Open in Colab

In [1]:
```
#from google.colab import drive
#drive.mount('/content/drive')
```

In [500…
```
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import warnings
import numpy as np
from sklearn.preprocessing import OneHotEncoder , StandardScaler, OrdinalEncoder
from sklearn.decomposition import PCA
from sklearn.feature_selection import RFE
from sklearn.pipeline import Pipeline
from sklearn.compose import ColumnTransformer
from sklearn.model_selection import train_test_split, cross_validate, GridSearch
from sklearn.metrics import r2_score, mean_squared_error, make_scorer
from sklearn.linear_model import LinearRegression, Ridge, Lasso, ElasticNet
from sklearn.tree import DecisionTreeRegressor
from sklearn.ensemble import RandomForestRegressor
from xgboost import XGBRegressor
import keras
from keras import models, layers
from keras.layers import Dense, Dropout, Activation
from keras.regularizers import l2
from keras.callbacks import ModelCheckpoint
from keras.wrappers.scikit_learn import KerasRegressor
%matplotlib inline
warnings.filterwarnings("ignore")
```

In [501…
```
# Functions

def get_results(results):

    '''Prints the mean negative rmse from the model that had the lowest mean rms

    print('The best model parameters produce a mean rmse score on train data of:
    print(results.cv_results_['mean_train_neg_root_mean_squared_error'][results.
    print('')
    print('The best model parameters produce a mean R-squared score on train dat
    print(results.cv_results_['mean_train_r2'][results.best_index_])
    print('')
    print('The best model parameters produce a mean rmse score on test data of:'
    print(results.cv_results_['mean_test_neg_root_mean_squared_error'][results.b
    print('')
    print('The best model parameters produce a mean R-squared score on test data
    print(results.cv_results_['mean_test_r2'][results.best_index_])


def get_results_preds(y_train, y_train_preds, y_test, y_test_preds):

    # Getting R squared scores for training and testing data
    y_tr_r2 = r2_score(y_tr, y_tr_preds)
    y_val_r2 = r2_score(y_val, y_val_preds)

    print(f'R-Squared score for the training data: {y_tr_r2}')
    print('')
    print(f'R-Squared score for the testing data: {y_val_r2}')
```

```
    print('')
    print('')

    # Getting Mean Squared Error for training and testing data
    y_tr_rmse = mean_squared_error(y_tr, y_tr_preds, squared = False)
    y_val_rmse = mean_squared_error(y_val, y_val_preds, squared = False)

    print(f'Root Mean Squared Error for the training data: {y_tr_rmse}')
    print('')
    print(f'Root Mean Squared Error for the testing data: {y_val_rmse}')


def replace_NaN(df, features, value):
    for feature in features:
        df[feature].replace(np.NaN, value , inplace=True)


categories = ['NA', 'Po', 'Fa', 'TA', 'Gd', 'Ex']

scale_dict = dict(zip(categories, range(0,6)))

def scale_function(category):
    return scale_dict[category]


def map_function(df, features, function):
    '''maps certain categorical variables to numerical values'''
    for feature in features:
        df[feature] = df[feature].map(lambda x : function(str(x)))


def get_cv_results(cv):
    train_scores = cv['train_score']
    mean_train_score = cv['train_score'].mean()
    test_scores = cv['test_score']
    mean_test_score = cv['test_score'].mean()
    print(cv)
    print('')
    print(f'CV Train Scores: {train_scores}')
    print('')
    print(f'Mean CV Train Score: {mean_train_score}')
    print('')
    print(f'CV Test Scores: {test_scores}')
    print('')
    print(f'Mean CV Test Score: {mean_test_score}')


def train_error_distribution(y, y_hat):
    train_error = y - y_hat
    plt.scatter(y_hat, train_error)
    plt.axhline(y=0, color='r', linestyle='-')
    plt.title('Distribution Of Training Error')
    plt.ylabel('Error')
    plt.xlabel('Prediction');


def test_error_distribution(y, y_hat):
    test_error = y_val - y_hat
    plt.scatter(y_hat, test_error)
    plt.axhline(y=0.5, color='r', linestyle='-')
```

```
    plt.title('Distribution Of Testing Error')
    plt.ylabel('Error')
    plt.xlabel('Prediction');


def visualize_nn(history, model, x_train, y_train, x_validation, y_validation):

    rmse = np.sqrt(history.history['mse'])
    val_rmse = np.sqrt(history.history['val_mse'])

    epochs = range(len(rmse))
    plt.plot(epochs, rmse, 'b-', label='Training RMSE');
    plt.plot(epochs, val_rmse, 'r-.', label='Validation RMSE');
    plt.title('Training And Validation MSE')
    plt.legend()
    plt.figure(figsize=(16,8));

    print('')
    print('Training Evaluation:')
    tr_eval = model.evaluate(x_train, y_train, batch_size=100)
    tr_eval
    print('')
    print('Validation Evaluation:')
    t_eval = model.evaluate(x_validation, y_validation, batch_size=50)
    t_eval
    print('')
    eval_rmse = np.sqrt(tr_eval[1])
    print(f'Train Evaluation RMSE: {eval_rmse}')
    print('')
    eval_val_rmse = np.sqrt(t_eval[1])
    print(f'Validation Evaluation RMSE: {eval_val_rmse}');
```

