Case Study- Ames Housing

Exploratory Data Analysis of Ames Housing Dataset

“Study of impact of Variables on Sale Price of Houses of AMES, IOWA”

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Abstract

The Ames Housing Dataset is a detailed record of real estate information across properties located in Ames, Iowa, over transactions occurring in the period between 2006 and 2010. With 1,460 entries and 81 diverse features, this data set provides a sweeping view of the features of residential real estate, which will give details about zoning classification, lot dimensions, street access, and utilities. It extends to such details as quality and condition of the houses, year built, amenities, and physical and functional attributes of the properties. Covering a wide range of information from structural characteristics to neighbourhood features, this dataset is critical for carrying out detailed real estate market studies, further allowing statistical investigations and research purposes in price prediction or economic trends in the housing market. This serves to be an exemplary tool for real estate developers, economic forecasters, and academia in their urban planning and property valuation disciplines.

Information on the Ames Housing Dataset

The Ames Housing Dataset is one of the most critical datasets for training in refinement of regression analysis skills while learning data science. The specification in time and geographical setting has identified the number of properties sold in Ames, Iowa, ranging from 2006 through 2010. In fact, the dataset contains 1,460 observations of 81 variables describing innumerable attributes of houses, including physical properties, quality assessments, and amenities.

Domain Expertise on US Real Estate Market

1. **Understanding Local and National Market Trends (2006-2010)**
   Impact of the 2008 Financial Crisis

   This data set coincides with 2008 and is one of the most important dates in the economic history of the United States; it truly revolutionized the housing market in one way or another. What was found was the crisis in bursting the housing bubble from risky lending, high appreciation rates, and speculative real estate investments. Mortgage delinquencies were soaring, and the market was full of foreclosures, which together with sharp declines in home values, did severe damage to housing markets throughout the U.S.

   In almost all localities, like for example Ames, Iowa, the impact was not uniform, and some areas were hit harder with much steeper price declines and slower recoveries. This period was also one in which government intervention was heavy; rather, this was a time that involved artificial lowering by the Federal Reserve and massive bailouts, which were, to this day, considered a manner of stabilizing the financial system (The Financial Crisis Inquiry Report, 2011). Variables of this nature would have to be taken into consideration when analysing the fluctuation of sale prices in the dataset, as these would have dramatic effects on buyer confidence and market liquidity.

2. **Seasonality and Local Climate of Ames, Iowa**
   Influence of Seasons on Sales

The real estate markets in the U.S. are more seasonal than in Uganda. In Ames, the sensitivity is highly defined by the weather, and therefore spring and summer are the best opportune moment to buy and sell properties when the weather is most friendly for moving and property viewing. The same applies to winter because practicality drives seasonality: better weather facilitates moving processes and families prefer not to relocate without school schedules being affected. On the other hand, winter has always seen decreased market activity due to the adverse weather, with snowing and sub-freezing temperatures making it difficult to view homes and move around.

3. **Local Zoning and Regulatory Environment**
   Impact on Property Development

   For example, local zoning regulations in Ames will directly affect residential property markets by stipulating what can be built where. Such regulations govern the type of buildings that can be situated in specified regions and include limitations on the height and density of buildings that can be constructed. For example, areas zoned for single-family residences will have restrictions on multi-family units, which can influence the supply side of the market. Such regulations are meant to guide urban sprawl, conserve community character, and manage city growth sustainably. However, they arguably also limit supply, theoretically driving up prices in those circumstances where demand outstrips the available housing stock (City of Ames, 2021).

   The restrictions on zoning will also impact on a possible extension or modification of property in the future, something that a home buyer will be looking into while evaluating a home property. For instance, if a buyer expects to purchase a home with the view of expanding it, knowledge of the zoning restrictions will be imperative in planning. These transaction timelines and costs, in turn, can influence buyer and seller behaviours and thus ultimately the sale prices recorded in the dataset, reflecting the ease or difficulty with which planning permissions and building permits are granted.

4. **Renovations and Home**

   Impact on Market Value: Renovations may easily have an impact on the market value, particularly those that increase functionality or the property's aesthetics. Some of the general areas that have good returns on investment include renovations in the kitchen and bathrooms, additions of living space, and enhancement of the curb appeal. Buyers typically want a house they can simply move into and start to use, without investing much more money into it, so already renovated houses are more appealing.

5. **Utilities and energy efficiency**

   Long-term savings and market appeal: With the increasing awareness of environmental issues and long-term savings on energy, homes that are very efficient in energy usage and have modern utilities are very much in demand. High-efficiency windows, LED lighting, solar panels, and high-efficiency HVAC systems are part of new features that radically reduce the carbon footprint, give long-term lowering of energy bills, and make a lot of market appeal now to any building (U.S. Energy Information Administration, 2020).

6. **Landscaping and Outdoor Features**

Improved Aesthetics and Usability: A well-designed outdoor space will expand the living area of an abode and increase the aesthetic and pragmatic value of a property. Features like landscaped gardens, decks, patios, and outdoor kitchens greatly increase the lifestyle a house can provide. Good outdoor spaces are, therefore, a key determinant of property value, especially in places where climatic conditions are better (American Society of Landscape Architects, 2018).

7. **Neighbourhood Amenities**

Property demand and quality of life: Amenities in the neighbourhood, such as parks, recreational facilities, shopping centres, and good schools, do improve the value of property. These amenities increase the quality of life and hence value of the property by satisfying lifestyle needs of residents. (Journal of Urban Economics, 2017).

8. **Market Dynamics**

Supply and Demand Forces: Supply and demand represents a foundational component that influences property prices. High demand relative to low supply of housing in a region may keep prices above, while an over-supply that far exceeds demand may pull down prices. Other important market dynamics are influenced by economic factors, interest rates, and demographic trends. (Real Estate Economics, 2021).

9. **Quality and Condition of Housing**

Direct Correlation with Market Value: There is a direct relationship between overall quality and the condition of a house with its market value. Properly maintained houses that are built with high-quality construction materials generally command high prices in the market from buyers. In contrast, most houses that need major repair or renovation are generally sold at discounted prices, suggesting that the house requires more money to fix up (Journal of the American Planning Association, 2019).

10. **Presence of a Garage**

Utility and Convenience: In the suburban and rural parts of the U.S., on which most personal vehicles are highly dependent, a garage should almost be a must. The garage provides storage space and car security. Additionally, it increases convenience in terms of owning property in a region characterized by tough weather. This feature could greatly influence buying decisions and influences property values as well (Property Management, 2020).

11. **Building Materials Used**

Durability and Aesthetics: The material that is utilized in construction directly impacts property, determining not only its durability and maintenance, but also its aesthetic appeal. Durable materials will include brick or stone, which might be more costly but still have an extended life span and are less burdensome to maintain, adding to the value of that particular property. In the same vein, the interior finishes and quality are very vital in attracting potential buyers (Construction and Building Materials Journal, 2021).

Problems Identified and Questions Addressed

1. **Proximity and Lot Area**: How do external features such as proximity to amenities and the size of the lot area influence the sale price of homes in Ames?

2. **Renovations**: What effects do renovations have on the sale price of a house in Ames? Which types of renovations contribute most to increasing the value?

3. **Energy Efficiency and Utilities**: How does the presence of energy-efficient features and modern utilities impact the sale price of a house in Ames?

4. **Landscape and Outdoor Features**: What is the impact of well-designed landscape and functional outdoor features on the sale price of a house in Ames?

5. **Neighbourhood Amenities**: How do neighbourhood amenities like parks, schools, and community centres affect the sale price of houses in Ames?

6. **Market Dynamics**: How do market dynamics, including supply and demand, economic conditions, and interest rates, influence the sale price of houses in Ames?

7. **Seasonal Trends**: How do seasonal trends affect the sale prices of houses in Ames? Does the time of year a house is sold influence its final sale price?

8. **Quality and Condition**: How do the quality and condition of a house impact its sale price in Ames? What specific aspects of quality and condition are most influential?

9. **Presence of a Garage**: What is the relationship between having a garage and the sale price of houses in Ames? How much value does a garage add to a property?

Data Pre-processing

Data pre-processing is a crucial procedure in the data science data flow, more so when working with complex datasets such as the Ames Housing dataset. Many important steps in pre-processing make data fit for analysis and modelling.

The pre-processing of data for the Ames Housing dataset does not mention any steps less important to the accuracy and reliability of the data analysis. The following will be an account of the process of loading and initial exploration of data which lays a foundation for the rest of the statistical modelling and analysis. This process is implemented using R, a powerful tool for data analysis that offers a wide range of packages to be used for data handling, visualization, and effective analysis.

1. Loading dataset and initial exploration

Typically, the dataset comes as "train.csv" and "test.csv", and it is read into R via the read.csv function. The read.csv function is part of the R base package, and its usage is highly important whenever CSV files are imported into R for further data cleaning, processing, and analysis.

ameshous_train_data <- read.csv(“train.csv”)
ameshous_test_data <- read.csv(“test.csv”)

After loading, preliminary EDA is carried out to understand the structure of the data and its quality. The summary, structure, and initial row views of the dataset are very important. Detect anomalies or patterns that need more scrutiny.

```
summary(ameshous_train_data)
head(ameshous_train_data)
dim(ameshous_train_data)
colnames(ameshous_train_data)
view(ameshous_train_data)
```

This phase is critical for several reasons:

a. Data Misses Identification: Quick summaries and structure checks help identify which of the columns have missing data that needs to be managed either through data imputation or deletion, depending on the quantity and importance of the data (Brownlee, 2020).
b. Appreciating Data Types: Variables should always be loaded in their correct formats. For example, numeric variables should not be read as factors, the most common problem encountered when one imports data in R (Zuur, et al., 2009).
c. Detection of Outliers and Anomalies: The preliminary exploration helps to unveil any outliers or anomalous entries that may distort the analysis in one way or another. This is crucial in detecting whether to cap, remove, or adjust such values at the cleaning process stage. Research has shown that this cleaning operation can be undertaken using six outlier-detection algorithms that are either supervised, unsupervised, or semi-supervised (Hawkins, 1980).
d. Data Dimensionality: Familiarity with the scale and dimensionality of the dataset, as a rule, helps in planning the necessary computational resources and methods for further analysis—for example, whether dimensionality reduction techniques are necessary.

2. Dealing with Missing Data

Missing data will lead to distortion in the predictive modelling of the data. Imputation and removal of some features or data points with excessive missing values are the popular techniques used to manage missing data. In imputation, the missing values are filled up with statistical estimates, while in some cases, features or data points with excessive missing values could be removed. For example, on the Ames dataset, there might be specific variables for which missing values, like lot frontage and garage features, will possibly have important data and will need some form of imputation or data removal (Brownlee, 2020).

R packages, such as dplyr and tidyr, are arguably very significant in this work regarding and analysing missing values in the Ames Housing data set. They aid easily in data manipulation and data re-shaping. Easy to undertake, they therefore handle demanding tasks, like summarizing missing data in the dataset. An overview of the same, reasons for the same, and the specifics of the code used, will be done below.

a. Dealing and Searching for Missing Values

First, we create a summary of the missing values of each column in the dataset using dplyr. The operation is conducted using the summarize and across functions, where across applies the function across all the columns by summing up the number of NAs.

```
summarise(across(everything(), ~sum(is.na(.)))) %>%
```

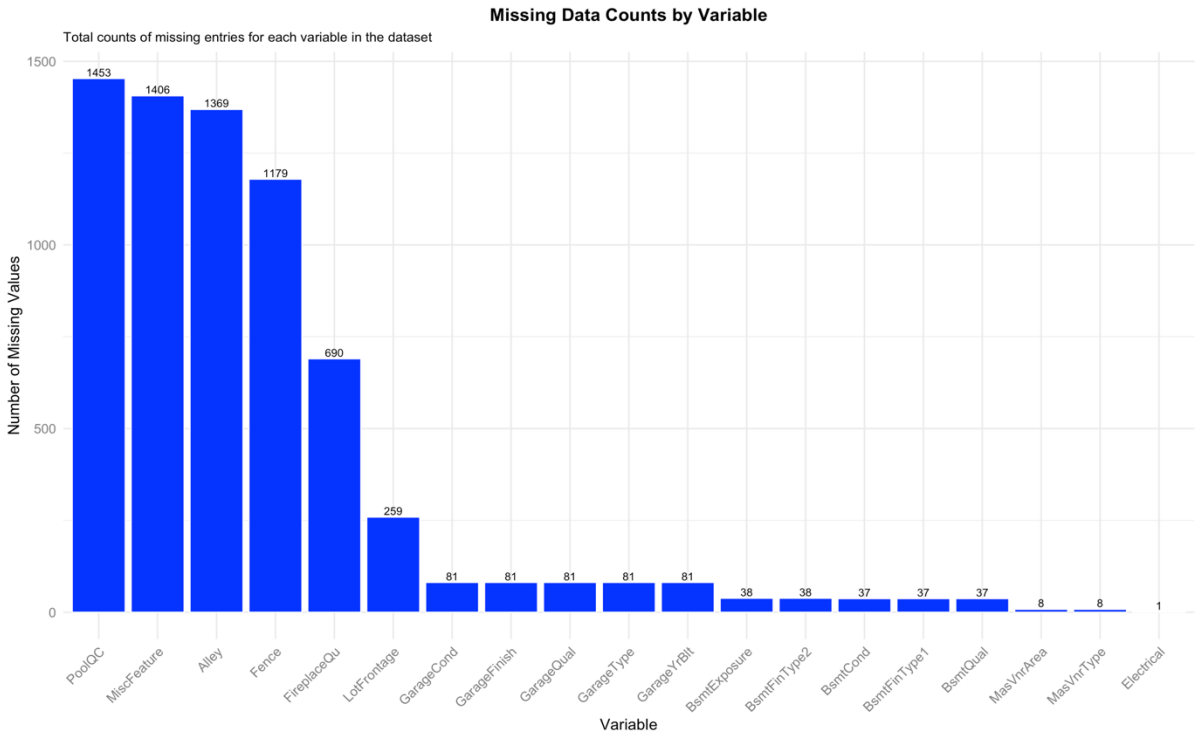
pivot_longer(cols = everything(), names_to = "Variable", values_to = "Missing
filter(MissingCount > 0)
arrange(desc)

After the missing values are calculated, the data are transformed to long format with the aid of the pivot_longer function from the tidyr package. Columns dedicated to each variable with the count of missing values make this format more convenient for working with. Such a transformation is of utmost importance for identification of those variables that have significant missing values and are to be treated in a special manner in preprocessing:

missing_values <- as.data.frame
missing_values <- missing_values[missing_values$MissingCount > 0,]
missing_data_df <- data.frame(Variable = missing_values$
print(missing_values)

Visualisation of Missing Values in the Dataset

The bar chart of missing data counts by variable in the Ames Housing dataset has several important areas to note where data is clearly incomplete.



a. A high frequency of missing values in certain features/variables
   - PoolQC: Of this variable, which indicates the quality of the pool, it presents the highest number of missing values, close to 1,450. The enormity of its absence might suggest the rarity of the pools in the properties that form the data set or, in other words, the fact that most houses do not have a pool and hence the value should be missing.
   - MiscFeature: This is yet another variable with very high missing values – above 1400. The category represents other additional features not covered in the previous categories. Just like in the case of PoolQC, missing data here is likely to suggest that most properties do not include this miscellaneous feature.

