2024

The Affordability of Rent: Forecasting the Rent-to-Income Ratio

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Business Problem

With high mortgage rates and low inventory, those who are looking to buy a home may be discouraged by a seller's market. Potential buyers are looking to rent a home instead until they can purchase their own; however, this comes with its own set of problems. According to CNN, half of renters in the United States have found themselves paying surging rent prices that they can't afford (Bahney, 2024). In the past, budgeting around 30% of your income toward rent has been the standard. (Heiling, 2024). To better prepare future renters, a time series model will be created to estimate the rent-to-income ratio for the next 2 years.

Background

Several datasets were used to calculate the rent-to-income ratio for the United States. The average monthly rent rates from 2015-2024 were collected from a dataset through Zillow that utilizes a weighted index called ZORI (Zillow Observed Rent Index) for single-family home rentals (Housing Data: Rentals, 2024). The cost of living was also considered at the regional level. A key to mapping the states to the four regions was made available on Kaggle (Schacham, 2018). Finally, the median income of households was collected utilizing the American Community Survey from 2015-2024 at the country and region level (American Community Survey, 2023).

Data Preparation

The datasets were inputted into four dataframes: US rent, US income, region rent, and region income. The date was split into another column for the year to assist in combining the rent and income datasets. The income dataset had null values for 2020, 2023, and 2024 that were replaced with the previous year's income increased by 3%. This percentage has been historically an industry average increase to income (Hayes, 2023).

The rent-to-income ratio was calculated by dividing the rent rate by the computed monthly income. Each region was separated into their own dataframes to allow independent trend and seasonality analysis. Data was then filtered to consider records from 2019-2024 with the date, ratio, and optionally region features for model creation.

Methods

The dataset will be evaluated based on seasonal decomposition to separate trend, seasonality, and residuals. The methods being considered for model creation are Holt-Winter forecasting, ARIMAX, and SARIMAX. The ARIMAX and SARIMAX models require variables such as the number of time lags (p), order of the moving-average (q), and seasonal differences (d). A library called pmdarima will perform a grid search of potential values to select order and seasonal order (Smith, 2023). The performance of the selected models will then be assessed with root mean square error (RMSE).

Analysis

Rent and income had an approximately normal distribution when examined. The features were then further compared to understand their relationship and the role that region may play in the rent-to-income ratio. In Figure 1 the income and rent values were filtered to 2021-2023 to evaluate the trend. The South and Midwest region appeared to have the lowest values while the Northeast and West regions were more widely distributed than other regions.

