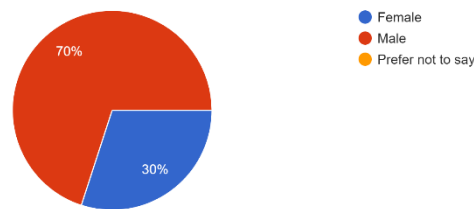
Google User Survey: <https://forms.gle/dDKKbGuDTJ6zMfMu5>

Appendix 13

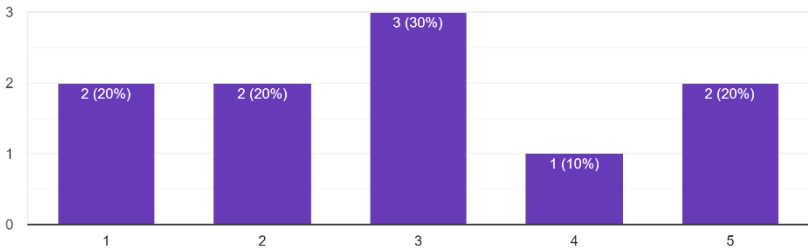
How old are you?
10 responses



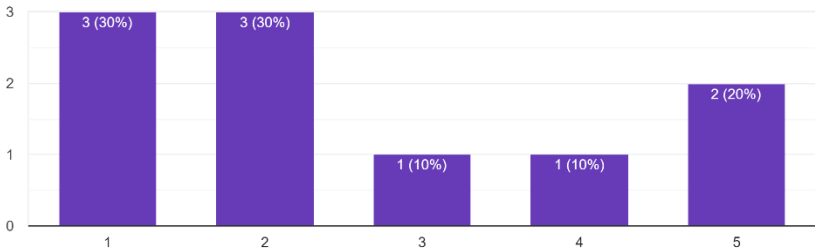
What gender are you?
10 responses



On a scale of 1 to 5, how experienced do you feel participating in the housing market?
10 responses

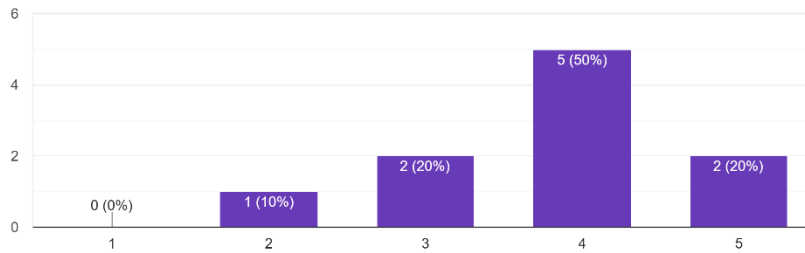


On a scale of 1 to 5, how experienced do you feel reading housing market information?
10 responses



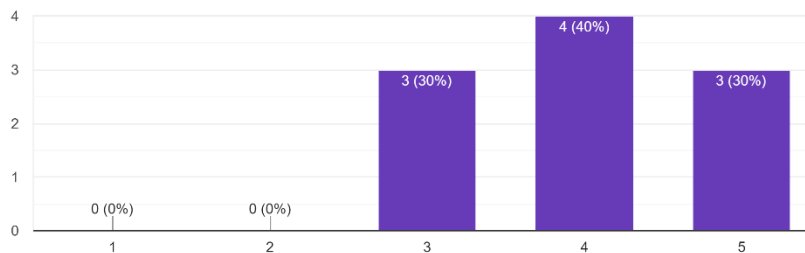
On a scale of 1 to 5, how easy or hard is it to understand the dashboard's interface?

10 responses



On a scale of 1 to 5, how easy or hard is it to use the dashboard's interface?

10 responses



What has your experience been trying to complete these tasks on the dashboard (disregard if non-applicable)?

- I liked it
- selecting a specific metro seemed easy, idk if the housing market is predicting right tho
- It seemed very easy to understand.
- Overall, the housing market dashboard was quite informative and useful. It provided a wide range of historical data on the housing market, such as home prices and sales volume, as well as predictions for future market trends.
- To select a specific metro area on the housing market dashboard, I clicked on the "Metro Area" dropdown menu and selected the area I was interested in. After selecting a specific metro area on the dashboard, I was able to see the housing price prediction for that area by navigating to the "Housing Price" section. Clicking on the "Statistics" page allowed me to see historical data based on the metro selected. To learn the meaning and impact of a specific statistic on the housing market, I used the "Statistics" feature on the dashboard.

Were there any specific benefits/easy-to-use aspects of the dashboard?