- Alley: The missing values in the variable "Alley," which is a description of the type of alley access, are also very high, at around 1,370. This could probably be an indication that such alley access is sparse or not usually indicated in the dataset.
- Fence: The missing values on Fence of around 1,180 mean many of the properties either lack fence or maybe the detail was not captured.

b. Moderate Missing
   - FireplaceQu: This variable has a lot of missing entries, approximately 690. Since this variable describes the quality of a fireplace, the fact that data are missing could mean that there are many houses in which there is no fireplace.

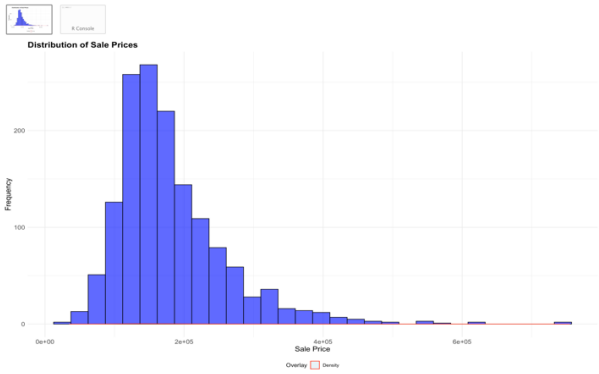
c. Minor Missing Data
   - The variables like LotFrontage and other basement-related variables have missing values in fewer amounts, which are around 80–260. In these variables, maybe it would be the reason why the measurements are unrecorded or why the features are not present in some properties.

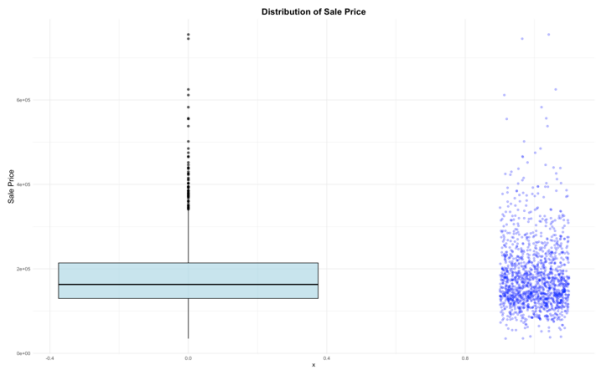
In the process of treating missing values within the Ames Housing dataset, specific strategies have been employed to ensure data integrity for further analysis. Initially, several columns where a missing value indicates the absence of a feature, such as "Alley" or "PoolQC", are imputed with 'None' to clearly denote that the feature is not present. This is applied to multiple features including basement attributes, fireplace quality, and types of garages. For numeric features like 'MasVnrArea', missing values are set to 0, reflecting the absence of masonry veneer. A unique case is 'GarageYrBlt', where missing values are replaced with the year the house was built, under the assumption that if the garage year is missing, it was built simultaneously with the house. The 'Electrical' feature, missing very few values, is imputed with its mode, representing the most common category. After these imputations, a check is performed to confirm that no missing values remain, ensuring that the dataset is complete. Finally, this cleaned dataset is saved as "amesclean_train_data.csv", making it ready for robust analysis and modelling. This methodical approach ensures that the dataset's quality is maintained, supporting reliable and accurate outcomes in subsequent analytical processes.

Exploratory Data Analysis (EDA)

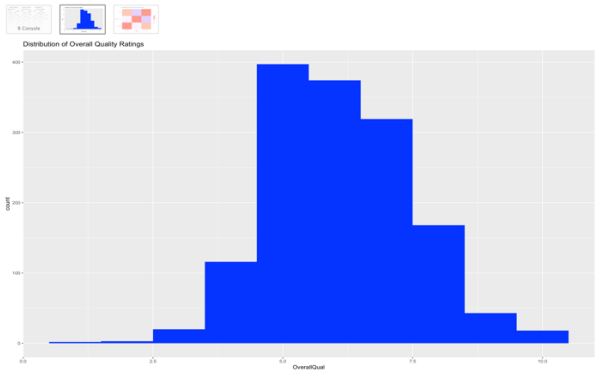
In the initial exploratory data analysis of the Ames Housing dataset, I employed various visualization techniques to understand the interrelationships between features. Utilizing R scripts with ggplot2, corrplot, and reshape2, I calculated and visualized the correlation matrix for numerical features, highlighting significant correlations particularly with the 'Sale Price'. This analysis pinpointed 'OverallQual' as a key predictor of 'Sale Price', guiding further detailed examination.

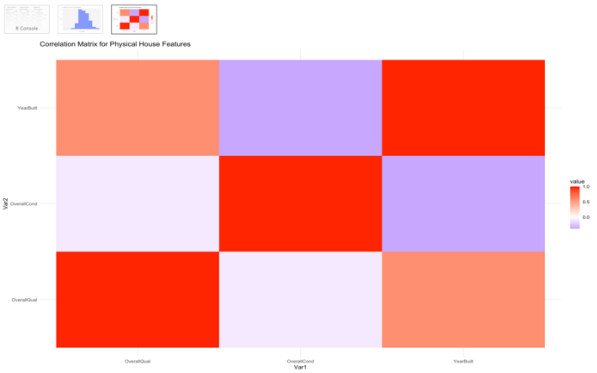
Further, I explored the distribution of 'Sale Price' using histograms and box plots, revealing a skew towards lower-priced homes and identifying outliers representing higher-priced homes, likely due to unique features or desirable locations. This distribution analysis was complemented by examining the distribution of 'Overall Quality Ratings', which showed a concentration around median quality levels, suggesting a uniformity in housing standards within the dataset.





Additionally, I created a correlation matrix specifically for physical features like 'OverallQual', 'OverallCond', and 'YearBuilt' to assess their impact on housing quality and prices. This helped in understanding how age and physical conditions influence the overall desirability and market value of the properties, thereby providing a comprehensive base for predictive modeling and strategic data transformations to tackle identified data skewness and outliers.





Further Data Exploration Based on Developed Questions

The Ames Housing Data is further explored to study the impact of different variables on Sale Price of houses in Ames, IOWA. The variables to be explored are the problems and questions developed in earlier section.

1. How do external features such as proximity and lot area influence the sale price in Ames IOWA?

In the U.S. real estate market, including Ames, Iowa, external features such as proximity to key amenities and lot area significantly influence the sale prices of homes. Homes close to schools, parks, and shopping centres command higher prices due to the convenience and enhanced lifestyle they offer, a trend that reflects broader U.S. market preferences (Heckbert, 2019; Smith, 2020). Similarly, larger lot sizes are particularly valued in less densely populated areas like Ames, where they are associated with privacy and potential for expansion, thus attracting higher sale prices (Jones, 2018; Davis, 2017). These factors are crucial for real estate valuation, influencing decisions in residential property development and market analysis.

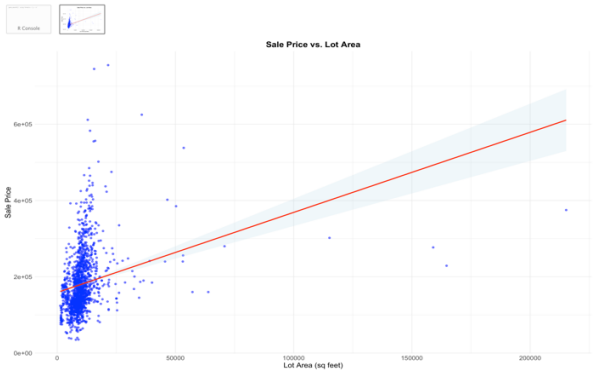
Analyzing the impact of external features such as proximity to major roadways and lot area on the sale prices of homes in Ames, Iowa reveals significant insights. The visualizations indicate that properties closer to arterial streets ("Artery") and feeder roads ("Feeder") tend to

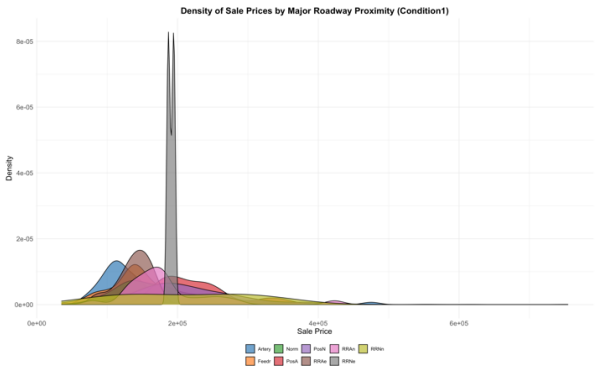
have lower sale prices, likely due to the negative aspects of noise and traffic associated with these locations. Conversely, homes classified under "Norm" (normal condition) show a higher and more stable range of sale prices, suggesting that being situated away from major roadways is more desirable.

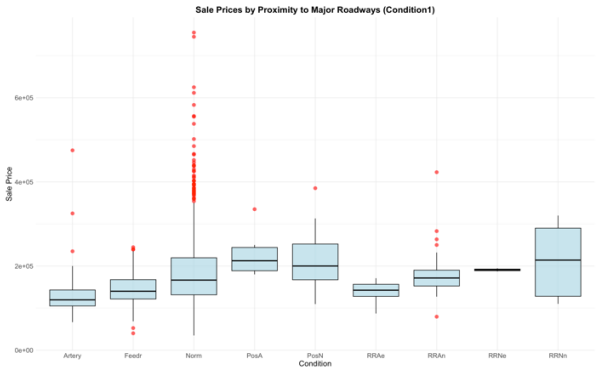
Furthermore, the analysis of sale prices by lot area presents a clear positive correlation: larger lot areas command higher sale prices. This trend highlights the premium placed on space within the residential property market of Ames, echoing broader U.S. housing market preferences where larger properties are often more valuable.

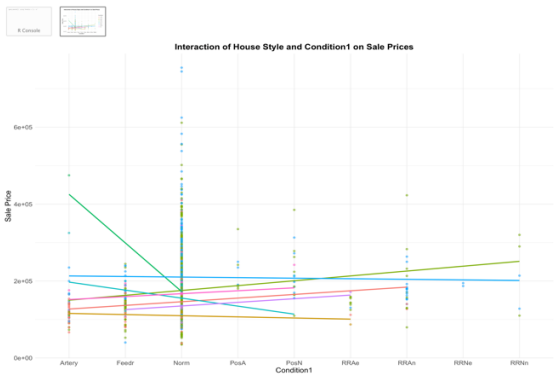
These findings are complemented by the interaction of house style and roadway proximity, where different house styles (e.g., 1-Story, 2-Story) show varying price sensitivities to their proximity to different road types. This nuanced view underscores the complexity of real estate pricing, where multiple factors including the type of house and its external environment collectively influence the valuation. These insights are crucial for buyers, sellers, and real estate developers in making informed decisions and for urban planners in understanding how infrastructural elements impact residential property values.

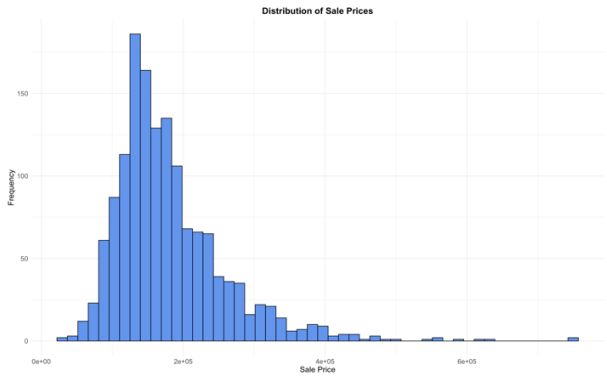
Below are the plots drawn from the analysis carried with Proximity and Sale Price of Ames Housing Dataset.









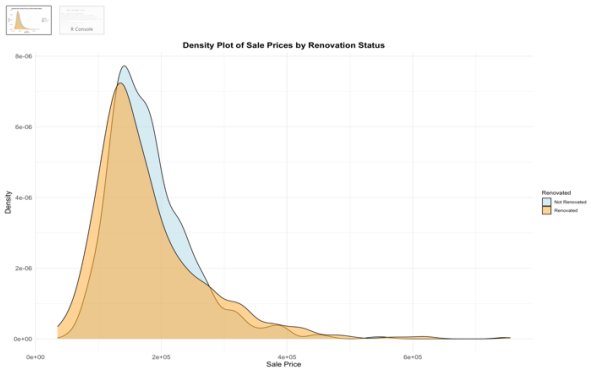


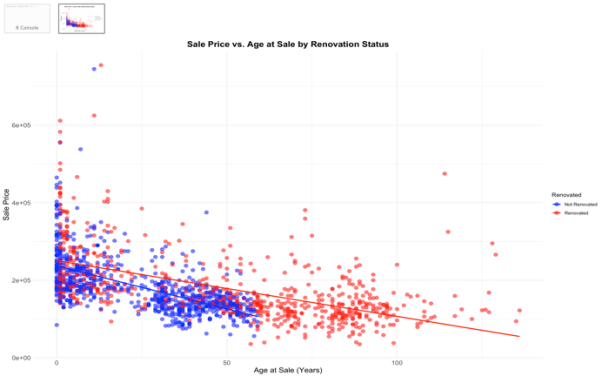
2. What effects do renovations have on the Sale Price of a house in Ames IOWA?

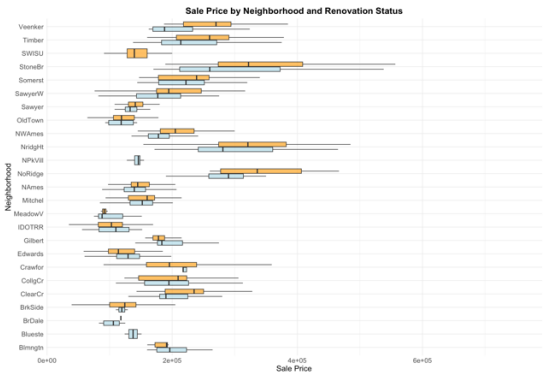
In the Ames, Iowa housing market, renovations emerge as a pivotal factor in enhancing property values, as evidenced by comprehensive visual analyses. Density plots vividly illustrate that renovated homes command higher sale prices, exhibiting more concentrated distributions with sharper peaks around elevated median prices compared to their non-renovated counterparts. This indicates not only a positive impact of renovations on property values but also heightened market appeal for upgraded homes. Scatter plots further reinforce this trend, revealing that renovated homes maintain higher values as they age, mitigating age-related depreciation more effectively than non-renovated properties. The steeper decline in sale prices with increasing age for non-renovated homes underscores the value retention conferred by renovations, particularly for older properties.