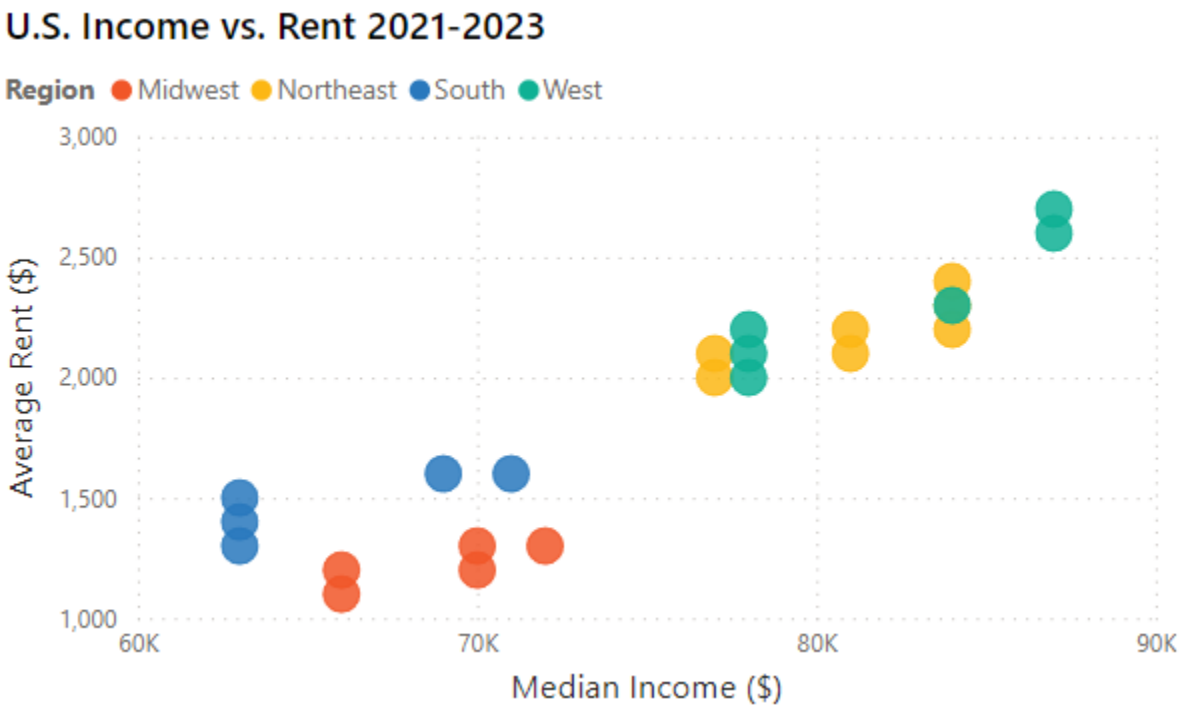


Figure 1: US Median Income vs Average Rent (Single Family Home) 2021-2023

In Figure 2 and 3, the rent-to-income ratio was compared from the country and region level. The variability found in the ratio appears to be related to the northeast and west regions.