EDA

In [502…
```
# Loading the data
train_df = pd.read_csv('data/train.csv')
```

In [503…
```
train_df.head()
```

Out[503…

	Id	MSSubClass	MSZoning	LotFrontage	LotArea	Street	Alley	LotShape	LandContour	Utili
0	1	60	RL	65.0	8450	Pave	NaN	Reg	Lvl	All
1	2	20	RL	80.0	9600	Pave	NaN	Reg	Lvl	All
2	3	60	RL	68.0	11250	Pave	NaN	IR1	Lvl	All
3	4	70	RL	60.0	9550	Pave	NaN	IR1	Lvl	All
4	5	60	RL	84.0	14260	Pave	NaN	IR1	Lvl	All

5 rows × 81 columns

In [504…
```
train_df.shape
```

Out[504…
```
(1460, 81)
```

In [505…

```
train_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1460 entries, 0 to 1459
Data columns (total 81 columns):
 #   Column          Non-Null Count  Dtype  
---  ------          --------------  -----  
 0   Id              1460 non-null   int64  
 1   MSSubClass      1460 non-null   int64  
 2   MSZoning        1460 non-null   object 
 3   LotFrontage     1201 non-null   float64
 4   LotArea         1460 non-null   int64  
 5   Street          1460 non-null   object 
 6   Alley           91 non-null     object 
 7   LotShape        1460 non-null   object 
 8   LandContour     1460 non-null   object 
 9   Utilities       1460 non-null   object 
 10  LotConfig       1460 non-null   object 
 11  LandSlope       1460 non-null   object 
 12  Neighborhood    1460 non-null   object 
 13  Condition1      1460 non-null   object 
 14  Condition2      1460 non-null   object 
 15  BldgType        1460 non-null   object 
 16  HouseStyle      1460 non-null   object 
 17  OverallQual     1460 non-null   int64  
 18  OverallCond     1460 non-null   int64  
 19  YearBuilt       1460 non-null   int64  
 20  YearRemodAdd    1460 non-null   int64  
 21  RoofStyle       1460 non-null   object 
 22  RoofMatl        1460 non-null   object 
 23  Exterior1st     1460 non-null   object 
 24  Exterior2nd     1460 non-null   object 
 25  MasVnrType      1452 non-null   object 
 26  MasVnrArea      1452 non-null   float64
 27  ExterQual       1460 non-null   object 
 28  ExterCond       1460 non-null   object 
 29  Foundation      1460 non-null   object 
 30  BsmtQual        1423 non-null   object 
 31  BsmtCond        1423 non-null   object 
 32  BsmtExposure    1422 non-null   object 
 33  BsmtFinType1    1423 non-null   object 
 34  BsmtFinSF1      1460 non-null   int64  
 35  BsmtFinType2    1422 non-null   object 
 36  BsmtFinSF2      1460 non-null   int64  
 37  BsmtUnfSF       1460 non-null   int64  
 38  TotalBsmtSF     1460 non-null   int64  
 39  Heating         1460 non-null   object 
 40  HeatingQC       1460 non-null   object 
 41  CentralAir      1460 non-null   object 
 42  Electrical      1459 non-null   object 
 43  1stFlrSF        1460 non-null   int64  
 44  2ndFlrSF        1460 non-null   int64  
 45  LowQualFinSF    1460 non-null   int64  
 46  GrLivArea       1460 non-null   int64  
 47  BsmtFullBath    1460 non-null   int64  
 48  BsmtHalfBath    1460 non-null   int64  
 49  FullBath        1460 non-null   int64  
 50  HalfBath        1460 non-null   int64  
 51  BedroomAbvGr    1460 non-null   int64  
 52  KitchenAbvGr    1460 non-null   int64  
 53  KitchenQual     1460 non-null   object 
 54  TotRmsAbvGrd    1460 non-null   int64  
 55  Functional      1460 non-null   object 
 56  Fireplaces      1460 non-null   int64  
 57  FireplaceQu     770 non-null    object 
```

```
 58  GarageType     1379 non-null   object
 59  GarageYrBlt    1379 non-null   float64
 60  GarageFinish   1379 non-null   object
 61  GarageCars     1460 non-null   int64
 62  GarageArea     1460 non-null   int64
 63  GarageQual     1379 non-null   object
 64  GarageCond     1379 non-null   object
 65  PavedDrive     1460 non-null   object
 66  WoodDeckSF     1460 non-null   int64
 67  OpenPorchSF    1460 non-null   int64
 68  EnclosedPorch  1460 non-null   int64
 69  3SsnPorch      1460 non-null   int64
 70  ScreenPorch    1460 non-null   int64
 71  PoolArea       1460 non-null   int64
 72  PoolQC         7 non-null      object
 73  Fence          281 non-null    object
 74  MiscFeature    54 non-null     object
 75  MiscVal        1460 non-null   int64
 76  MoSold         1460 non-null   int64
 77  YrSold         1460 non-null   int64
 78  SaleType       1460 non-null   object
 79  SaleCondition  1460 non-null   object
 80  SalePrice      1460 non-null   int64
dtypes: float64(3), int64(35), object(43)
memory usage: 924.0+ KB
```