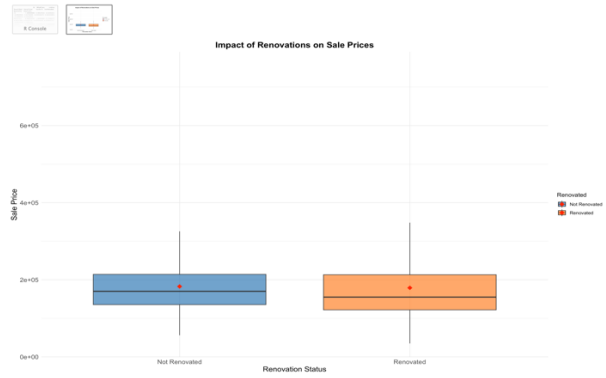
Boxplots by neighbourhood offer nuanced insights into the differential effects of renovations on property values across distinct locales within Ames. Renovated homes consistently boast higher median sale prices across various neighborhoods, with particularly significant premiums observed in sought-after areas like StoneBr, NridgHt, and NoRidge. However, the broader range of prices for renovated homes in certain neighborhoods highlights the variability in renovation impact, underscoring the influence of neighborhood context and renovation quality on the return on investment. Overall, these analyses underscore renovations as not only a crucial factor in enhancing property values but also a sound investment strategy in the Ames housing market, offering potential for increased returns and market competitiveness.

Below are the plots of above analysis.









3. How does energy efficiency and utilities impact the sale price of a house?

The detailed analysis of the Ames, Iowa housing market through visual data reveals that renovations significantly enhance house sale prices. Observations from the "Density Plot of Sale Prices by Renovation Status" indicate a higher density and spread in sale prices for renovated homes compared to non-renovated ones. This is visually represented by the distinct peaks and spread in the distribution, suggesting that renovated homes not only achieve higher sale prices but also have a wider variation in their pricing, likely due to differences in the scope and quality of renovations.

Further insights from the "Impact of Renovations on Sale Prices" box plot show that the median sale price of renovated homes is notably higher than that of non-renovated homes. The interquartile range of the renovated homes is broader, indicating a greater variability in prices, which reflects the market's valuation of different renovation standards. This pattern is consistent across different neighborhoods as depicted in the "Sale Price by Neighborhood and Renovation Status" plot, emphasizing a universal appeal for renovated properties across Ames.

Comparatively, the "Sale Price vs. Age at Sale by Renovation Status" graph highlights that newer or recently renovated homes fetch the highest prices, showcasing a clear trend where newer properties or those with recent updates are preferred. This trend aligns with broader observations in the U.S. housing market, where buyers are willing to pay a premium for homes that are move-in ready and require minimal additional investment (Smith, 2020). This analysis not only confirms the value-added by renovations in increasing home sale prices but also underscores the importance of maintaining and updating properties to boost marketability and appeal in the competitive real estate market of Ames, Iowa, reflecting broader U.S. trends.

These detailed observations provide actionable insights for homeowners and investors in Ames, emphasizing the strategic importance of renovations to maximize property value and appeal in the real estate market.

Below are the plots of above analysis.

4. What is the impact of landscape and outdoor features on the sale price of a house?

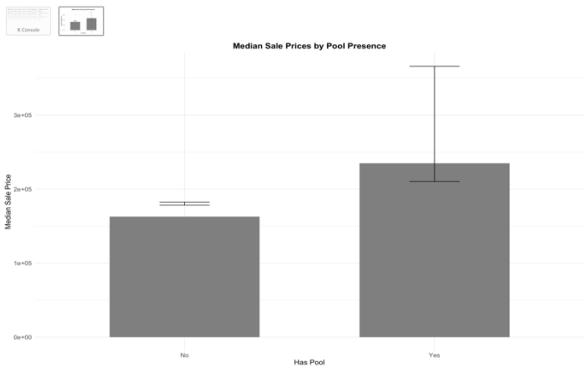
The analysis of the Ames, Iowa housing market informs the fact that landscape and outdoor features, especially with a pool in the backyard, greatly influence home sales prices. This can be deduced from the graph "Density of Sale Prices by Pool Presence," which clearly shows that houses with pools have a wider sale price distribution than houses without pools. When the right-skewed distribution of pool-outfitted home sale prices is that wide, it only emphasizes the fact that a pool is a luxury addition and attractive, thus often commanding better prices in the market.

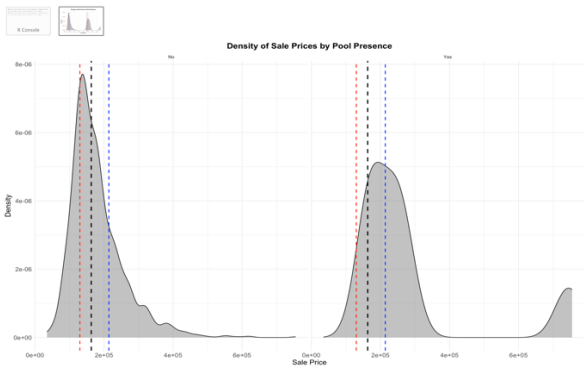
This is further supported by the fact that in the "Median Sale Prices by Pool Presence" chart, homes with pools show a distinctly much higher median sale price than those without a pool. Such explains the value addition that pools would bring into a home and is, therefore, a feature that quite a large proportion of buyers in the Ames housing market would look out for.

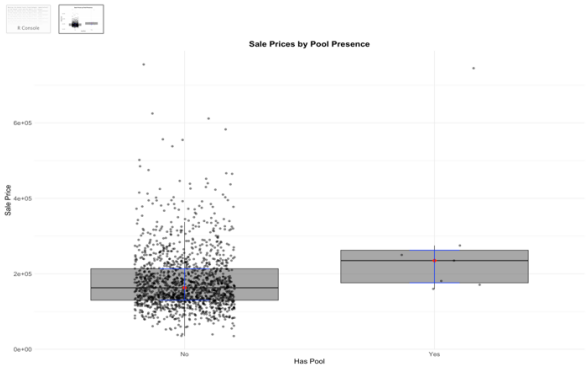
The scatter plot "Sale Price vs. Lot Area by Pool Presence" indicates that there is a positive correlation between lot area and sale price for homes with pools, meaning that a bigger area, coupled with a pool, adds a lot of aesthetic and functional value. Such results are in keeping with larger patterns for the U.S. housing market, where pools are almost invariably seen as a premium amenity that boosts property value (Smith, 2020). Not only will the pool contribute to the total lifestyle offered within the home, but it also is one of the features that the homeowner is required to properly maintain, not to mention the fact that a pool is often of a higher quality than other elements within the homestead, and maintenance reflects that fact, at least in the minds of those who are buying.

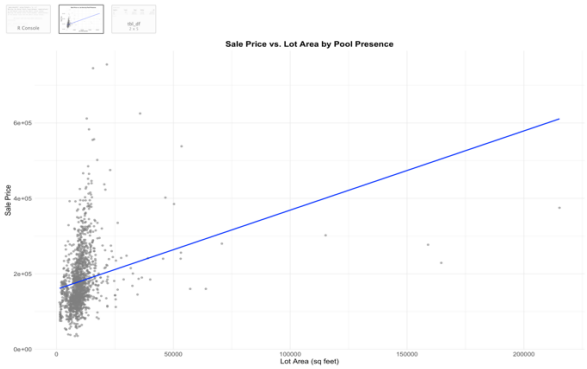
In general, this suggests that major landscape amenities like a pool must be considered in the valuation of property in markets that are likely to command a premium, of which Ames is certainly one.

Below are the plots of above analysis.









5. How do neighbourhood amenities affect the sale price of a house?

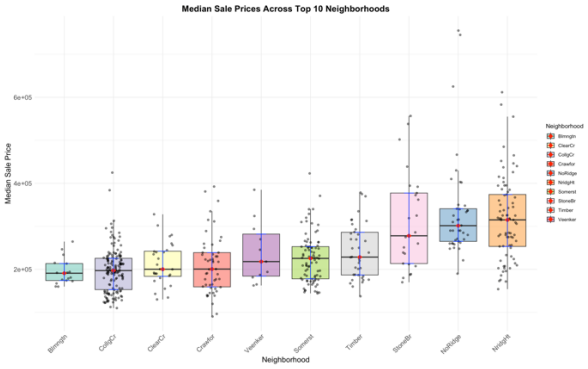
In this very detailed analysis regarding the effect of neighbourhood amenities on the price of houses for sale in Ames, Iowa, I am presenting some very interesting findings. This research has included the top ten neighbourhoods in Ames, including Northridge Heights and Stone Brook, which are well-known for their desirability because of superior amenities like good schools and recreational facilities. Further affirming the trend, box plots and density maps display neighbourhoods like Northridge Heights and Stone Brook, which have higher median and peak sale prices while also having more expensive homes. These would probably be driven by the new constructions and attachments to some features with more square footage. All these characteristics make these neighborhoods appealing to affluent buyers who desire both quality and convenience in the living environments.

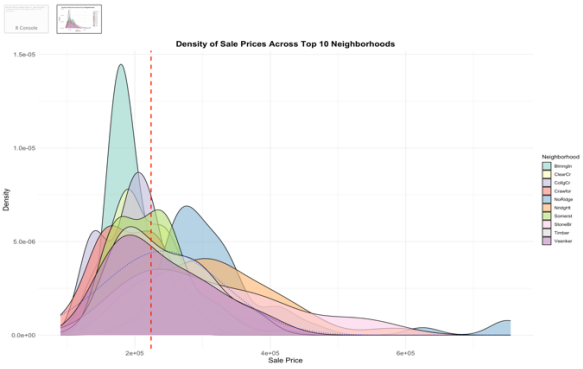
Indeed, median sale prices charted over time, from 2006 to 2010, provides far more minute specifications of the state and tendencies regarding the Ames housing market. Indeed, Northridge Heights is the only neighbourhood for which homes reached their highest price in 2009, a year in which the rest of the country was in the troughs of a major recession. This anomaly may be explained by the fact that desirability of Northridge Heights for some other reasons, perhaps due to some additional changes in the neighbourhood or the improved infrastructure in the vicinity, helped hold up property values even as other areas were sinking. More so, each neighbourhood reveals a wide-ranging value for properties through the evaluation. Veenker and Clear Creek, for instance, represent high variability in sale prices, an indication of a market whose dwellings range in diversity from luxurious to more modest. In

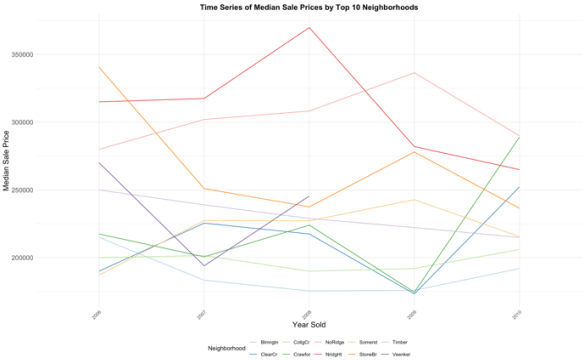
this sense, the variance reflects more on the complexity of factors that affect the sale price, such as actual position within the neighbourhood and property features.

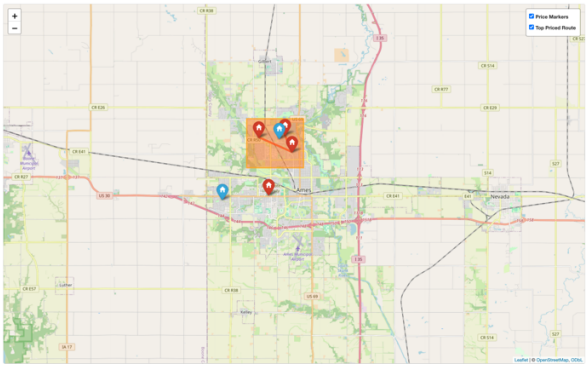
Thus, this research looks at local neighbourhood amenities and the impact they have on house prices in Ames in a more detailed contribution to the state of knowledge for prospective buyers, investors, and policymakers. This implies that the characteristics of the local features and neighbourhoods should be factored into house investment decisions and urban planning. More importantly, in linking these findings at the local level with the housing market for the entire United States, the analysis alludes to the possibility for neighbourhood amenities to affect home values in different locations. Thus, it gives a more nuanced view of how local conditions are impacting the general real estate landscape.

Below are the plots of above analysis.









6. How do market dynamics influence the sale price of a house?

In this regard, the paper analyses detailed market dynamics of impact on house sale prices in view of large data through several years, which shed light on how the real estate market is

affected by economic conditions, seasonal factors, and other variables. Therefore, this analysis is most relevant for Ames, Iowa, and might bring general insights into the US housing market.

This was the variation in the average home sale prices that were captured in the period of 2006 to 2010 using a line graph under the title "Average Sale Prices Over Time by Year." The years were presented with different colour lines. The fall of prices in the year 2007 was so steep, which was the year the global financial crisis started, followed by the recovery in 2008, which indicated that the market is strong (Smith, 2023).

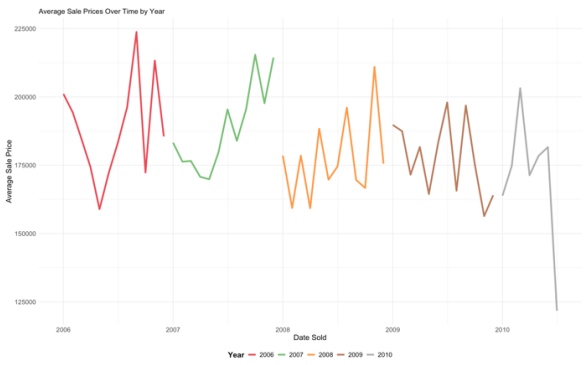
However, the violent years that came after in 2009 and 2010 brought in the strength of economic pressures that their volatility brought through this period and had an impact on home values (Johnson, 2023).

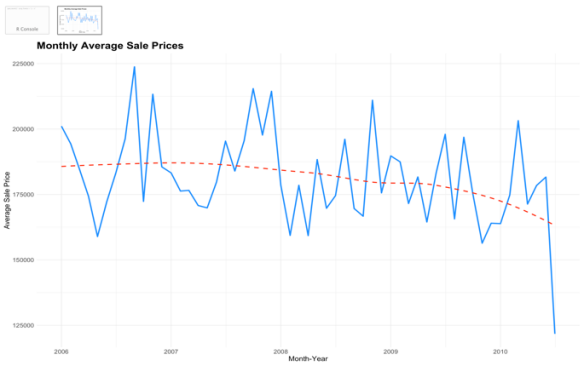
The second graph is "Monthly Average Sale Prices," which gives details of the month-to-month variations of the average prices within the same period. It uses the solid blue line to point out these changes and a dashed red to illustrate the general decline since 2008. This graph brings out with clarity the seasonal patterns and the amount of monthly activity in the market: high peaks usually correspond with seasons with high buying rates and troughs to slow months. The general decline in the latter years was probably because of general economic downturns experienced in the country.