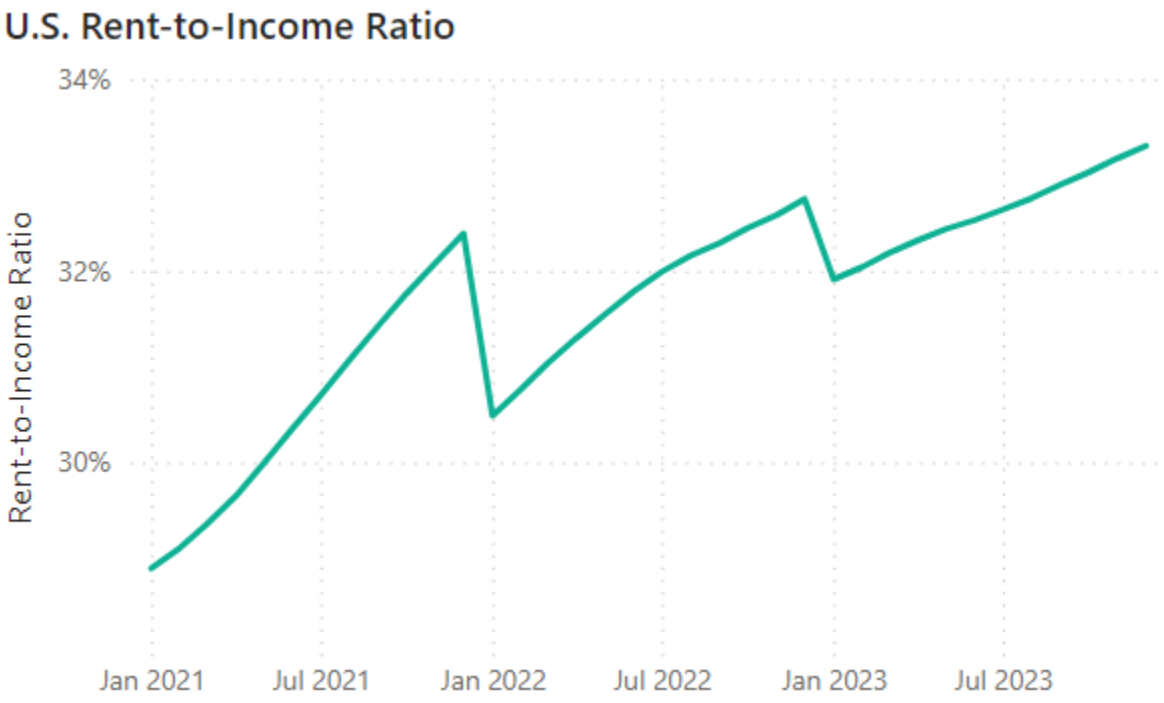


Figure 2: U.S. Rent-to-Income Ratio 2021-2023

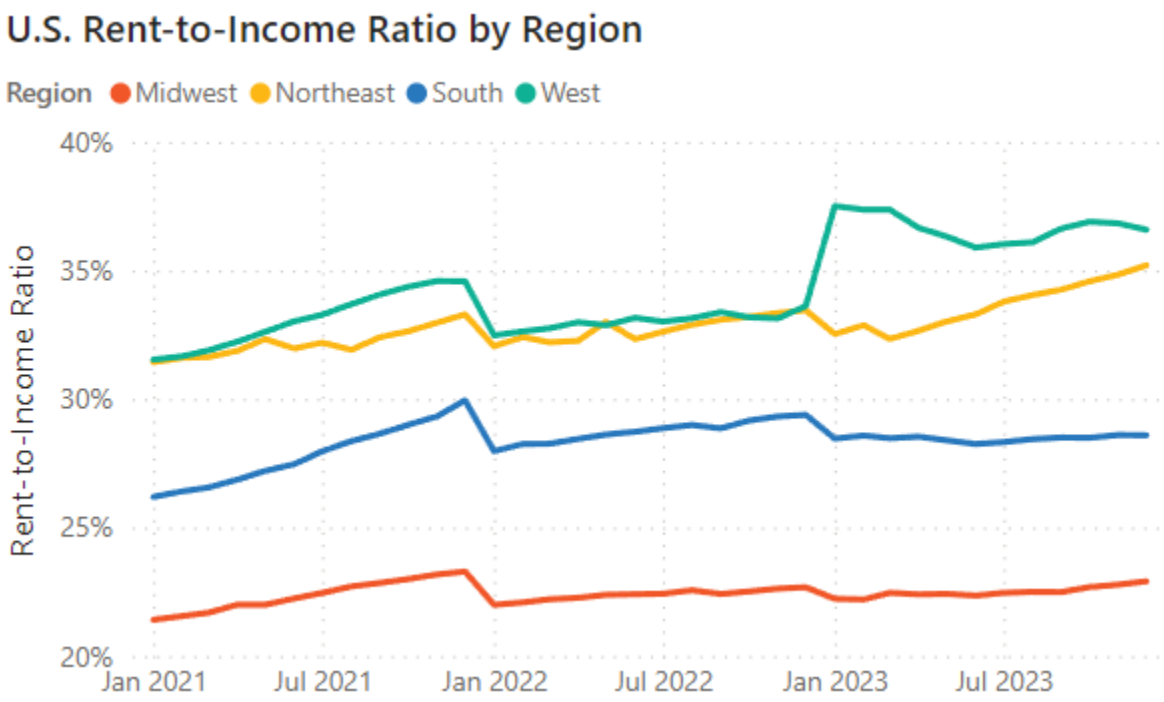


Figure 3: U.S. Rent-to-Income Ratio by Region 2021-2023

Next, the seasonal decomposition was reviewed for the country and region level data. The resulting plot showed seasonality and trends for both views of the data. The dataset was split with the test data starting from September 2023 to February 2024.

The autoarima library provided base values for the order and seasonal order based on the decomposition found within the country and regional view of the data. After reviewing the parameters of each model type, the SARIMAX model provided the best results when evaluating the RMSE. Table 1 provides the RMSE based on the test dataset for each level.

Level	RMSE
Country	0.43%
Midwest	0.38%
Northeast	0.78%
South	0.56%
West	1.5%

Table 1: SARIMAX Model RMSE

Conclusion

The SARIMAX model that was created from the analysis was utilized to predict the rent-to-income ratio level. The resulting model and predictions are listed in Table 2.