- The dashboard streamlined the ability to gather up-to-date knowledge on housing market trends within a specific metropolitan area.
- Can't say
- not really
- It made finding the data very easy.
- One of the benefits of the housing market dashboard was its user-friendly interface. It was easy to navigate and had intuitive features that made it simple to access the data and predictions.

- One of the benefits of the housing market dashboard was the ability to compare different markets and regions. I could easily switch between different areas and see how the housing market was performing in each location.
- For a free service, it displays useful data.

Were there any specific struggles with using the dashboard?

- No.
- Nothing specific.
- no
- not really
- The old dashboard had a lot of features, which made it overwhelming at first. It took some time to become familiar with all of the options and functions, which may be a challenge for users who are less experienced with market analytics. Now it doesn't seem to have as many.

Do you believe the predictions are accurate?

- I am not confident in my ability to determine the accuracy of these predictions. However, they make sense within the context of the information given.
- Cannot speak on the data that was gathered. Everything makes sense given that the data is accurate.
- idk
- Probably.
- No, I believe the housing market bubble will crash. Based on the data provided, it may not be able to predict such a future.
- Statistically speaking, yes. Realistically speaking, perhaps not.

Appendix 14

Introduction:

- Introduce the usability test, explain the purpose, and provide necessary background information on the product.
- Explain how the test will be conducted and what is expected from the participant.
- Obtain the participant's consent to record the session (notes or screen recording).

Task 1:

- Provide the participant with a brief overview of the dashboard and the task they need to perform.
- Instruct the participant to select a state and then choose a city to view the prediction graph.
- Observe the participant's actions and note any issues or areas for improvement.
- Ask follow-up questions to gain insights into the participant's thought process.

Task 2:

- Explain the scenario for the second task, where the participant needs to select a specific metro and choose two different data points.
- Provide the necessary information and instructions to complete the task.
- Observe the participant's actions and note any issues or areas for improvement.
- Ask follow-up questions to gain insights into the participant's thought process.

Task 3 (if applicable):

- For experienced users, ask them to choose a city they know well and evaluate the predictions.

- Observe the participant's actions and note any issues or areas for improvement.
- Ask follow-up questions to gain insights into the participant's thought process.

Task 4 (if applicable):

- Ask the participant to investigate a specific term and explain what it means.
- Observe the participant's actions and note any issues or areas for improvement.
- Ask follow-up questions to gain insights into the participant's thought process.
- Bonus: Ask the participant to explain what they think the term means after reading the explanation.

Wrap-up:

- Thank the participant for their time and effort.
- Ask for any concluding thoughts or feedback.
- End the session and review notes to prepare for the next session.

Appendix 15

“Please select the state of Texas and choose a city to view the prediction graph.”

Participant quickly found Houston after checking the dropdown list. They commented on the size of the graph being too small to read easily. I found it weird that the graph did not automatically show up on the side when clicking on the state.

Follow-up questions:

- How did you feel about the dropdown menu? “I thought the dropdown menu was very user-friendly and easy to navigate.”
- Was it easy to find the city you were looking for? “I was able to find the city I was looking for after scrolling for a bit.”
- How did you find the graph size? “The scale seemed off for some data points.”

Task 2:

“Please select the metro of New York City and ask them to view the population growth and average housing price on the graph.”

Participant struggled a bit with finding the metro but managed to find it after checking the dropdown list. They commented that it would be helpful to have a search function for the dropdown.

Follow-up questions:

- Was it easy to find the metro you were looking for? “Kind of, I would have preferred it to be a search function maybe?”
- How did you find the process of finding the population data? “I was able to find it easily as the graph auto generated which was nice.”

Task 3:

“Do you know any cities well enough to evaluate the predictions? If yes, please choose one and evaluate the predictions.”

Participant chose Los Angeles and evaluated the predictions without any issues. Found that it may not be entirely correct as it is not taking into account government policies. However, given the actual data used, it seemed fairly accurate.

Task 4:

Please investigate the term "SARIMA" and explain what it means.

Participant clicked on the "Stats" page and navigated to the section to read the explanation. They were able to explain what the term meant without any issues.

Follow-up questions:

- How did you find the process of investigating the term? "I feel like "stats" is not the right label for it."
- Did you find the explanation helpful? "Yes, it made sense."

Wrap-up:

"Thank you for your time and effort. Do you have any concluding thoughts or feedback you would like to share with us?"

Participants commented that they enjoyed the test and found the dashboard easy to use overall. They suggested adding a search function to the dropdown menus to make finding cities and metros easier.

Appendix 16

Task 1:

"Please select the state of Texas and choose a city to view the prediction graph."