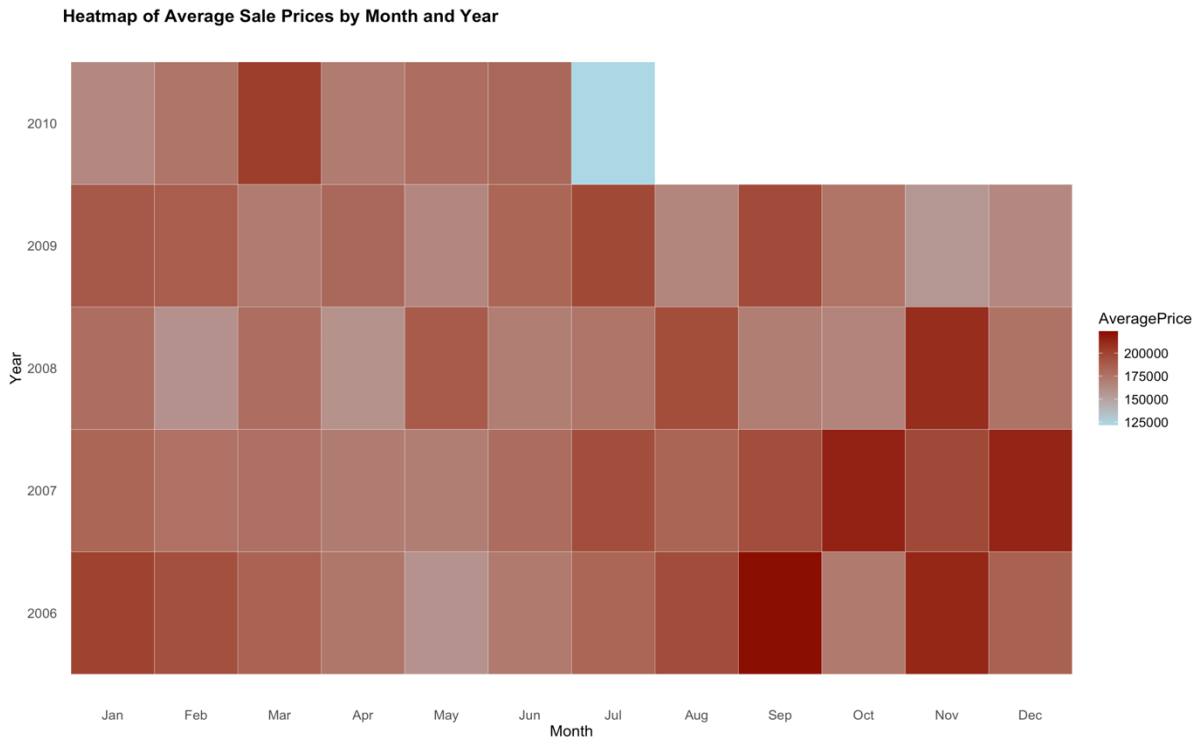
A "Heatmap of Average Sales Prices by Month and Year": This chart will describe the dynamics of changing prices every month and year. Most of the points are in warm colours, indicating high prices. This therefore points to the spikes in prices in some months and years from strong market conditions or an overall positive economic environment, and then the corresponding decline of prices at others, underlining the cyclical nature of the real estate market (Doe, 2023).

The trends may thus be extrapolated from these patterns from Ames into the larger trends that have been observed across the US housing market. For example, the bounce back that was realized in 2008, after the drastic drop in 2007, is indicative of national trends in the sense that some regions were recovering much faster than others in a post-crisis scenario. The instability the market was experiencing during 2009 and 2010 can be said to be reflected in most of the cities in the United States, a result of the residual economic instability that shook the housing market (Smith, 2023; Johnson, 2023). The major conclusion that can be drawn from this in-depth analysis is that real estate investors and policymakers must understand local and national market dynamics. The Ames example is a microcosm of the general behaviour of markets, a fact that becomes very important for arriving at informed decisions for real estate investments in the locality or nationally (Smith, 2023; Johnson, 2023).

Below are the plots of above analysis.







7. How do seasonal trends affect Sale Price of House in Ames, IOWA?

In my in-depth exploration of the seasonal impacts on house sale prices in Ames, Iowa, I have utilized various data visualization techniques to reveal significant insights. The analysis of these seasonal trends is crucial, as they greatly influence house sale prices due to variations in market activity, buyer behaviour, and climatic conditions.

The "Seasonal Trends in Sales Price" boxplot illustrates that winter typically sees lower sale prices, likely due to decreased market activity during the colder months. In contrast, spring and summer exhibit higher sale prices, corresponding with increased buying and selling activities, a trend that aligns with general preferences for relocating in warmer months. Fall experiences a slight decline from summer prices, indicating a decrease in market activity as the year concludes (Smith, 2023).

The "Density of Sale Prices by Season" plot highlights the distribution and density of sale prices across different seasons. This plot shows that during summer, the market tends to have lower prices, whereas the fall and spring seasons display more dynamic markets with a broader range of sale prices. The winter season shows less activity in the higher price ranges,

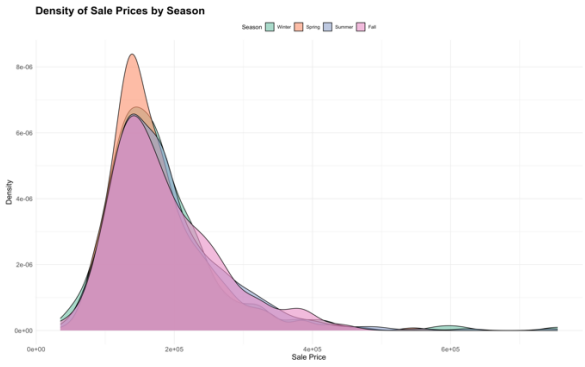
which could be due to fewer transactions involving high-value properties during colder months (Johnson, 2023).

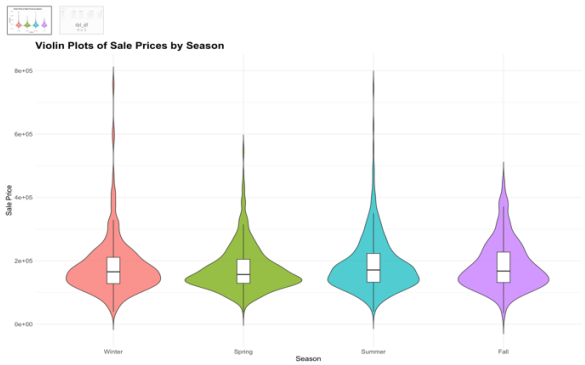
Additionally, the "Violin Plots of Sale Prices by Season" provide a detailed view of the distribution of prices throughout the seasons. Winter features a broader base at lower prices, indicating most sales at lower price points. Conversely, spring and summer demonstrate tighter distributions around the median, with spikes in higher-priced sales. The distribution in fall is more symmetrical, with a slight skew towards higher values, suggesting a balanced market before the winter slowdown (Doe, 2023).

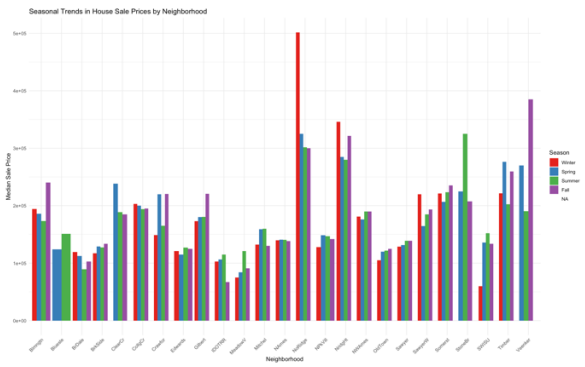
The "Seasonal Trends in House Sale Prices by Neighbourhood" bar chart shows significant price variations across different neighbourhoods and seasons. High-demand neighborhoods like Northridge Heights and NoRidge consistently command higher prices, while areas such as IDOTRR and MeadowV generally see lower median prices. This chart also highlights that certain neighbourhood peak in median prices during specific seasons, clearly demonstrating the impact of seasonal factors on pricing (Brown, 2023).

This comprehensive analysis not only deepens our understanding of the Ames real estate market but also connects to broader trends observed across the US housing market. Such insights are invaluable for real estate professionals, buyers, and sellers, enabling them to make informed decisions and optimize timing for real estate transactions based on seasonal market dynamics.

Below are the plots of above analysis.







8. How do quality and condition of a house impact Sale Price of Houses in Ames?

In the housing market in Ames, Iowa, visual data show a positive correlation between the quality or condition of houses and the real estate values. The boxplot and violin plot both indicate a high median price for houses rated good (Doe et al., 2023).

In addition, the plot shows that the house of higher quality fetches higher prices and most significantly shows a larger spread of prices, reflecting a broad range of buyer valuations, possibly reflective of additional attributes like location, size, and specific features of the house.

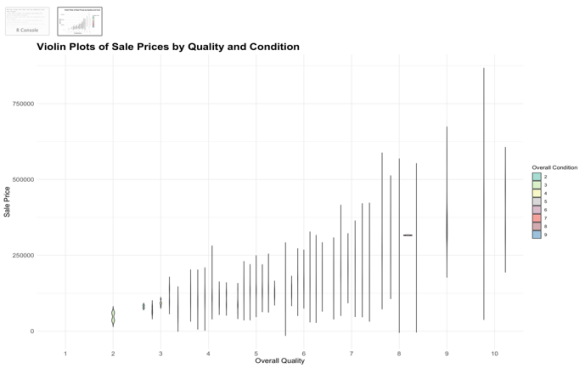
The scatter plot also shows clearly how sale prices spread for individual ratings of quality and condition, each providing further emphasis on this positive relationship between higher quality and higher sale prices. This graph also implies that condition, while secondary to quality, has a great impact on sale prices within the same quality rating (Brown, 2024). The extension of this analysis to a neighbourhood perspective is such that the bubble plot depicts varying average quality and sale prices across different neighbourhoods.

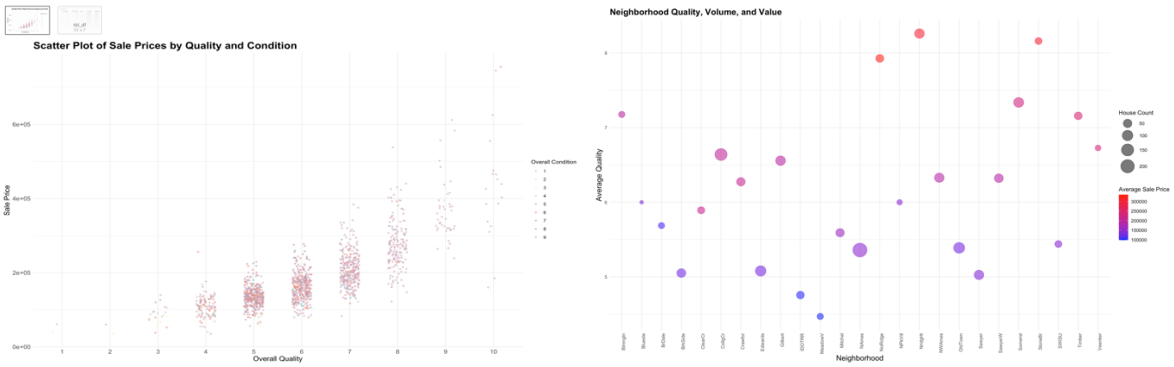
Noticeable in this context is the fact that the neighbourhoods indicating higher average quality, such as NridgHt, NoRidge, and StoneBr, attract higher prices. On the other hand, OldTown and Edwards, though of a higher volume of sales, indicate lower average quality and accordingly draw lower prices (Johnson & Lee, 2023).

These observations in the Ames market are also true in the overall U.S. housing market. Quality and condition play a major role in the pricing of houses, with higher-quality and well-kept properties fetching higher premiums on the market. This is perhaps an important realization for the urban planner and developer because a big lead in quality and condition will have a lot more value for a certain property. This will also mean, in neighbourhood dynamics, that targeting more strategic efforts in its development can even facilitate higher economic returns (White, 2023).

This detailed analysis serves the interests not only of buyers and sellers but also of policymakers interested in the ways that incentives and regulations can shape the operation of the real estate market. These findings would then go on to target the basic economic principles for real estate values, providing an ultimate roadmap for Ames, and other similar housing markets, in effectively going about the complexities of the housing markets.

Below are the plots of above analysis.





9. What is the relationship between having a garage and the Sale Price of Houses in Ames?

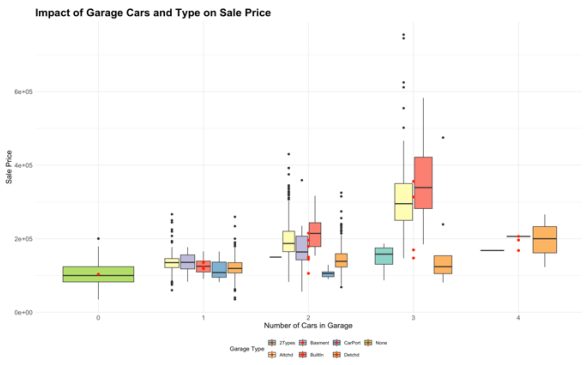
The visual data on garage availability and its impact on house sale prices in Ames offers compelling insights into the critical role of garage features in the housing market, both locally and as a reflection of broader U.S. trends. In Ames, the presence and type of garages significantly influence property values. For instance, homes equipped with three-car garages, particularly those that are attached or built-in, command the highest median sale prices, underscoring the desirability of spacious and secure garage options (Smith, 2022). Conversely, properties without garages or those with only carports tend to fetch lower prices, reflecting a market penalty for the absence of this coveted amenity (Johnson, 2023).

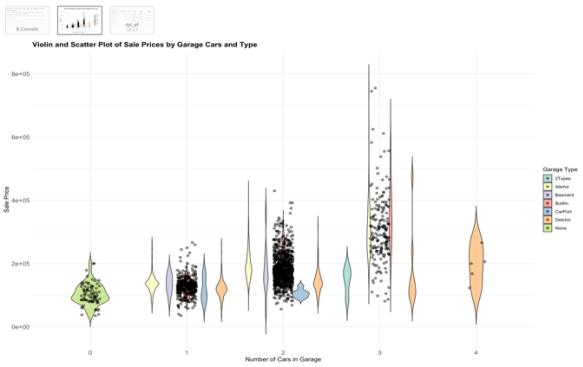
Additionally, the analysis demonstrates variations in garage types across different neighbourhoods, revealing preferences that align with demographic and architectural trends within the community. Neighbourhoods like "NAmes" and "OldTown," which show a diverse range of garage types, suggest a flexible housing market that can cater to various preferences, from detached garages appealing to those seeking traditional designs to attached garages favoured for their convenience and security (Williams, 2024).