Year	Level	Avg Rent-to-Income Ratio
2024	**Country**	29.85%
	Midwest	22.65%
	Northeast	33.69%
	South	27.80%
	West	35.59%
2025	**Country**	30.10%
	Midwest	22.42%
	Northeast	33.91%
	South	27.67%
	West	36.39%

Table 2: Rent-to-Income Ratio: 2 Year Forecast

Based on the forecast, it is estimated that the rent-to-income ratio will continue to slowly increase to 30.1% by December 2025 across the United States. The northeast and west regions continue to see a rent increase higher than the median income. It can be assumed that in those areas the cost of living may rise by the end of 2025.

Figures 4 and 5 show the predictions of rent-to-income for each month from March 2024 – December 2025 for the country as well as the region level.

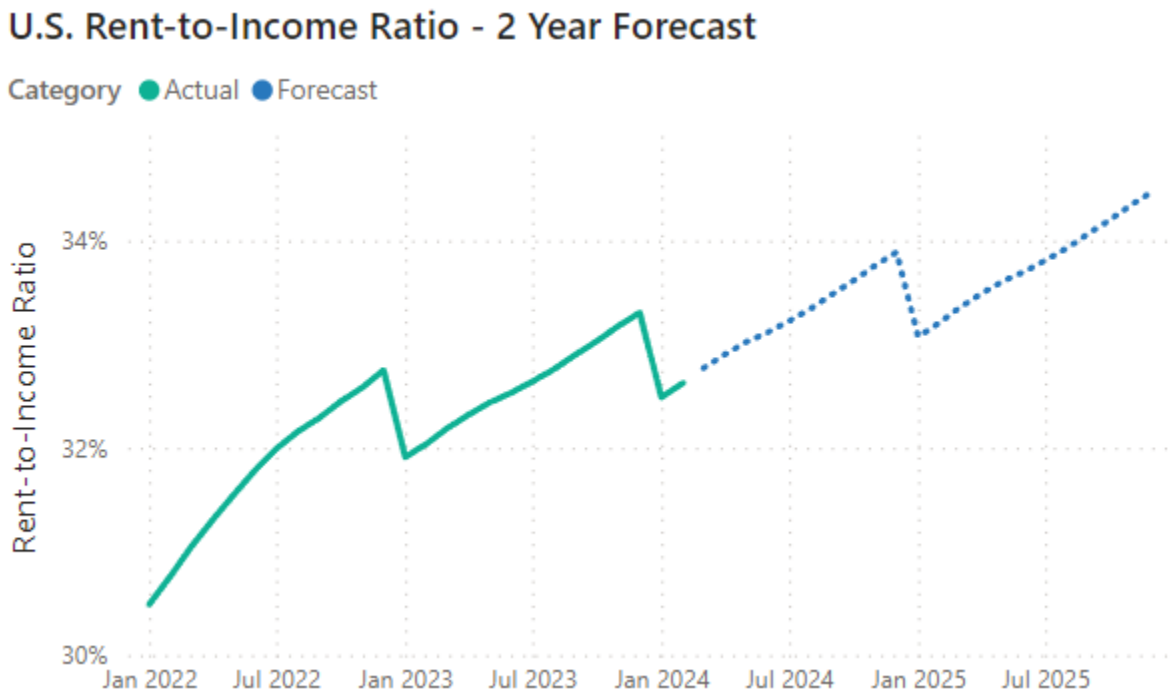


Figure 4: U.S. Rent-to-Income Ratio – 2 Year Forecast

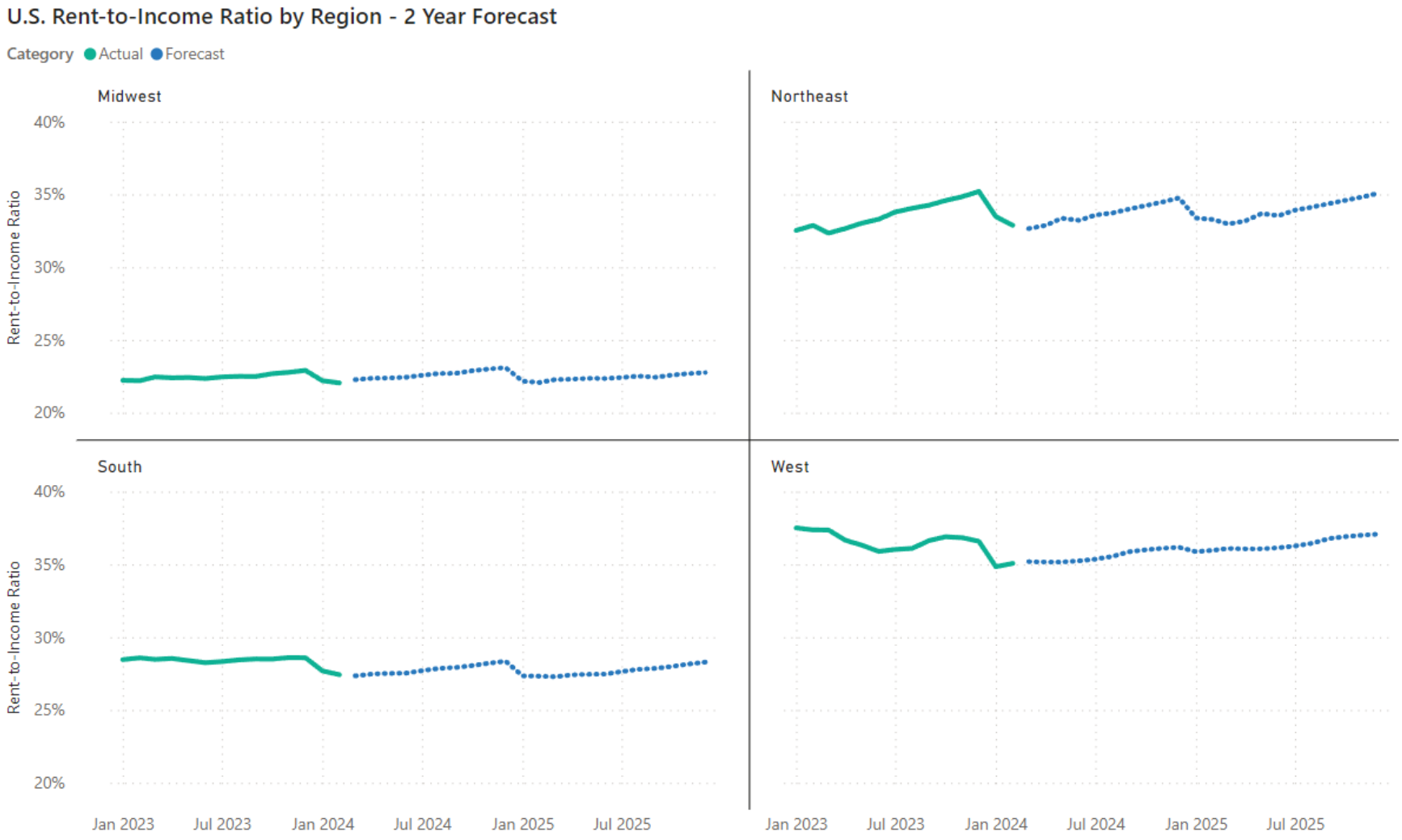


Figure 5: U.S. Rent-to-Income Ratio by Region – 2 Year Forecast

Assumptions

To calculate the rent-to-income ratio, the median income was used to reduce the chance of outliers skewing the income data. Due to the unavailability of data for 2020, 2023, and 2024 from the United States Census Bureau, the median income was assumed to increase by 3%.

Limitations and Challenges

Although the dataset included data from 2015-2018, it wasn't significant due to the income rant changing drastically during and after COVID. One of the challenges with creating the time series model was finding the right order and seasonal order values due to the cost-of-living differences between regions.

Future Applications

The prediction model can be expanded past December 2025 to give current and future renters a base estimate of what to expect if they choose to rent a single-family home.