Predictors that need to be dropped, because of too many null values – ['Alley', 'FireplaceQu', 'PoolQC', 'Fence', 'MiscFeature']

In [506…
```
train_df.describe()
```

Out[506…

	Id	MSSubClass	LotFrontage	LotArea	OverallQual	OverallCond	Ye
count	1460.000000	1460.000000	1201.000000	1460.000000	1460.000000	1460.000000	1460.(
mean	730.500000	56.897260	70.049958	10516.828082	6.099315	5.575342	1971.2
std	421.610009	42.300571	24.284752	9981.264932	1.382997	1.112799	30.2
min	1.000000	20.000000	21.000000	1300.000000	1.000000	1.000000	1872.(
25%	365.750000	20.000000	59.000000	7553.500000	5.000000	5.000000	1954.(
50%	730.500000	50.000000	69.000000	9478.500000	6.000000	5.000000	1973.(
75%	1095.250000	70.000000	80.000000	11601.500000	7.000000	6.000000	2000.(
max	1460.000000	190.000000	313.000000	215245.000000	10.000000	9.000000	2010.(

8 rows × 38 columns

In [507…
```
target = train_df['SalePrice']
```

In [508…
```
target.describe()
```

Out[508…
```
count      1460.000000
mean     180921.195890
std       79442.502883
min       34900.000000
25%      129975.000000
50%      163000.000000
75%      214000.000000
```

```
max      755000.000000
Name: SalePrice, dtype: float64
```

By using a log transformation on the target variable, the distribution is now closer to normal. Hopefully this satisfies the assumption of normality. We will only truly know when we see the distribution of the errors of a baseline linear regression model.