The participant easily found the state of Texas on the map and chose a city from the dropdown menu. Suggested that it would be better if the graph was displayed automatically on the side when selecting a city.

Follow-up questions:

- How did you find the dropdown menu? "I found the dropdown menu to be very straightforward and easy to use."
- Was it easy to find the city you were looking for? "Yes, I was able to find Houston quickly."
- How did you find the size of the graph? "The graph was too small to read easily, and I had to squint to see some of the data points."

Task 2:

"Please select the metro of New York City and ask them to view the population growth and average housing price on the graph."

The participant was able to find the city without issues. They were able to find the data points easily.

Follow-up questions:

- How did you find the process of finding the population data? "Once I selected the metro, the population growth and average housing price graphs appeared automatically, which was nice."

Task 3:

“Do you know any cities well enough to evaluate the predictions? If yes, please choose one and evaluate the predictions.”

They did not feel experienced enough to evaluate it.

Task 4:

Please investigate the term "SARIMA" and explain what it means.

The participant went to the "Stats" page and found the explanation for SARIMA after exploring the “Info” page first. They were able to explain what the term meant.

Follow-up questions:

- How did you find the process of investigating the term? "It was pretty straightforward once I knew where it was located. The actual explanation was easy to find."
- Did you find the explanation helpful? "Yes, it provided a clear and concise explanation of what SARIMA means."

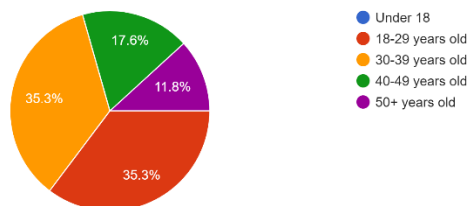
Wrap-up:

“Thank you for your time and effort. Do you have any concluding thoughts or feedback you would like to share with us?”

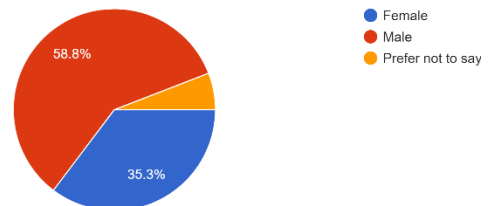
The participant said that they found the test to be engaging and enjoyable overall. They didn't like the design, but the functionality worked out well.

Appendix 17

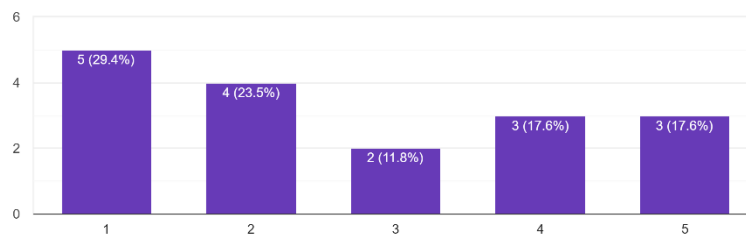
How old are you?
17 responses



What gender are you?
17 responses

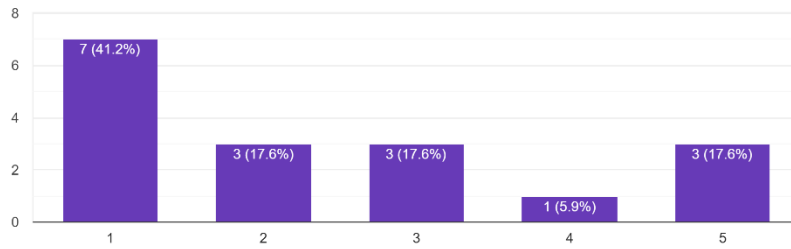


On a scale of 1 to 5, how experienced do you feel participating in the housing market?
17 responses



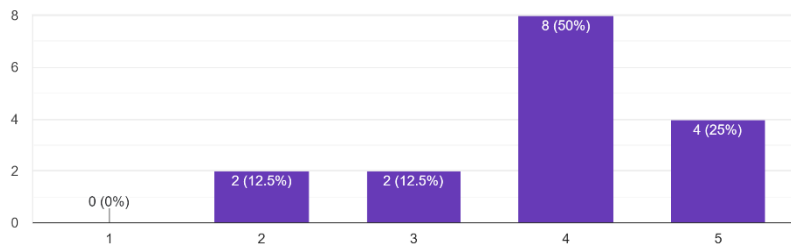
On a scale of 1 to 5, how experienced do you feel reading housing market information?