Recommendations

Once the American Community Survey releases the median income data for 2023, the model should be updated to reflect a more accurate representation of the rent-to-income ratio for the country and subsequent regions. The model should be made available for public consumption and could be useful for new outlets who are reporting on the changes in the renter's market to spread awareness of future rent affordability.

Implementation Plan

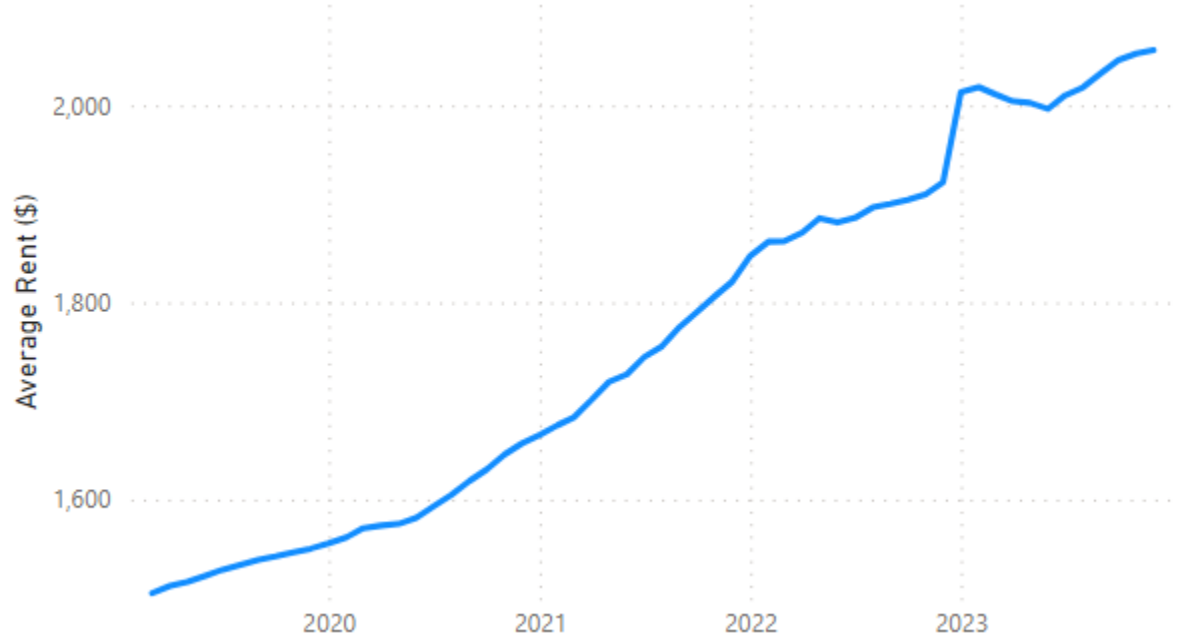
The data preparation, model, and subsequent report will be made available through GitHub as well as Kaggle for research for other members of the data science community. This will give the opportunity for other organizations to review the results as well.