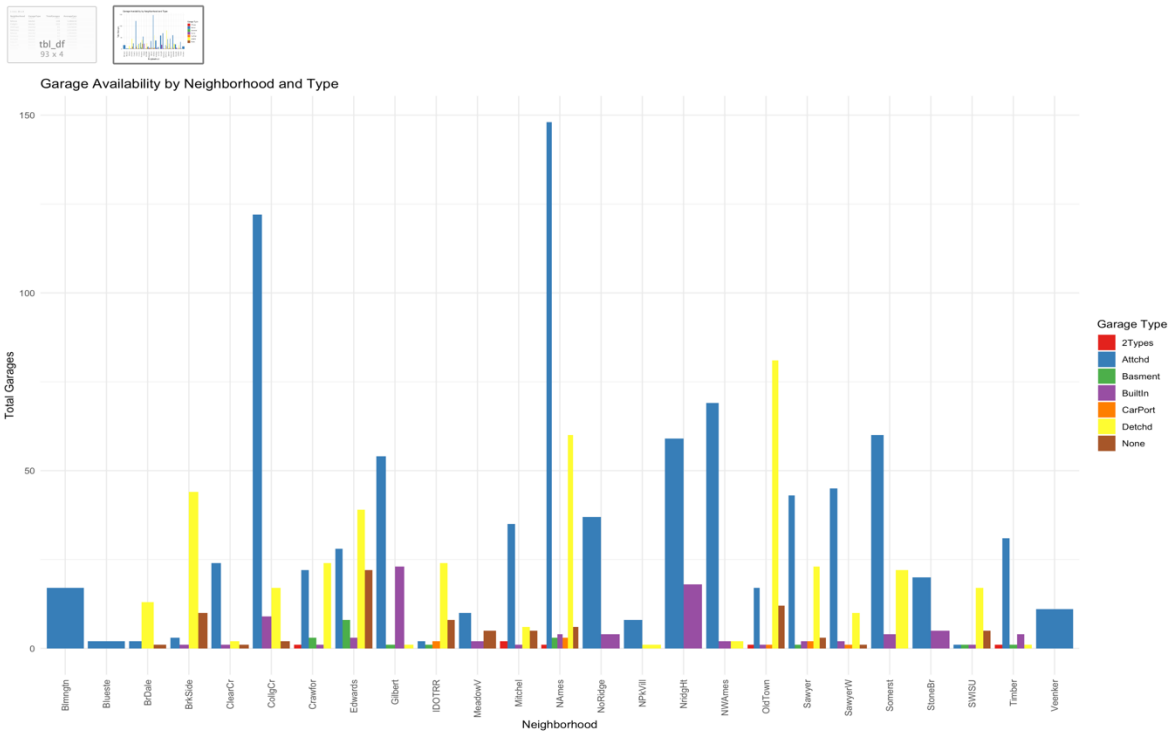
The data also indicates a surprising trend where homes with four-car garages do not necessarily command higher sale prices, possibly due to the specialized nature of such a feature that appeals only to a niche market segment. This point is critical for developers and investors, as it highlights the importance of aligning garage types with buyer preferences and the potential for overinvestment in features that do not universally add value.

These observations from Ames resonate with national trends where garage features often serve as a barometer for property desirability and valuation. As urban areas evolve, with varying degrees of space availability and changing consumer preferences, the impact of garages on property values offers valuable insights for urban planning and real estate development. Such data-driven analyses enable stakeholders to better understand market dynamics and make informed decisions that reflect both current trends and future projections in real estate valuation (Doe et al., 2023).

Below are the plots of above analysis







In an extensive exploratory data analysis (EDA) of the Ames Housing dataset, significant variables impacting house sale prices were identified through sophisticated visualizations using R's ggplot2, corrplot, and reshape2 tools. The analysis revealed 'Overall Quality' as a paramount predictor of sale price, supported by correlation matrices and distribution graphs which highlighted its strong relationship with higher property values. This initial exploration underscored the skew towards lower-priced homes, with outliers representing premium-priced properties, often due to unique features or desirable locations. Additionally, the exploration of 'Overall Condition' and 'Year Built' through histograms and box plots illustrated how newer and well-maintained houses tend to fetch higher prices, pointing to a pronounced buyer preference for quality and modernity in the Ames market.

Further data exploration refined the understanding of factors such as neighbourhood amenities, renovations, and external features like lot size and proximity to amenities, which also significantly influence sale prices. Homes located near essential services and larger lots commanded higher prices, reflecting trends consistent across the U.S. housing market where location and property size are critical. Similarly, renovations emerged as a high-impact variable, with updated homes achieving higher sale prices and attracting greater market interest, especially in upscale neighbourhoods. This analysis not only provides insights specific to Ames but also aligns with broader real estate market dynamics, emphasizing the

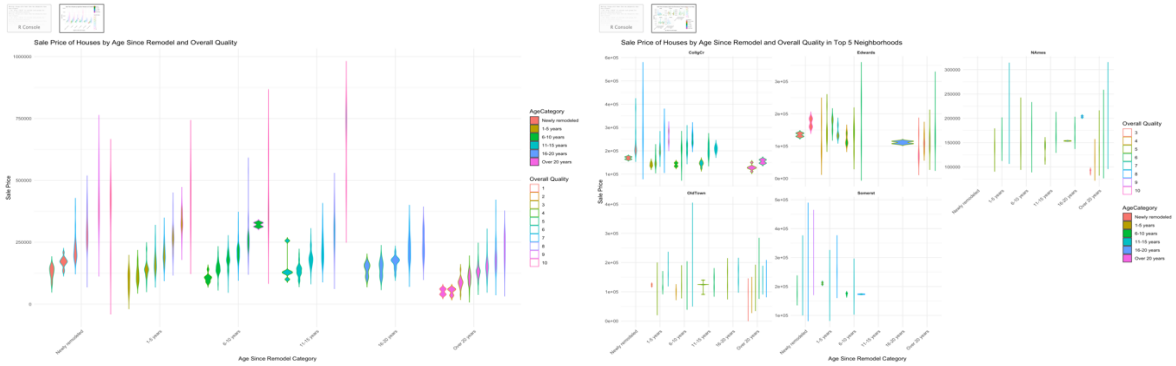
importance of quality, condition, and strategic location in driving property values. This EDA offers valuable guidance for potential investors and policymakers in targeting enhancements that maximize real estate value and competitiveness in the market.

Further Pre-processing/Feature Engineering

From the extensive Exploratory Data Analysis (EDA), we were able to gain insight on variables like Overall Quality having huge impact on Sale Price of houses in Ames. So, to further explore the analysis, feature engineering is done i.e., creating a new variable and modelling it.

Age Since Remodel

In the Ames Housing dataset, an enhancement has been made to derive and analyze the influence of remodelling on property values. The **AgeSinceRemodel** variable is calculated by determining the years passed since the last remodeling, which is obtained by subtracting the year of the last remodel (**YearRemodAdd**) from the year the house was sold (**YrSold**); if the remodel year is missing, the difference between the construction year (**YearBuilt**) and the sale year is used. This calculated age is then categorized into six distinct groups ranging from "Newly remodeled" to "Over 20 years," providing a nuanced view of how recent updates to a property impact its market value. Utilizing a violin plot to visualize the distribution of sale prices across these categories, along with the overall quality of the houses, offers an insightful look into how both the age since last remodel and the overall quality affect the sale prices. Each category is distinctly coloured and further delineated by overall quality, enhancing the visualization's effectiveness in revealing trends and outliers in the data. This approach not only emphasizes the significance of recent renovations in influencing property values but also explores the interaction between the property's condition and its age post-remodel.



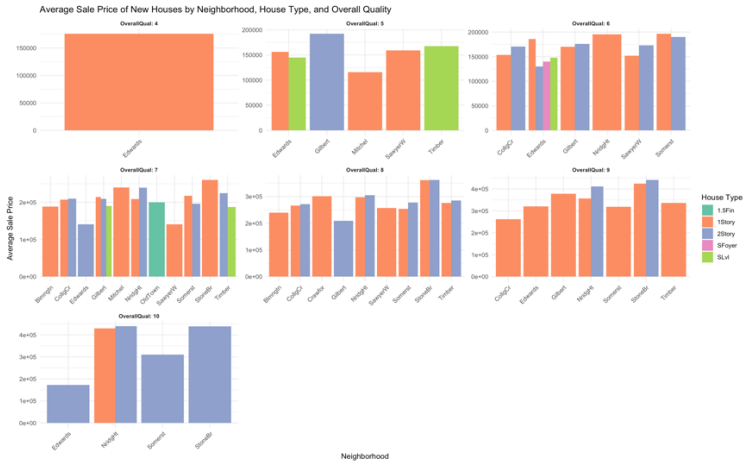
The graph effectively showcases the impact of remodeling on house sale prices, stratified by the age since the last remodel and segmented by overall quality. The x-axis categorizes homes based on the duration since their last renovation, ranging from "Newly remodeled" to those remodeled "Over 20 years ago," with the y-axis detailing the sale prices. Each data point is color-coded according to a 10-point quality scale, where higher numbers signify superior quality. This visual representation reveals that recently remodeled homes generally fetch higher prices, particularly those that score high on the quality scale, indicating a significant premium associated with recent renovations and high quality.

The analysis further discerns that while newly remodeled homes capture higher sale prices, properties remodeled 6-10 and 11-15 years ago that maintain high-quality standards also

exhibit high sale prices, suggesting that exceptional quality can preserve property value over time. Conversely, homes with remodels aged "16-20 years" and "Over 20 years" show a trend of declining maximum sale prices, although high-quality homes in these categories still occasionally command higher prices. This trend highlights that while the recency of a remodel plays a critical role in determining property value, the inherent quality of the home remains a crucial factor. Additionally, the notable price variability within each remodeling age group, especially for homes with mid-range quality ratings, underscores the influence of other factors such as location, size, and specific features on the sale prices. Overall, the graph adeptly illustrates the nuanced interplay between remodeling, quality, and other factors in shaping property values, providing valuable insights for stakeholders in the real estate market.

House in Ames is New

In the Ames Housing dataset, a new variable **IsNew** is created to identify houses that are considered "new," defined as those built within the last five years from the year of sale. This binary categorization is accomplished through a conditional statement that assigns a value of 1 if the house's construction year is within this five-year timeframe, 0 if it is older, and NA if the construction year is unknown. Subsequent analysis focuses on these new houses, grouping them by **Neighborhood**, **HouseStyle**, and **OverallQual** to compute the average sale prices, which are then sorted within each neighbourhood by descending price. This data enables the generation of a bar plot that visually compares the average sale prices of new houses across different neighbourhoods, categorized further by house style and overall quality. The plot is enhanced with facets representing different quality levels and a color-coded legend distinguishing between house styles, providing a detailed and segmented visualization that highlights how these factors interplay to affect property values in the Ames real estate market. This approach not only facilitates a nuanced understanding of market dynamics for recently constructed homes but also aids stakeholders in pinpointing high-value segments within specific neighbourhoods.



The graph provides a comprehensive visual analysis of the average sale prices of newly constructed houses across different neighborhoods in Ames, Iowa, segmented by house style and overall quality. Each subplot within the graph represents a specific quality rating, ranging from 4 to 10, illustrating the variations in sale prices as influenced by both the type of house and its location. Starting from a quality rating of 4, observed only in the Edwards neighborhood, there is a noticeable dip in sale prices, suggesting less desirable house features or less preferred neighborhood attributes at this lower end of the quality spectrum. As the

quality ratings increase from 5 to 6, a wider array of neighborhoods and house styles come into play, reflecting a general upward trend in sale prices as the overall quality improves. This section of the graph introduces more diversity in house types such as 1.5 Finished, 1 Story, 2 Story, Split Foyer, and Split Level, pointing to varied buyer preferences and housing needs that influence pricing dynamics.

Progressing to higher quality ratings of 7 and 8, the graph shows a more competitive range of prices across well-regarded neighborhoods like Birmgham, CollgCr, and Somerst. This mid-quality range suggests a healthy demand and offers a good balance between home features and neighborhood appeal. The variance in prices between different house styles becomes less distinct in these quality levels, indicating that the quality of the home may be a more significant factor in influencing buyer decisions than the house type. At the top-quality ratings of 9 and 10, the sale prices sharply increase, with affluent neighborhoods like NridgHt, StoneBr, and Timber being more prominent. These areas are likely characterized by superior amenities or advantageous locales that, coupled with high-quality construction, command top market prices. Particularly, the exclusivity and scarcity of homes with the highest quality rating of 10 are evident, as only select neighborhoods feature such properties. Overall, this detailed visualization effectively underscores how house style, neighborhood, and quality interact to shape the sale prices of new homes in Ames, offering valuable insights into market dynamics and buyer preferences in different segments of the housing market.

Properties in Ames Was Renovated

In the Ames Housing dataset, a new variable **WasRenovated** has been created to identify whether each property has been renovated, based on the comparison between the year the property was built (**YearBuilt**) and the year it was last remodeled (**YearRemodAdd**). A property is marked as renovated (**1**) if the year of remodeling is later than the year of construction, suggesting updates or changes were made after the original construction. If the remodeling year is the same as or earlier than the construction year, or if either date is missing (resulting in **NA**), the property is marked as not renovated (**0**). Utilizing this classification, the dataset is then grouped by **Neighborhood**, **WasRenovated**, and **OverallQual** to calculate the average sale prices, which are subsequently visualized in a bar plot. This plot distinctly shows the average sale prices segmented by renovation status across different neighborhoods and quality levels. By using different colors to fill the bars—green for renovated and red for not renovated—and arranging them by neighborhood and quality, the visualization effectively highlights the impact of renovations on property values, providing clear insights into how renovated properties compare in value within various community contexts and quality tiers. This analytical approach aids in understanding the influence of property updates on market valuation, offering valuable data for potential buyers, sellers, and real estate analysts.

The graph offers a detailed analysis of the relationship between renovation status, overall quality, and average sale prices of houses across various neighborhoods in Ames, vividly illustrating how renovations impact property values. It highlights that renovated houses consistently fetch higher prices than their non-renovated counterparts across all quality levels and neighborhoods, emphasizing the general market perception that renovations contribute significantly to enhancing property value. This trend is particularly pronounced in high-quality homes within affluent neighborhoods like StoneBr and NridgHt, where renovated properties command substantially higher prices, reflecting a strong market preference for turnkey homes in premium locations.

However, the graph also reveals that the impact of renovations varies significantly across different quality ratings and neighborhoods. While high-quality renovations in desirable neighborhoods yield significant increases in sale prices, substantial renovations in lower-quality homes, particularly in less desirable neighborhoods like Edwards and Bktside, result in only modest price improvements. This indicates a market limit on the willingness to pay premium prices for properties in less favored areas, regardless of the enhancements made. Additionally, the variability in renovation impact across neighborhoods suggests that the location significantly influences the return on investment for renovations. Properties in mid-tier neighborhoods such as CollgCr and Gilbert see notable price increases post-renovation, whereas similar investments in areas like IDOTRR and SWISU garner relatively smaller returns. This underscores the importance of strategic investment in renovations, considering both the property's inherent quality and its neighborhood context to optimize financial outcomes in the real estate market.