17 responses



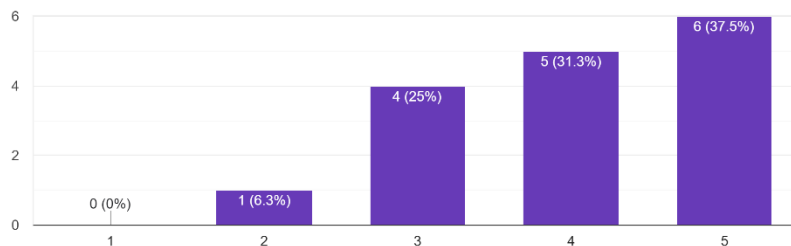
On a scale of 1 to 5, how easy or hard is it to understand the dashboard's interface?

16 responses



On a scale of 1 to 5, how easy or hard is it to use the dashboard's interface?

16 responses



What has your experience been trying to complete these tasks on the dashboard (disregard if non-applicable)?

- I got confused when I had to click on a state first to select a city later. Also, the graph did not show up at the start which was weird.
- I had a mostly smooth experience, but there were a few minor interaction difficulties that made it a bit frustrating. However, these issues were relatively small, and I'm hopeful they can be fixed soon.
- To be honest, I've found using the dashboard to be quite frustrating. I've run into a few technical issues that have impeded my ability to complete the tasks easily. Additionally, the user interface could be more intuitive and user-friendly. There's definitely room for improvement.
- My experience with the dashboard has been pretty smooth so far. I appreciate the simplicity and ease-of-use of the platform and haven't encountered any major roadblocks or issues. Of course,

there's always room for improvement, but overall, I'm quite satisfied with the functionality of the system.

- pretty good, some issues
- As a professional, I have some critiques about the dashboard, but overall, I do think it's a good tool for being free.
- In terms of completing tasks on the dashboard, my experience has been decent. However, I did encounter some issues with the user interface and finding the specific data I needed. I also believe that there should be different key indicators.
- Experience is good. Dashboard easy. Found info quick. No struggles. Not sure how accurate the housing prices but cool to see.
- was weird to use. seemed like an old website design. overall, could be better.

Were there any specific benefits/easy-to-use aspects of the dashboard?

- It showed multiple data points, which was cool.
- I really appreciated being able to see where the data was sourced from and the analysis that went into building the models.
- Unfortunately, I didn't really find any benefits or easy-to-use aspects of the dashboard. I found the user interface to be quite clunky and confusing. Hopefully there are improvements made in the future.
- Absolutely! One of the benefits of the dashboard was its simplicity and ease-of-use. I appreciated that everything was clearly laid out and easy to understand and didn't run into any major issues or roadblocks. Overall, I found the platform to be quite user-friendly.
- pretty straightforward
- One benefit of the dashboard is the general metro information it provides, such as population and employment data. It's also helpful to see the history of average housing prices for a given area.
- Experience is good. Dashboard easy. Found info quick. No struggles. Not sure how accurate the housing prices but cool to see.

Were there any specific struggles with using the dashboard?

- I got confused when I had to click on a state first to select a city later.
- While I did have a bit of trouble getting the prediction graph to start, once I selected a metro it was much easier to understand the pricing data. There were some minor scale issues, but overall, I found the information provided to be quite helpful.
- Absolutely. I had numerous struggles while using the dashboard, specifically confusing user interface elements. It was a bit of a headache trying to navigate through everything as it doesn't seem like it was styled correctly, and it definitely slowed me down.
- Fortunately, I didn't run into any major struggles while using the dashboard. There were a few minor issues here and there, but nothing that impeded my ability to understand the data provided.
- kind of, weird buttons
- On the other hand, I did struggle with the accuracy of the predicted housing prices for 2024. While the data may be reliable for the most part, I found that there were specific factors such as governmental influences that were not taken into account.
- Experience is good. Dashboard easy. Found info quick. No struggles. Not sure how accurate the housing prices but cool to see.

Do you believe the predictions are accurate?

- Probably? I am not sure.
- Absolutely, based on the data that was provided, I feel confident in the assessment.

- Overall, I do believe that the predictions are accurate. Of course, there may be some outliers or inaccuracies here and there, but for the most part I found the data to be quite reliable.
- Yes, I do believe that the predictions are accurate. I found the data to be quite reliable and consistent throughout my use of the dashboard.
- maybe, not experienced with predicting
- Overall, I think the dashboard is a good tool for those looking to gain a general understanding of a given metro area and its housing market. However, for more detailed and accurate information, I would recommend seeking out additional resources and data sources.
- Experience is good. Dashboard easy. Found info quick. No struggles. Not sure how accurate the housing prices but cool to see.