Ethical Assessment

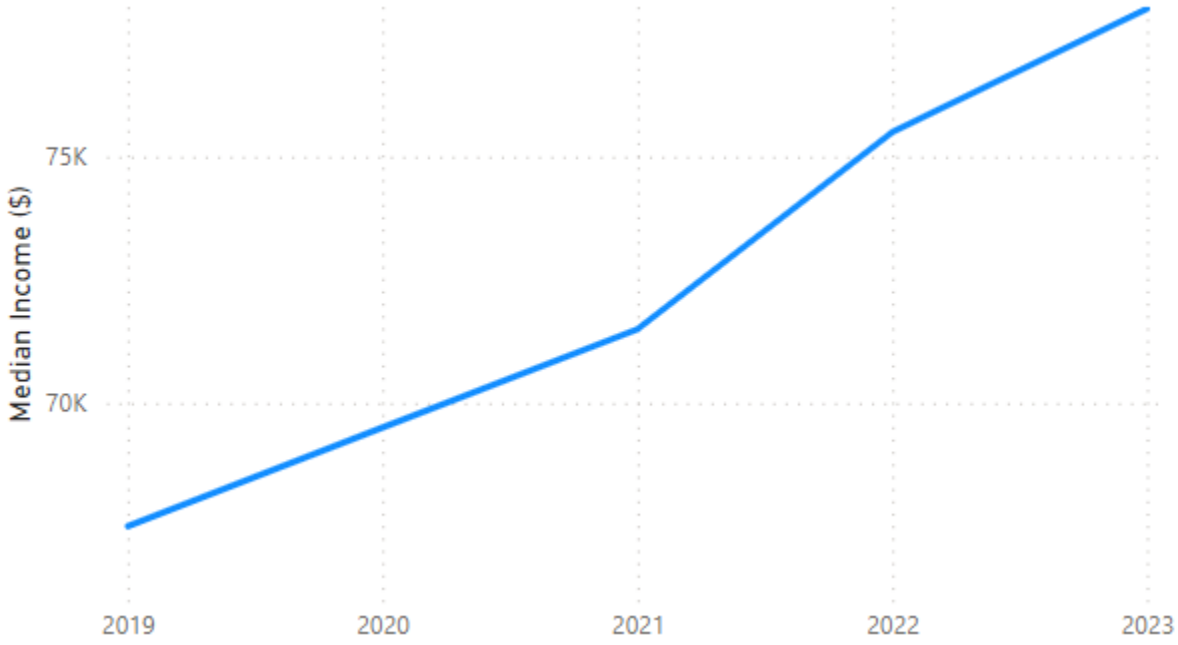
One ethical concern of note is that the datasets utilize the average rent based off Zillow's rental-index utilizing the 40^{th} to 60^{th} percentile range for single-family homes. There are alternatives to Zillow that could potentially contain a more representative sample of the rental market.

Appendix

Appendix A: U.S. Average Rent 2019-2023



Appendix B: U.S. Median Income 2019-2023



Appendix C: Detailed 2-Year Predicted Rent-to-Income Ratios (U.S.)

Year	Month	Avg Rent-to-Income Ratio
2024	March	32.77%
	April	32.90%
	May	33.02%
	June	33.12%
	July	33.22%
	August	33.34%
	September	33.48%
	October	33.62%
	November	33.76%
	December	33.89%
2025	January	33.07%
	February	33.21%
	March	33.35%
	April	33.49%
	May	33.61%
	June	33.70%
	July	33.81%
	August	33.92%
	September	34.07%
	October	34.19%
	November	34.35%
	December	34.47%

Appendix D: Detailed 2-Year Predicted Rent-to-Income Ratios (Region)

Year	Month	Midwest	Northeast	South	West
2024	March	22.27%	32.65%	27.35%	35.19%
	April	22.37%	32.87%	27.47%	35.17%
	May	22.39%	33.37%	27.52%	35.17%
	June	22.44%	33.22%	27.53%	35.25%
	July	22.57%	33.59%	27.70%	35.36%
	August	22.70%	33.72%	27.86%	35.55%
	September	22.71%	33.99%	27.92%	35.87%
	October	22.89%	34.24%	28.05%	36.01%
	November	23.01%	34.48%	28.22%	36.11%
	December	23.10%	34.76%	28.35%	36.18%
2025	January	22.17%	33.38%	27.34%	35.88%
	February	22.08%	33.28%	27.33%	35.97%
	March	22.28%	32.97%	27.29%	36.10%
	April	22.31%	33.18%	27.41%	36.07%
	May	22.37%	33.69%	27.45%	36.07%
	June	22.36%	33.54%	27.47%	36.15%
	July	22.42%	33.93%	27.64%	36.27%
	August	22.52%	34.13%	27.80%	36.45%
	September	22.44%	34.36%	27.86%	36.78%
	October	22.59%	34.60%	27.99%	36.91%
	November	22.70%	34.83%	28.16%	37.01%
	December	22.77%	35.09%	28.29%	37.08%

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