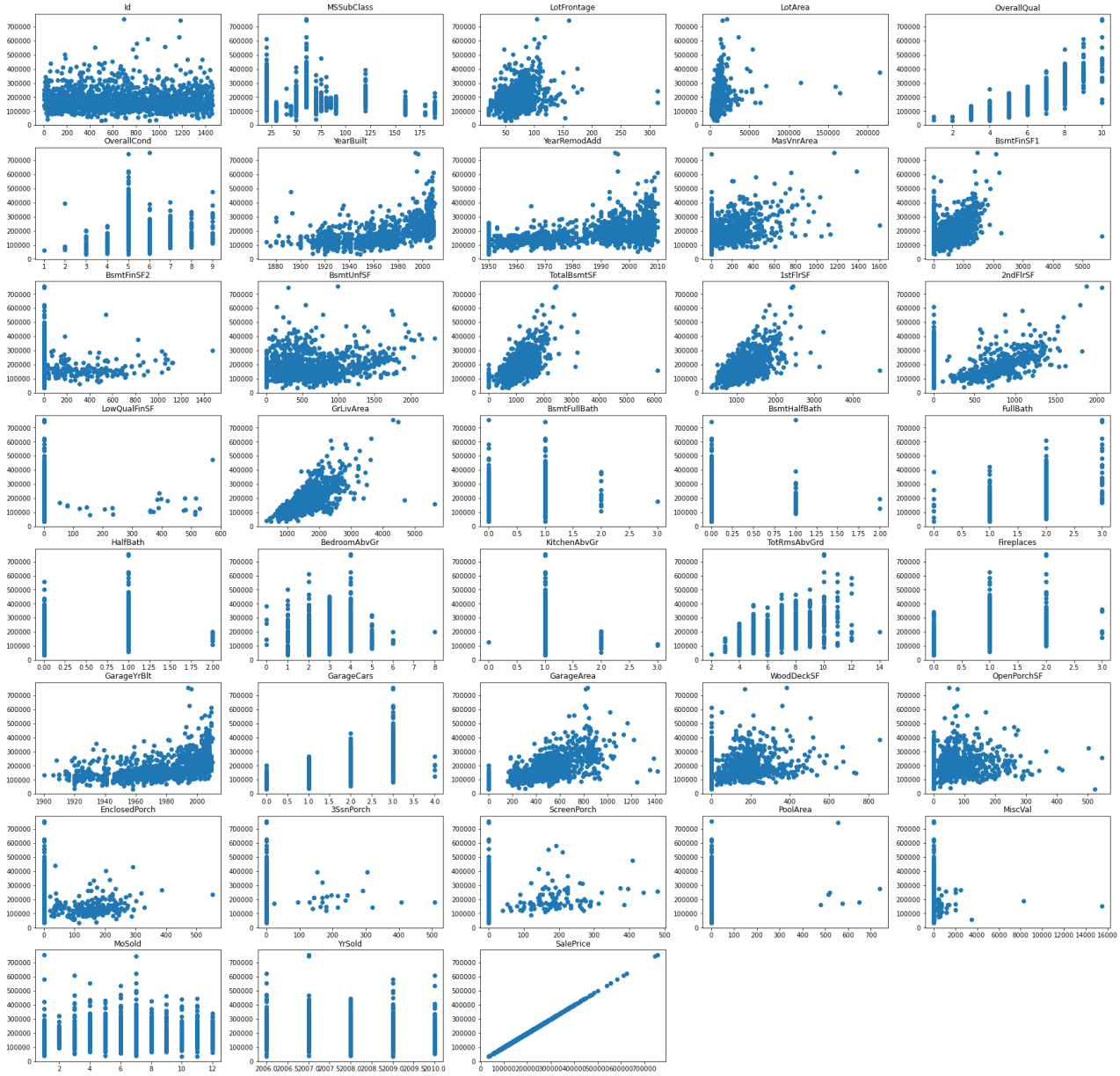
Checking Viability of Linear Model

Inspecting Linear Relationships Between Predictors And Target

In [509…
```
num_cols = list(train_df.select_dtypes(exclude=['object']))
len(num_cols)
```

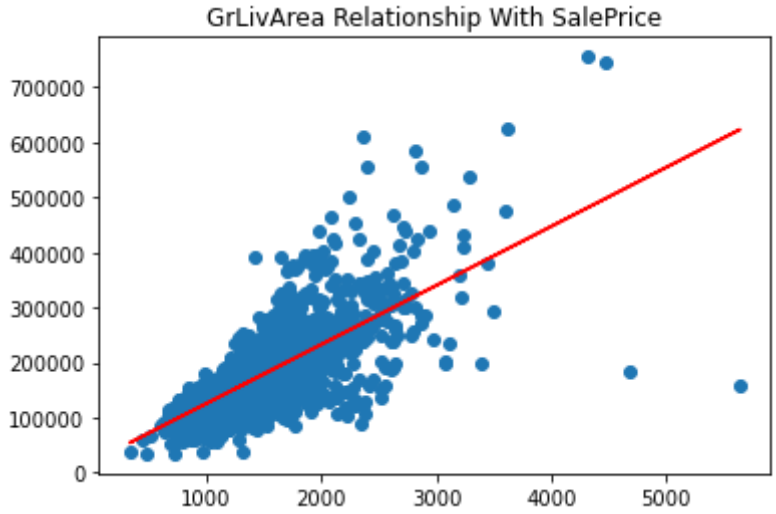
Out[509…
```
38
```

In [510…
```
fig = plt.figure(1, figsize=(30,30))
columns = 5
rows = 8

for i, col in enumerate(num_cols):
    fig.add_subplot(rows, columns, i+1)
    plt.scatter(train_df[col], train_df['SalePrice'])
    plt.title(col);
```