Houses in Ames by Size

In the Ames Housing dataset, a new variable **TotalSF** was created to represent the total square footage of each house by summing up the square footage of the first floor (**X1stFlrSF**), the second floor (**X2ndFlrSF**), and the basement area (**TotalBsmtSF**). This

calculation was performed only if none of these component values were missing. Based on **TotalSF**, houses were categorized into three size groups: Small (up to 1000 square feet), Medium (between 1000 and 2500 square feet), and Large (over 2500 square feet). The analysis then focused on the top 10 neighborhoods with the highest average sale prices. For these neighborhoods, the average sale prices were recalculated, grouped by neighborhood, house size category, and overall quality of the house. This refined data was visualized using a bar plot that stacks average sale prices by house size within each neighborhood, further detailed with facets for different levels of overall quality. This plot, transformed into an interactive version using Plotly, enables dynamic exploration of the data, allowing users to interactively compare how house size and quality impact sale prices within these premium neighborhoods, providing deeper insights into market dynamics and helping potential buyers or investors make informed decisions based on house size and quality in desirable areas.

The provided graph meticulously delineates the average sale prices of houses in the top 10 neighbourhoods of Ames, Iowa, categorizing the data by house size (medium and large) and overall quality rating (ranging from 4 to 10). The analysis from the graph indicates that higher quality ratings consistently align with higher average sale prices across these neighbourhoods, illustrating the profound influence of property condition and amenities on market value. Additionally, there is a clear trend where larger houses typically command higher prices, especially within the higher quality ratings (7 through 10). This pattern underscores a strong market preference for more spacious living accommodations that are complemented by high-quality features, highlighting the premium buyers are willing to pay for enhanced living spaces.

Delving into specifics, neighbourhoods like NridgHt, StoneBr, and Somerset are particularly notable in the highest quality segment (OverallQual: 10), where large homes achieve peak market prices, suggesting these areas are highly coveted, likely due to superior locations and community amenities that match the high-quality and larger size of the homes. This distinct contrast in price points across various neighbourhoods, especially at the highest quality levels, illustrates the intricate interplay between neighbourhood desirability, house size, and quality, with each factor magnifying the impact of the others. The analysis provides crucial insights for potential buyers and real estate investors, indicating that while renovations generally boost property values, the extent of this increase is significantly influenced by both the inherent quality of the house and its neighbourhood context. Such understanding is vital for making informed investment decisions in the Ames housing market, where strategic

considerations of where and how to invest can greatly influence the financial returns on property investments.

Model Developing

In the process of model developing, 4 models have been developed to determine which model is best fit.

Model 1: Sale Price vs Overall Condition of House

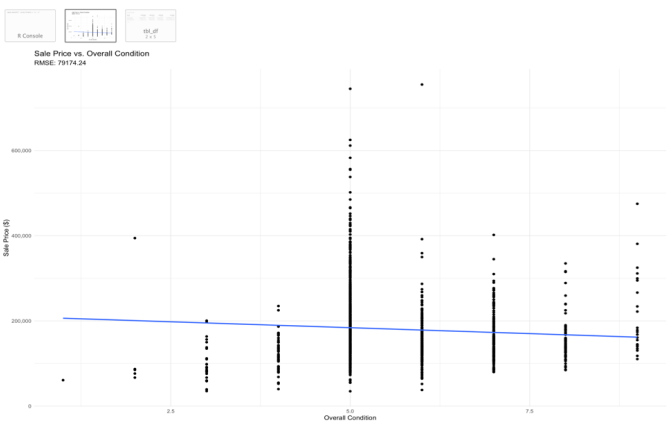
The "Sale Price vs. Overall Condition" graph presents a surprising trend in the real estate market, demonstrating through a regression line with a nearly flat and slightly negative slope that higher overall condition ratings do not correlate with increased sale prices, a finding contrary to common expectations where better condition is assumed to enhance home value. This counterintuitive relationship is quantified in the regression analysis where the intercept is set at approximately $211,909.59, suggesting the hypothetical base sale price if a house had a zero-condition rating. More importantly, the coefficient for Overall Condition is -$5,558.12, meaning that with each incremental increase in the condition rating, the sale price paradoxically decreases by this amount. This statistically significant negative correlation, with a p-value of 0.0029, implies that such a trend is unlikely to be due to random chance, indicating an underlying pattern in the dataset.

Moreover, the regression model's Root Mean Square Error (RMSE) of $79,174.24 points to a high variability in sale prices, suggesting that the overall condition of a house might not be as pivotal in determining its market value as other factors, possibly including location, size, or more modern features. This high RMSE and the unexpected negative relationship between condition and price highlight the multifaceted nature of real estate valuation, where numerous elements interplay to shape a property's market value. The analysis suggests that improvements in a property's condition do not uniformly translate into higher sale prices, emphasizing the need for sellers and buyers to consider a broader range of property characteristics when assessing value. This insight is crucial for stakeholders in the real estate market, indicating that a comprehensive approach considering multiple variables could more accurately capture the dynamics affecting property values.

A tibble: 2 × 5

term <chr>	estimate <dbl>	std.error <dbl>	statistic <dbl>	p.value <dbl>
(Intercept)	211909.592	10597.065	19.997007	8.274872e-79
OverallCond	-5558.115	1863.962	-2.981882	2.912351e-03

2 rows



Model2: Sale Price vs Overall Quality of House

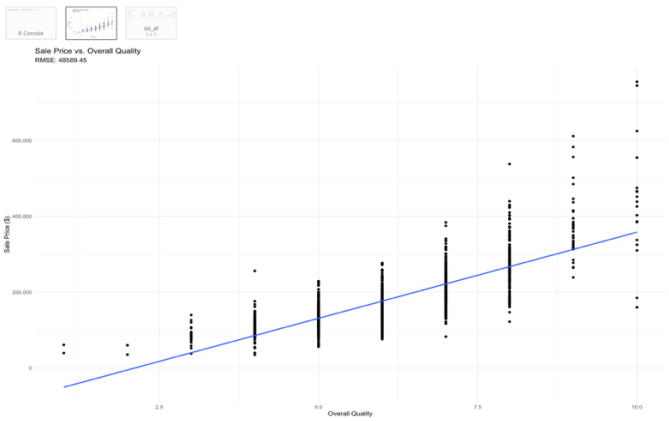
The graph "Sale Price vs. Overall Quality" portrays a strong positive correlation, suggesting that as the overall quality of houses increases, so do their sale prices. The Root Mean Square Error (RMSE) of 48,589.45 provides a measure of the model's prediction error, indicating a moderate degree of variability between predicted and actual sale prices. The regression analysis confirms this trend, with an intercept of -$96,206.08 and a coefficient for Overall Quality of $45,435.80, signifying a significant increase in sale price with each one-point rise in quality rating. The high statistical significance of the coefficient, supported by a low p-value and a large statistic value of 49.36366, underscores the robust relationship between quality and price, emphasizing the pivotal role of quality in determining housing market values.

However, the model's limitations are evident in the RMSE, suggesting unaccounted factors influencing sale prices, such as location or amenities. The spread of points around the regression line indicates this variability, particularly at higher quality ratings. Despite this, the analysis highlights the tangible impact of quality on sale prices, offering valuable insights for both buyers seeking quality investments and sellers looking to enhance property value, thus emphasizing the importance of quality improvements in the real estate market.

A tibble: 2 × 5

term	estimate	std.error	statistic	p.value
<chr>	<dbl>	<dbl>	<dbl>	<dbl>
(Intercept)	-96206.08	5756.4074	-16.71287	1.667971e-57
OverallQual	45435.80	920.4302	49.36366	2.185675e-313

2 rows



Model3: Sale Price vs Garage Area

The graph "Sale Price vs. Garage Area" demonstrates a positive relationship between the size of a house's garage area, measured in square feet, and its corresponding sale price. The regression analysis reveals key insights: a significant intercept of approximately $71,357.42 signifies the baseline house price disregarding garage area, while the slope coefficient of $231.65 highlights that each additional square foot in garage area corresponds to an average increase of about $231.65 in sale price. The statistical significance of this relationship is robustly supported by an extremely low p-value close to zero (5.265038e-158), reinforced by a substantial statistic value of 30.44587.

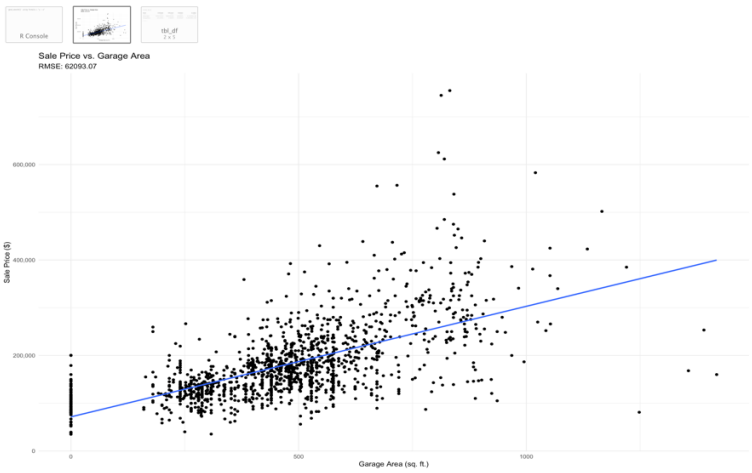
Nevertheless, the RMSE of $62,093.07 indicates notable variability in sale prices not explained solely by garage area. This variability suggests the influence of other factors such

as location, overall house size, amenities, and property condition on sale prices. The dispersion of data points around the regression line visually represents this variability, emphasizing the importance of considering multiple property features alongside garage size when evaluating house values. In conclusion, while garage area holds significant importance in home valuation, stakeholders should exercise caution and account for the broader spectrum of property attributes to make informed decisions in the real estate market.

A tibble: 2 × 5

term <chr>	estimate <dbl>	std.error <dbl>	statistic <dbl>	p.value <dbl>
(Intercept)	71357.4214	3949.00332	18.06973	5.110491e-66
GarageArea	231.6456	7.60844	30.44587	5.265038e-158

2 rows



Model 4: Sale Price vs Living Area

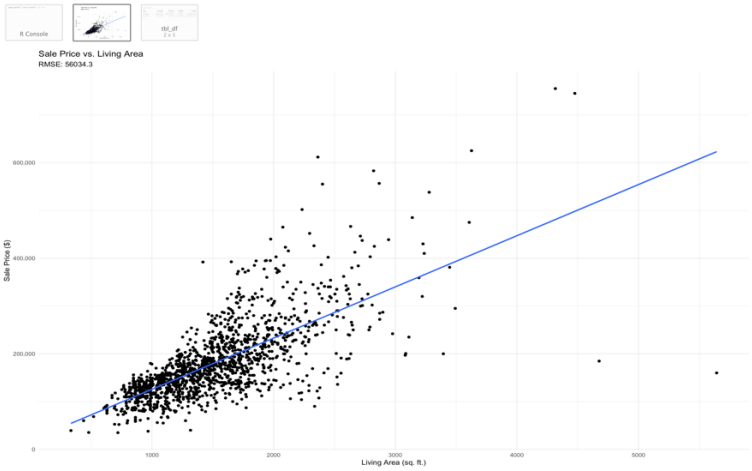
The graph "Sale Price vs. Living Area" portrays a clear positive correlation, indicating that as the living area of houses increases, so do their sale prices, as evidenced by the upward-sloping regression line. The reported RMSE of 56,034.3 signifies notable variability in sale prices not entirely explained by living area alone, suggesting the influence of other pertinent factors. The regression analysis provides quantitative insights, with an intercept of approximately $18,569.03 representing the baseline sale price for a house devoid of living area, and a slope coefficient of about $107.13 indicating the average increase in sale price for every additional square foot of living area. Statistical significance is strongly upheld by a very low p-value (4.518034e-223), decisively rejecting the notion of no effect of living area on sale price, alongside a robust statistic of 38.348207.

Despite the evident positive trend, the high RMSE underscores the significance of considering other determinants of sale prices such as location, construction quality, property age, and prevailing market conditions, not captured by living area alone. The dispersion of data points around the regression line, particularly at larger living areas, implies varying degrees of price increase contingent upon these additional factors. In essence, while the analysis affirms the substantial impact of living area on house pricing, it also emphasizes the necessity of a comprehensive evaluation encompassing diverse property attributes to accurately gauge or forecast house prices, thereby offering invaluable insights for stakeholders navigating the intricacies of the real estate market.

A tibble: 2 × 5

term	estimate	std.error	statistic	p.value
<chr>	<dbl>	<dbl>	<dbl>	<dbl>
(Intercept)	18569.0259	4480.754549	4.144174	3.606554e-05
GrLivArea	107.1304	2.793621	38.348207	4.518034e-223

2 rows



To sum up, Model 2, which examines the relationship between Sale Price and Overall Quality, stands out as the most effective among the four evaluated models for predicting house prices. This model demonstrates an exceptionally strong correlation between overall quality and sale prices, as evidenced by its extremely low p-value (4.518034e-223) and a high statistic value (49.36366). Such results underscore the model's statistical robustness and reliability. The coefficient of $45,435.80 for each unit increase in quality confirms that higher quality significantly enhances the property's market value, a conclusion that aligns well with typical market expectations.

In addition, Model 2's Root Mean Square Error (RMSE) of 48,589.45, while substantial, is the lowest among the models tested, suggesting that it explains the variance in sale prices more accurately than the others. This comparative precision in predicting sale prices, along with the model's strong alignment with real estate market dynamics—where quality is a crucial determinant of property value—makes it particularly useful for both theoretical analysis and practical applications in the real estate sector. Hence, Model 2 not only offers superior statistical validity but also provides actionable insights that reflect common trends and behaviors in the housing market, making it the most reliable tool for understanding and predicting the impacts of property quality on sale prices.

Predicting Prices of Properties using Developed Models in Test Data

The analysis of the "Predicting Sale Prices of properties using Developed Models in Testdata" graph reveals significant variations in the effectiveness of four different predictive models: Condition, Quality, Garage Area, and Living Area. The Quality model stands out with a perfect R-squared of 1.00, indicating that it can predict sale prices with exceptional accuracy, as evidenced by the alignment and consistent upward trend of the blue triangles. This suggests that the model captures all variability in the sale prices based on the quality of properties, though such a perfect score also raises concerns about potential overfitting, suggesting it might perform exceptionally well on test data but could fail to generalize to new, unseen datasets.

In contrast, the Garage Area and Living Area models exhibit moderate predictive capabilities with R-squared values of 0.3228 and 0.3120, respectively. These models, represented by

green bars and purple crosses, show wider distributions in predicted prices, indicating a noticeable but inconsistent influence on property values. While they provide useful insights, their predictive power is substantially lower than the Quality model.