In [511…

```
plt.scatter(train_df['GrLivArea'], train_df['SalePrice'])
theta = np.polyfit(train_df['GrLivArea'], train_df['SalePrice'], 1)
line = theta[1] + theta[0]*train_df['GrLivArea']
plt.plot(train_df['GrLivArea'],line, 'r')
plt.title('GrLivArea Relationship With SalePrice');
```

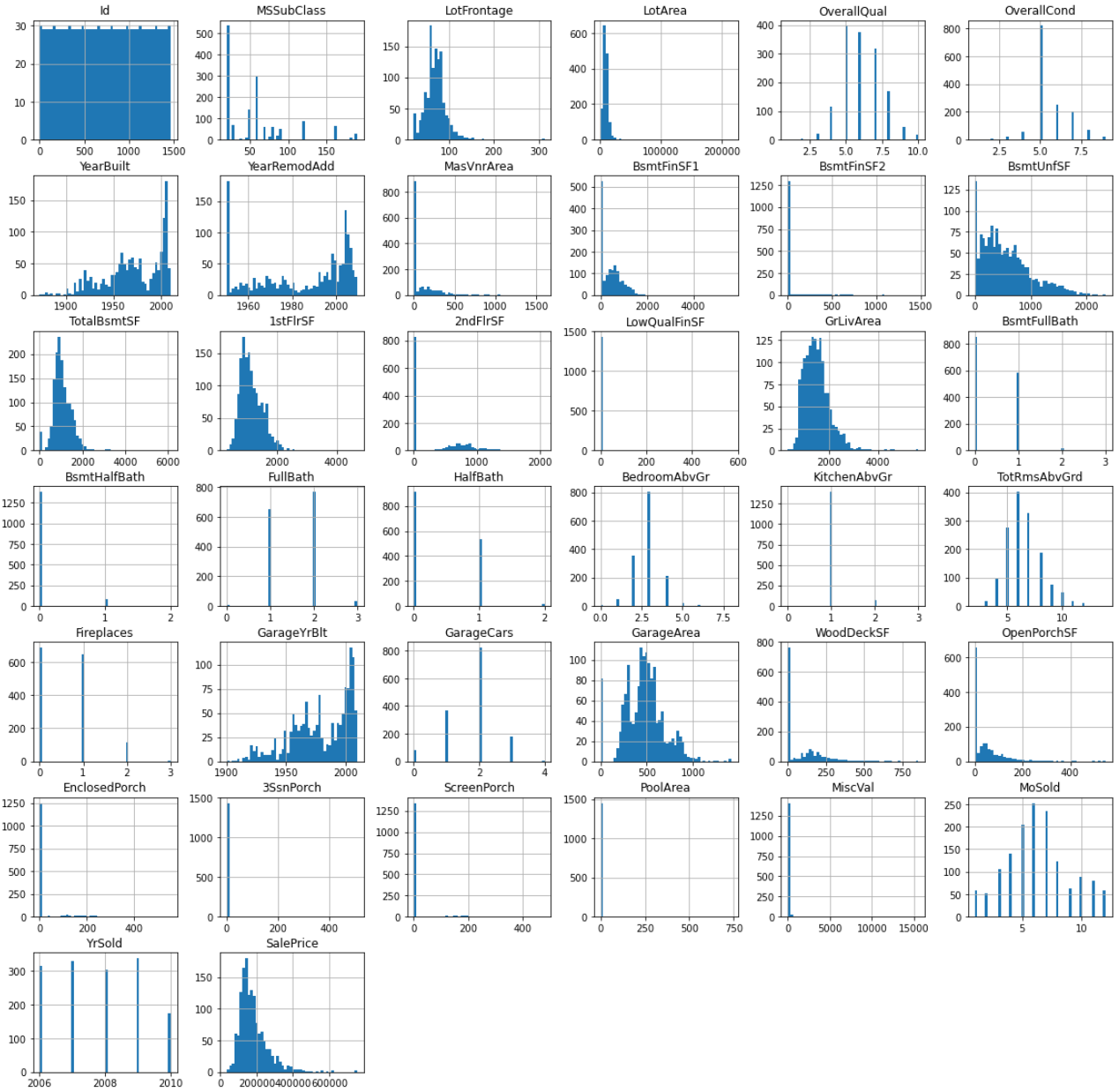


The independent variables that clearly do not have a linear relationship with the target are 'MSSubClass' and 'KitchensAbvGr'. I will consider dropping these variables during the feature selection stage.