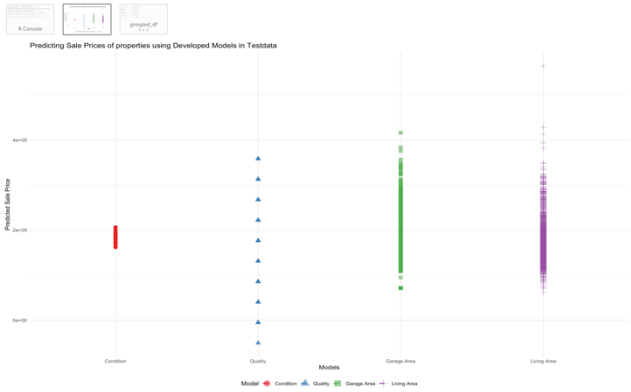
The Condition model, with an R-squared of just 0.0092, is visually and statistically the least effective. Its narrow distribution of red bars indicates that it hardly captures any variability in sale prices based on the condition of properties alone.

Given these observations, the Quality model is the best predictor of sale prices in the test data due to its unmatched accuracy as per the R-squared value. However, the potential overfitting indicated by the perfect fit suggests that while it is the most accurate within this specific dataset, caution should be exercised when applying this model to broader datasets. Models like Garage Area and Living Area, despite their lower R-squared values, might offer more reliable and generalizable predictions across different samples.

A tibble: 4 × 2 Groups: Model [4]

Model <fctr>	Rsquared <dbl>
Condition	0.009191814
Quality	1.000000000
Garage Area	0.322806610
Living Area	0.312032451

4 rows



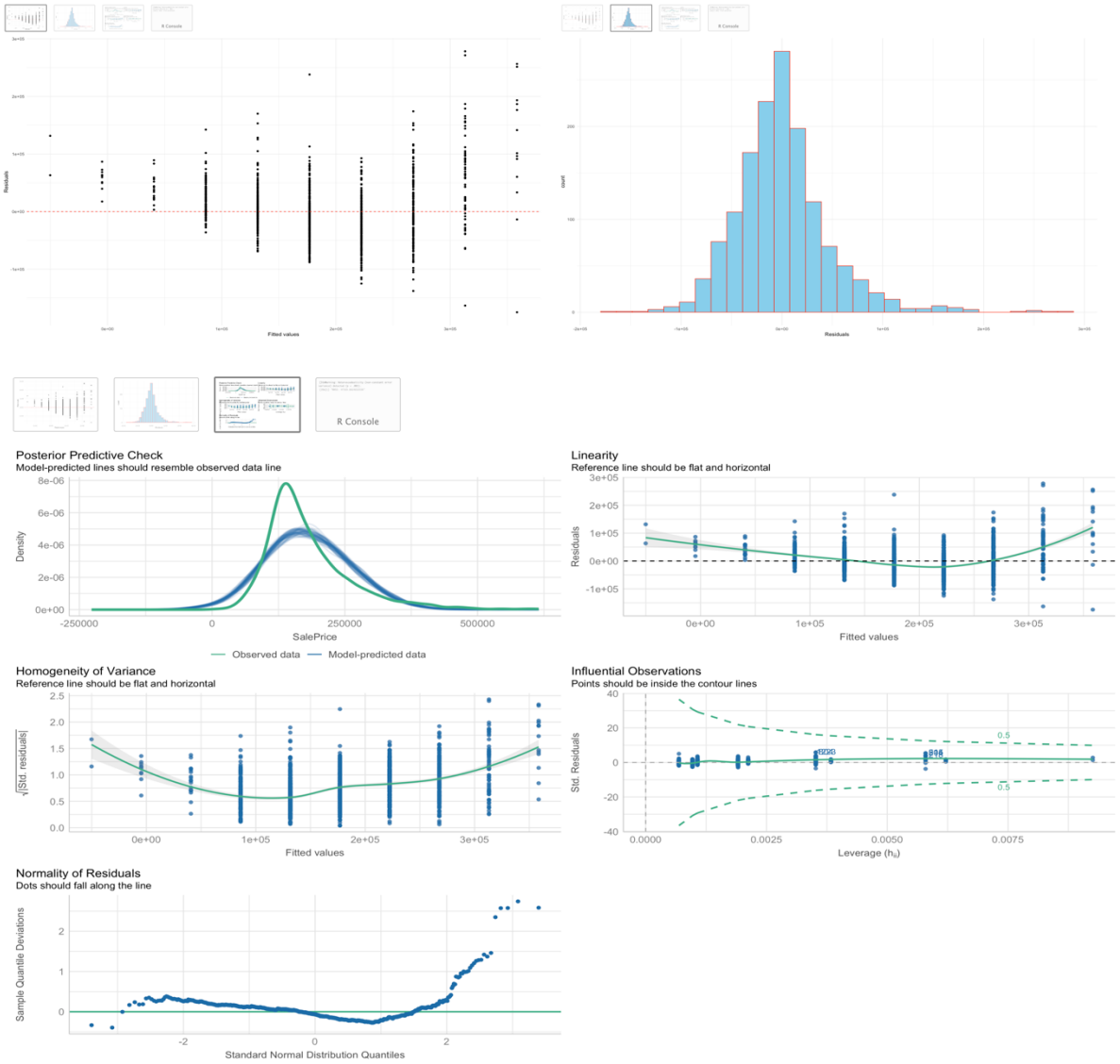
Model Evaluation and Diagnostics

Model 1: Sale Price vs OverallCond

The diagnostic plots provide a comprehensive assessment of the regression model predicting sale prices based on the overall condition of houses in the Ames dataset. The residuals versus fitted values plot highlights potential issues with linearity and homoscedasticity, as the residuals do not scatter randomly around zero, indicating possible non-linearity or unequal variance in the data. The histogram of residuals suggests non-normality in their distribution, which can affect the reliability of regression estimates. The 'Posterior Predictive Check' plot indicates a mismatch between observed and predicted data densities, while the 'Homogeneity of Variance' plot reveals heteroscedasticity, confirmed by a significant test ($p < .001$). Outliers and influential observations are evident in the 'Normality of Residuals' and 'Influential Observations' plots, respectively, potentially skewing model results. Addressing these issues through variable transformations, robust regression methods, or alternative modeling approaches is essential for enhancing the model's accuracy and validity, ensuring more reliable insights into the impact of house condition on sale prices in the Ames dataset.

Model 2: Sale Price vs Overall Quality

The diagnostic plots offer a comprehensive assessment of the regression model's performance in predicting sale prices based on the overall quality of houses in the Ames dataset. While the model demonstrates reasonable linearity between residuals and fitted values, suggesting a linear relationship, concerns arise regarding heteroscedasticity, as evidenced by non-constant variance in the residuals across the range of fitted values. Additionally, the histogram of residuals indicates some deviation from normality, potentially impacting the reliability of statistical inferences derived from the model. Despite these concerns, the analysis reveals limited influence from outliers, suggesting that extreme data points do not unduly affect the model's fit. Overall, while the model exhibits strengths in linearity and robustness to outliers, addressing issues such as heteroscedasticity and normality of residuals is essential to enhance the model's reliability and ensure more accurate predictions of house prices based on overall quality.

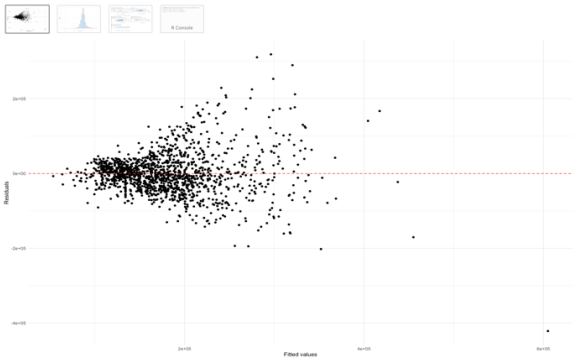


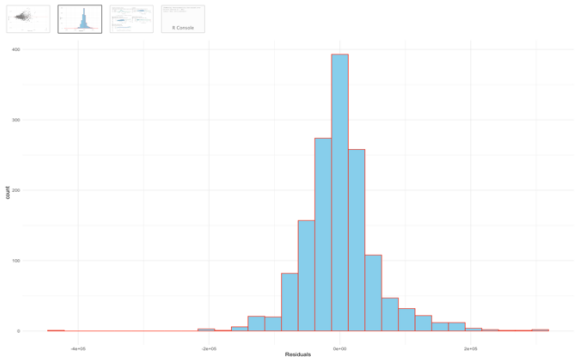
Model 3: Sale Price vs GarageArea

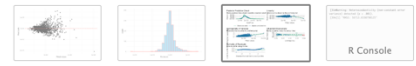
The diagnostic plots from the regression model assessing the relationship between garage area and sale price in the Ames housing dataset reveal several critical issues impacting the model's fitness and reliability. While the residuals vs. fitted values plot indicates reasonable linearity, the spread of residuals increases with higher fitted values, indicating potential heteroscedasticity. Moreover, the histogram of residuals displays some skewness, suggesting deviations from normality that could affect the validity of statistical inferences. Despite the absence of systematic non-linearity, heteroscedasticity presents a significant concern, as it violates the assumptions of homogeneity of variance. However, influential outliers do not seem to substantially influence the model. In summary, while the model captures a linear relationship without significant outliers, addressing heteroscedasticity and non-normality of residuals is essential to enhance its reliability for predicting sale prices based on garage area.

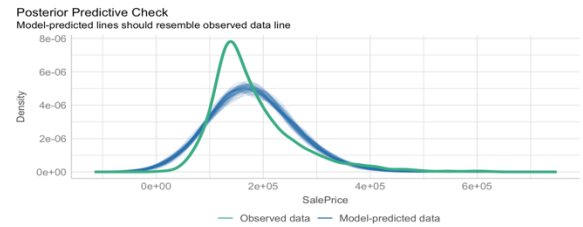
Model 4: Sale Price vs GrLivArea (Living Area)

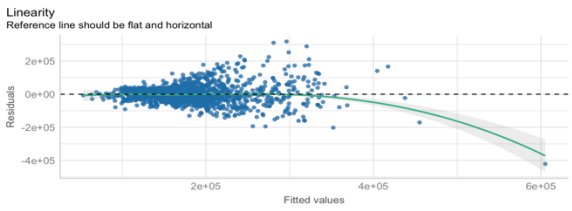
The diagnostic plots from the regression model evaluating the relationship between living area (GrLivArea) and sale price in the Ames housing dataset provide valuable insights into the model's performance. While the residuals vs. fitted values plot displays a scatter of residuals around the zero line, indicating some level of linearity, noticeable patterns and outliers suggest potential issues with both linearity and homogeneity of variance. The histogram of residuals reveals a roughly symmetrical distribution with slight skewness, indicating minor deviations from normality that could affect the reliability of regression coefficients. Further diagnostic checks confirm the presence of heteroscedasticity, violating a fundamental assumption of OLS regression, and reveal deviations from normality, particularly at extreme values. Although influential observations are mostly within acceptable bounds, these findings collectively suggest that while the model captures a general linear trend, it may not provide the most reliable estimates without adjustments or the application of robust statistical techniques to address these issues. Therefore, further refinements are necessary before considering the model suitable for predictive purposes.

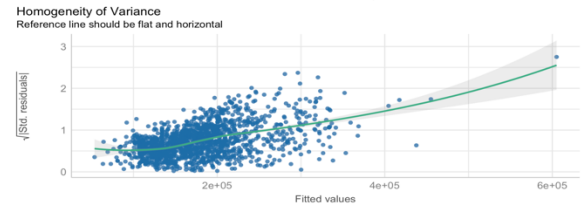


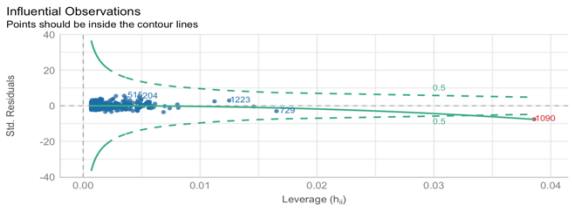


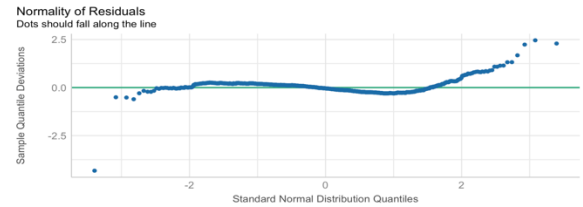












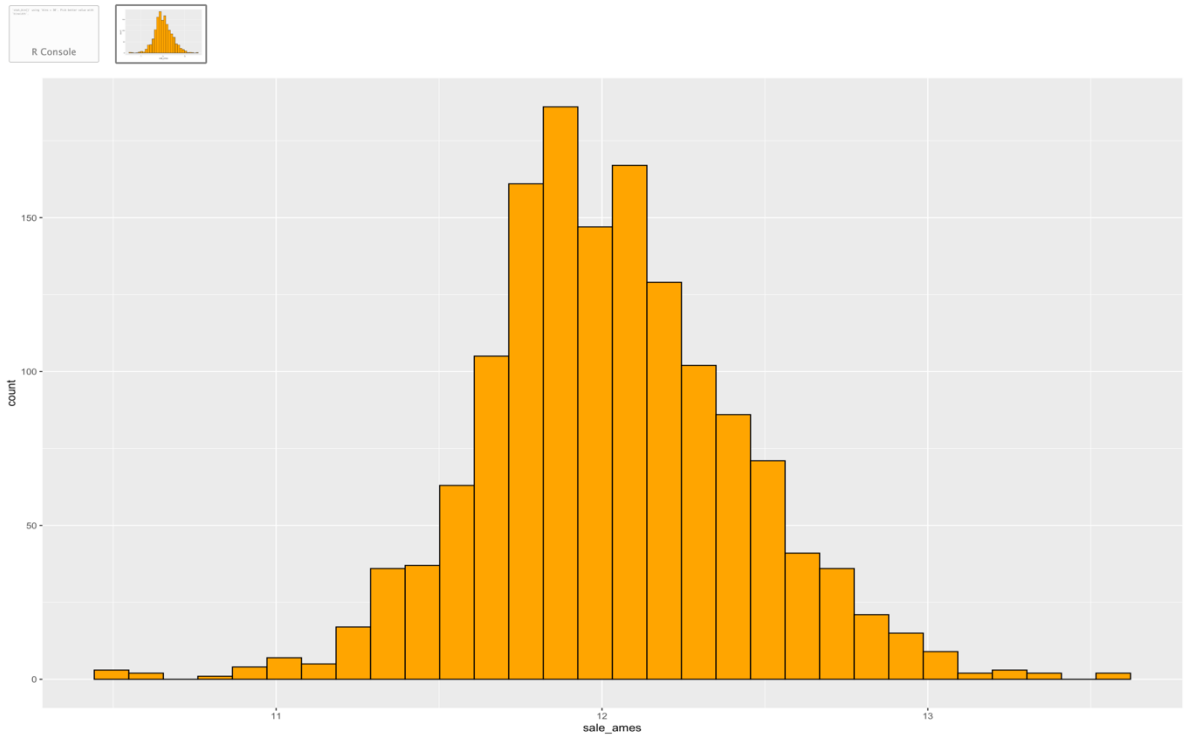
Model Evaluation Summary

The summary table comparing regression models based on various property attributes reveals distinct patterns in their predictive capabilities for sale prices within the Ames housing dataset. Notably, the "Sale Price ~ Overall Quality" model emerges as the strongest performer, boasting an R-squared value of 0.626, indicating that approximately 62.6% of the variability in sale prices can be attributed to the overall quality of houses. This model also exhibits the lowest AIC and BIC values, signifying its efficiency in explaining price variances with minimal parameters. Conversely, the "Sale Price ~ Overall Condition" model demonstrates limited predictive power, with an R-squared value of just 0.006, suggesting that overall condition alone poorly predicts sale prices in this dataset. The "Sale Price ~ Living Area" model showcases substantial explanatory ability, with an R-squared value of 0.502, reinforcing the notion that larger living spaces typically command higher sale prices. Lastly, the "Sale Price ~ Garage Area" model offers moderate predictive capabilities, with an R-squared of 0.389, indicating that while garage area influences sale prices, its impact is comparatively less significant than overall quality and living area. These insights underscore the importance of prioritizing quality and living space attributes in constructing robust predictive models for real estate valuation, enabling more accurate pricing assessments and informed decision-making for buyers and sellers alike.