Checking Multivariate Normality

In [512…

```
train_df.hist(figsize=(20,20), bins=50);
```

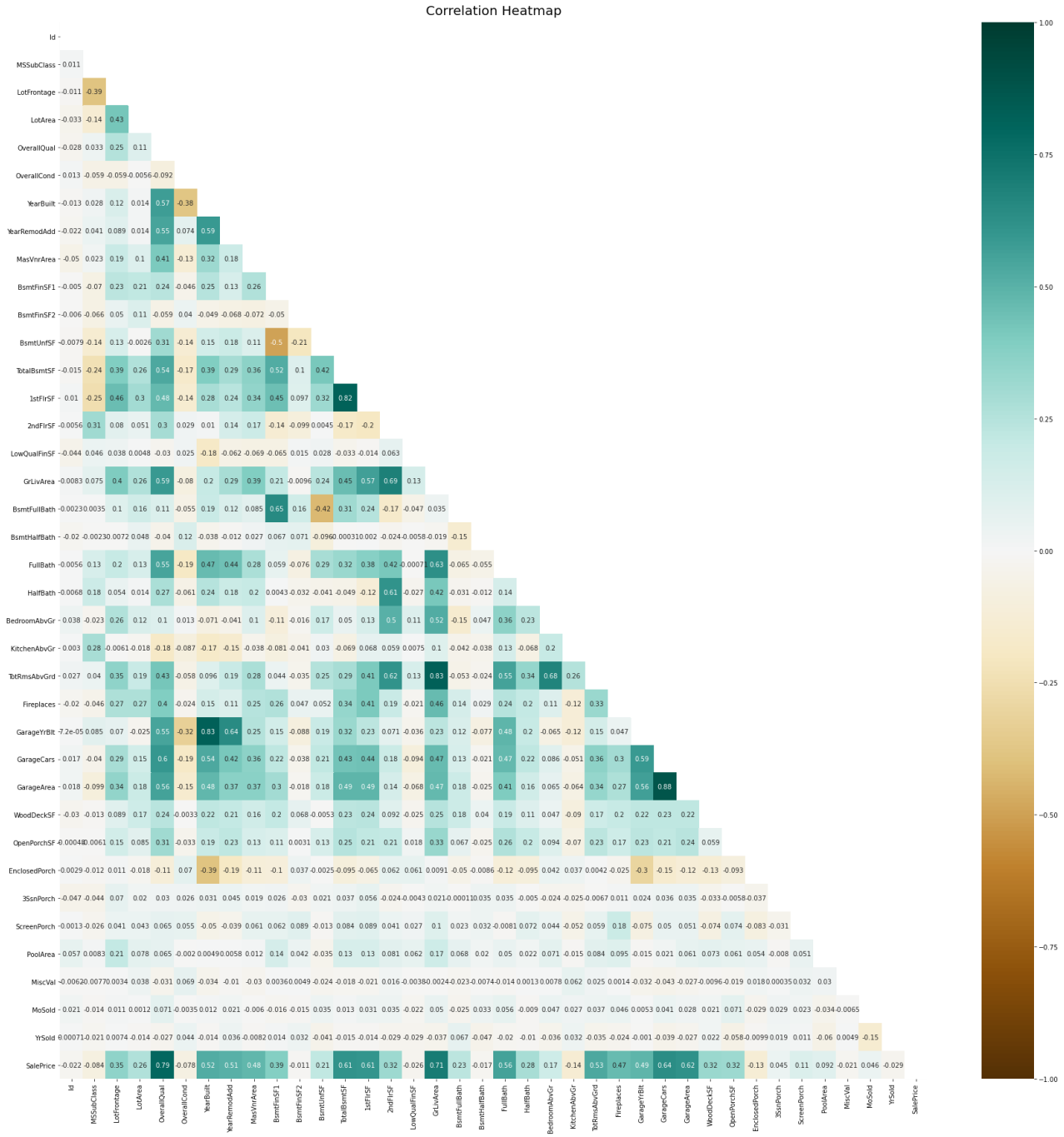


It appears that many variables in this dataset are slightly non-normally distributed. However, this is most likely an effect of the outliers, which I would like to keep for now in an effort to model the real world. And given that predictors with continous values that are not in units of time, such as 'LotFrontage' and 'LotArea', are mostly normal, I am going to try training models on just a standard scaled raw dataset.

Checking For Multicollinearity

In [513…

```
plt.figure(figsize=(30, 30))
mask = np.triu(np.ones_like(train_df.corr(), dtype=np.bool))
heatmap = sns.heatmap(train_df.corr(), mask=mask, vmin=-1, vmax=1, annot=True, c
heatmap.set_title('Correlation Heatmap', fontdict={'fontsize':20}, pad=12);
```

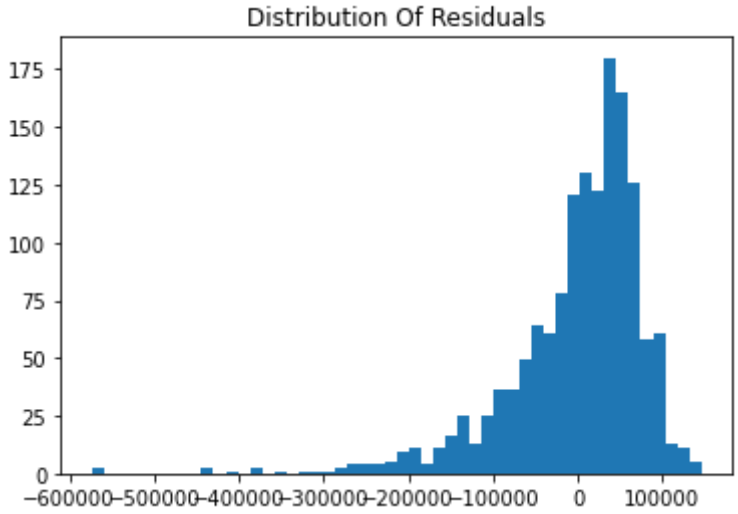


There are a few dark green points on the heatmap indicating a high correlation between two variables. When I start the process of data cleaning, I will take out multicollinear variables.

Checking Homoscedasticity of Target

In [514…

```
# Using the mean of the target as a theoretical prediction for each observation
plt.hist((train_df['SalePrice'].mean() - train_df['SalePrice']), bins=50)
plt.title('Distribution Of Residuals');
```



It is clear that this distribution of baseline residuals skews left, however not terribly. Using linear regression is feasible, though multicollinearity needs to be reduced. I will check the residuals of the first basic linear regression for homoscedasticity.