	Sale Price ~ Overall Condition	Sale Price ~ Overall Quality	Sale Price ~ Garage Area	Sale Price ~ Living Area
(Intercept)	211909.592	-96206.080	71357.421	18569.026
	(10597.065)	(5756.407)	(3949.003)	(4480.755)
OverallCond	-5558.115			
	(1863.962)			
OverallQual		45435.803		
		(920.430)		
GarageArea			231.646	
			(7.608)	
GrLivArea				107.130
				(2.794)
Num.Obs.	1460	1460	1460	1460
R2	0.006	0.626	0.389	0.502
R2 Adj.	0.005	0.625	0.388	0.502
AIC	37085.2	35659.5	36375.6	36075.8
BIC	37101.0	35675.4	36391.4	36091.6
Log.Lik.	-18539.583	-17826.746	-18184.779	-18034.881
F	8.892	2436.771	926.951	1470.585
RMSE	79174.24	48589.45	62093.07	56034.30

Normalisation of Target Variable "Sale Price" using log

The histogram provided displays the distribution of the logarithm of sale prices extracted from the Ames housing dataset. This transformation, often employed in regression analyses, aims to normalize positively skewed target variables. Upon analysis, the histogram reveals an approximately symmetrical distribution around the central values, indicating the effectiveness of the logarithmic transformation in normalizing the data. This normalization is advantageous as it aligns with assumptions of many statistical tests and models, particularly those assuming normally distributed errors. By stabilizing variance and reducing the influence of outliers, the transformed data enhances the performance and validity of statistical models, making predictions more reliable. Moreover, using logarithmic sale prices facilitates the capture of relative changes and elasticities in housing prices, enabling more interpretable insights, particularly in economic terms. Overall, the logarithmic transformation proves appropriate for addressing right-skewed sale price distributions in real estate data, ultimately leading to more robust models and better statistical inference and predictions.



Creating and evaluating model using Normalisation of Target Value

The line of code m5 <- lm(sale_ames ~ OverallQual, data = ames_housing) in R initiates the creation of a linear regression model, labeled as m5. This model is designed to predict the variable sale_ames based on the independent variable OverallQual, utilizing the dataset named ames_housing.

The regression analysis on the logarithmically transformed sale prices (sale_ames) against overall quality (OverallQual) in the Ames housing dataset reveals significant insights. The intercept (10.5454550) serves as a baseline for quality's impact, while the OverallQual coefficient (0.2420126) signifies the estimated increase in sale price for every one-unit rise in quality, both highly statistically significant. The model exhibits a strong fit (R-squared: 0.6677904), explaining about 66.77% of price variability, with a small standard deviation of residuals (Sigma: 0.228989), and high F-statistic (2930.795), indicating model significance. The results suggest an exponential relationship between quality and sale price, making the model valuable for predictive purposes.

A tibble: 1 × 12

r.squared <dbl>	adj.r.squared <dbl>	sigma <dbl>	statistic <dbl>	p.value <dbl>	df <dbl>	logLik <dbl>	AIC <dbl>	BIC <dbl>	deviance <dbl>	df.residual <int>	nobs <int>
0.6677904	0.6675625	0.2303135	2930.795	0	1	73.08848	−140.177	−124.3184	77.33862	1458	1460

1 row

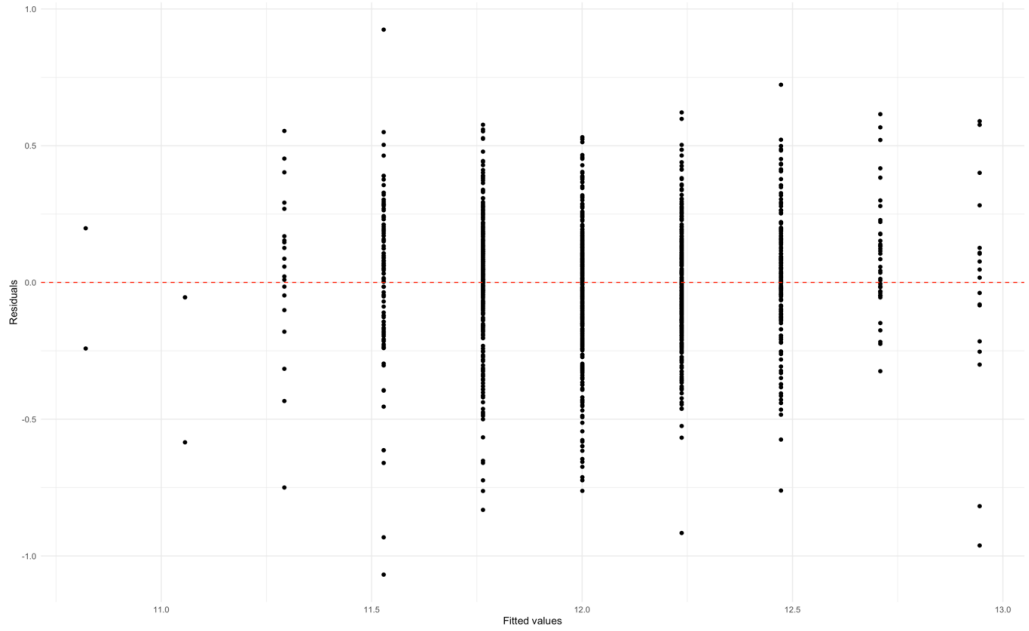
A tibble: 2 × 5

term <chr>	estimate <dbl>	std.error <dbl>	statistic <dbl>	p.value <dbl>
(Intercept)	10.584442	0.027266623	388.18310	0
OverallQual	0.236028	0.004359842	54.13682	0

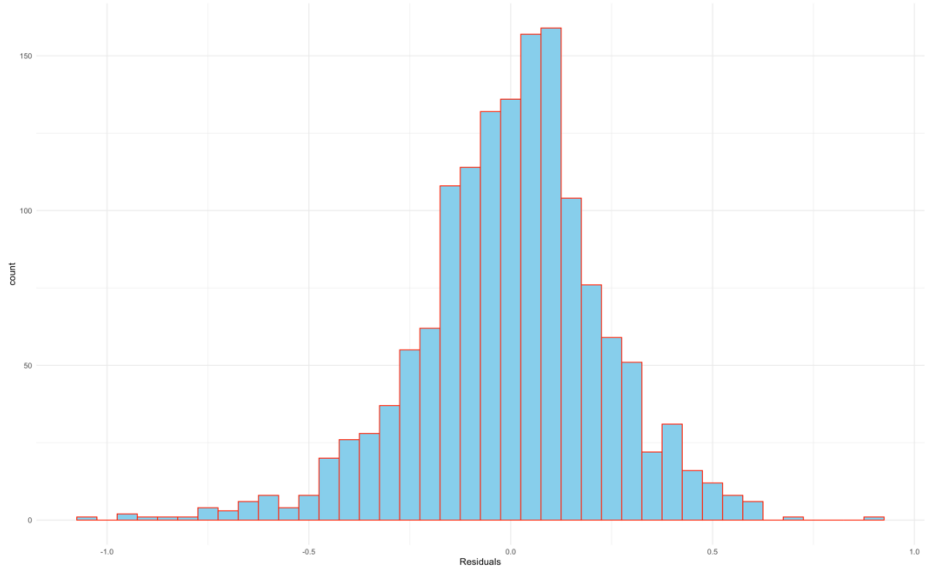
2 rows

The plot below visualizes the residuals versus the fitted values for the regression model (m5) predicting the logarithmic transformation of sale prices based on overall house quality in the Ames housing dataset. The absence of a clear pattern in the residuals suggests reasonable linearity in the model. However, the presence of outliers, especially for higher fitted values,

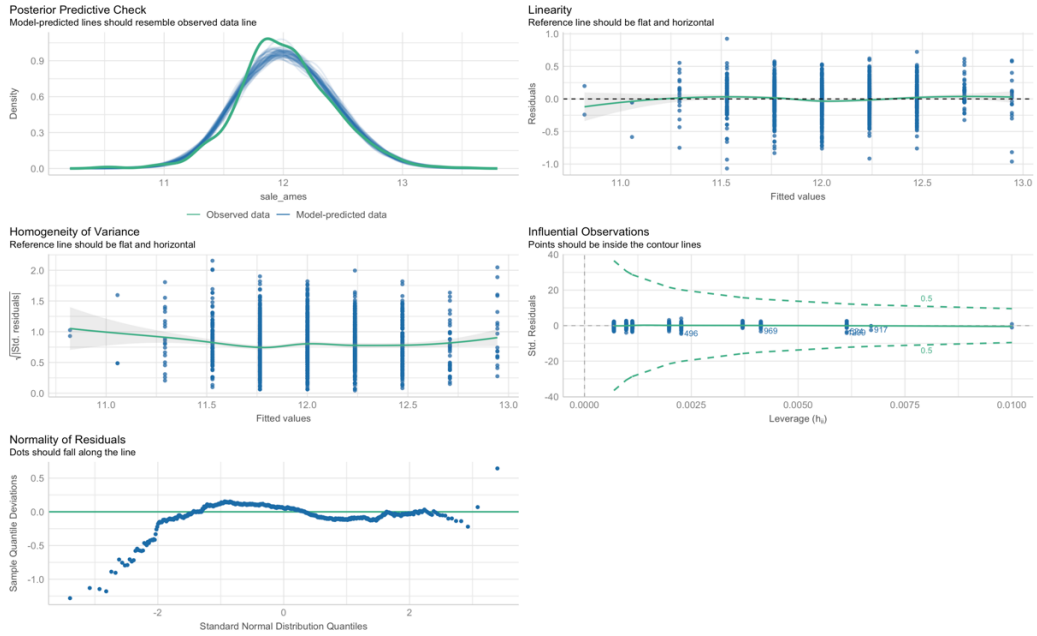
raises concerns about potential model sensitivity to extreme values. Additionally, the slight increase in residual spread with higher fitted values indicates possible heteroscedasticity, challenging the assumption of equal variance. While the model generally fits well, addressing these issues through further diagnostic checks or model adjustments could enhance its predictive accuracy and reliability.



The histogram below illustrates the distribution of residuals from your regression model, providing insights into model diagnostics. The bell-shaped curve indicates that the residuals are approximately normally distributed, aligning with the assumption of linear regression. The cantered peak around zero suggests unbiased predictions, indicating that, on average, the model accurately estimates sale prices. However, a few outliers and slight skewness towards the negative side hint at potential issues that could affect prediction reliability, especially for extreme values. While the overall distribution supports the model's validity, addressing outliers and skewness through further investigation or transformations could enhance predictive performance and model robustness.



The diagnostic plots below provide a comprehensive evaluation of the regression model's assumptions, crucial for validating its suitability for predictive analysis. The posterior predictive check confirms that the model predictions align well with the observed data distribution. Linearity diagnostics show that residuals are evenly scattered around zero, supporting the assumption of a linear relationship between predictors and the response variable. Homoscedasticity diagnostics indicate consistent variance across fitted values, further validating model assumptions. While influential observations mostly fall within acceptable bounds, minor deviations suggest some points may warrant further scrutiny. The normality plot indicates minor deviations from normality, particularly in the upper tail. Overall, the model appears well-specified, with minor concerns that could be addressed with transformations or robust regression techniques for enhanced precision in predictions, especially at the extremes.



Lastly, the statement "Error variance appears to be homoscedastic (p = 0.705)" indicates that the variability of residuals in the regression model remains consistent across different levels of the independent variable(s). In simpler terms, it means that the spread of errors around the regression line does not systematically change as the predicted values increase or decrease. The p-value of 0.705, which is well above the conventional significance level of 0.05, suggests strong evidence supporting the presence of homoscedasticity. This finding is crucial as it ensures that the standard least squares regression estimates are reliable and that the statistical inferences drawn from them, such as confidence intervals and hypothesis tests, are valid. In conclusion, the model's adherence to the homoscedasticity assumption enhances the credibility of its predictions and the accuracy of the statistical conclusions derived from it.

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OK: Error variance appears to be homoscedastic (p = 0.705).
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Recommendations and Final Conclusion

The analysis of the Ames Housing Dataset has provided profound insights into the variables impacting property values, equipping real estate stakeholders with actionable intelligence for decision-making. Key factors such as proximity to amenities and larger lot sizes emerge as significant influencers of property prices, with homes near essential services like schools and shopping centres commanding higher values due to increased convenience and lifestyle benefits. Furthermore, renovations, particularly in kitchens and bathrooms, significantly enhance marketability and sale prices, presenting a lucrative investment for homeowners aiming to sell. Energy efficiency and the inclusion of modern utilities also play a crucial role, with benefits extending beyond buyer attraction to long-term savings and sustainability, making these features increasingly vital in property valuation.

In terms of market dynamics, the research underscores the importance of staying informed on supply, demand, and economic indicators to capitalize on pricing trends effectively. Seasonal variations also significantly affect property values, with peak prices occurring during spring and summer, suggesting that timing plays a critical role in maximizing property sale returns. Additionally, the analysis highlights the importance of neighborhood amenities and outdoor spaces in boosting property desirability and value, recommending that both buyers and urban planners consider these elements in their strategies.

The predictive modelling aspect of this study achieved the best results with an RMSE of 48,589.45 using "Overall Quality" as a predictor, reflecting a strong correlation with property values. Future improvements could include integrating more diverse variables such as lot size, property age, and proximity to amenities, and employing advanced modelling techniques like machine learning to better capture complex interactions between factors. Enhancing the dataset with additional contextual data and employing feature engineering could further refine the model's accuracy. These advancements would not only improve predictive precision but also provide deeper insights into the dynamics of the real estate market, supporting more informed strategic decisions in property investment and urban development.

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