Data Preprocessing

In [515…

```
train_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1460 entries, 0 to 1459
Data columns (total 81 columns):
 #   Column         Non-Null Count  Dtype  
---  ------         --------------  -----  
 0   Id             1460 non-null   int64  
 1   MSSubClass     1460 non-null   int64  
 2   MSZoning       1460 non-null   object 
 3   LotFrontage    1201 non-null   float64
 4   LotArea        1460 non-null   int64  
 5   Street         1460 non-null   object 
 6   Alley          91 non-null     object 
 7   LotShape       1460 non-null   object 
 8   LandContour    1460 non-null   object 
 9   Utilities      1460 non-null   object 
 10  LotConfig      1460 non-null   object 
 11  LandSlope      1460 non-null   object 
 12  Neighborhood   1460 non-null   object 
 13  Condition1     1460 non-null   object 
 14  Condition2     1460 non-null   object 
 15  BldgType       1460 non-null   object 
 16  HouseStyle     1460 non-null   object 
 17  OverallQual    1460 non-null   int64  
 18  OverallCond    1460 non-null   int64  
 19  YearBuilt      1460 non-null   int64  
 20  YearRemodAdd   1460 non-null   int64  
 21  RoofStyle      1460 non-null   object 
 22  RoofMatl       1460 non-null   object 
 23  Exterior1st    1460 non-null   object 
 24  Exterior2nd    1460 non-null   object 
 25  MasVnrType     1452 non-null   object 
 26  MasVnrArea     1452 non-null   float64
 27  ExterQual      1460 non-null   object 
 28  ExterCond      1460 non-null   object 
 29  Foundation     1460 non-null   object 
```

```
 30  BsmtQual       1423 non-null   object
 31  BsmtCond       1423 non-null   object
 32  BsmtExposure   1422 non-null   object
 33  BsmtFinType1   1423 non-null   object
 34  BsmtFinSF1     1460 non-null   int64
 35  BsmtFinType2   1422 non-null   object
 36  BsmtFinSF2     1460 non-null   int64
 37  BsmtUnfSF      1460 non-null   int64
 38  TotalBsmtSF    1460 non-null   int64
 39  Heating        1460 non-null   object
 40  HeatingQC      1460 non-null   object
 41  CentralAir     1460 non-null   object
 42  Electrical     1459 non-null   object
 43  1stFlrSF       1460 non-null   int64
 44  2ndFlrSF       1460 non-null   int64
 45  LowQualFinSF   1460 non-null   int64
 46  GrLivArea      1460 non-null   int64
 47  BsmtFullBath   1460 non-null   int64
 48  BsmtHalfBath   1460 non-null   int64
 49  FullBath       1460 non-null   int64
 50  HalfBath       1460 non-null   int64
 51  BedroomAbvGr   1460 non-null   int64
 52  KitchenAbvGr   1460 non-null   int64
 53  KitchenQual    1460 non-null   object
 54  TotRmsAbvGrd   1460 non-null   int64
 55  Functional     1460 non-null   object
 56  Fireplaces     1460 non-null   int64
 57  FireplaceQu    770 non-null    object
 58  GarageType     1379 non-null   object
 59  GarageYrBlt    1379 non-null   float64
 60  GarageFinish   1379 non-null   object
 61  GarageCars     1460 non-null   int64
 62  GarageArea     1460 non-null   int64
 63  GarageQual     1379 non-null   object
 64  GarageCond     1379 non-null   object
 65  PavedDrive     1460 non-null   object
 66  WoodDeckSF     1460 non-null   int64
 67  OpenPorchSF    1460 non-null   int64
 68  EnclosedPorch  1460 non-null   int64
 69  3SsnPorch      1460 non-null   int64
 70  ScreenPorch    1460 non-null   int64
 71  PoolArea       1460 non-null   int64
 72  PoolQC         7 non-null      object
 73  Fence          281 non-null    object
 74  MiscFeature    54 non-null     object
 75  MiscVal        1460 non-null   int64
 76  MoSold         1460 non-null   int64
 77  YrSold         1460 non-null   int64
 78  SaleType       1460 non-null   object
 79  SaleCondition  1460 non-null   object
 80  SalePrice      1460 non-null   int64
dtypes: float64(3), int64(35), object(43)
memory usage: 924.0+ KB
```

In [516…

```
# This dataset already contains very little data, and given the description, Lot
# So I am replacing null values of Lot Frontage with the variable mean of the ni
# to avoid dropping the 200+ rows of data or dropping the variable entirele
def impute_lot_frontage(row):
    if np.isnan(row['LotFrontage']):
        neighborhood = row['Neighborhood']
        lot_frontage_mean = train_df[train_df['Neighborhood'] == neighborhood]['
        row['LotFrontage'] = lot_frontage_mean

    return row
```

In [517…
```
train_df = train_df.apply(impute_lot_frontage, axis=1)
```

In [518…
```
# Replacing NaN values in certain garage features to 'U' for Unknown
replace_NaN(train_df, ['GarageType', 'GarageFinish', 'GarageQual', 'GarageCond']
```

Feature Selection And Engineering

In [519…
```
# Finding Multicollinear Predictors
# save absolute value of correlation matrix as a data frame
# converts all values to absolute value
# stacks the row:column pairs into a multindex
# reset the index to set the multindex to seperate columns
# sort values. 0 is the column automatically generated by the stacking
train_df_mc = train_df.corr().abs().stack().reset_index().sort_values(0, ascendi

# rename correlation column as cc rather than 0
train_df_mc.columns = 'v1', 'v2', 'corr'

# drop duplicates. This could be dangerous if you have variables perfectly corre
# for the sake of exercise, kept it in.
train_df_mc.drop_duplicates(inplace=True)

# reset index for future concatenation
train_df_mc.reset_index(inplace=True)
```

In [520…
```
def corr_target(row):
    row['v1_y_corr'] = train_df.corr()['SalePrice'][row['v1']]
    row['v2_y_corr'] = train_df.corr()['SalePrice'][row['v2']]
    return row
```

In [521…
```
train_df_mc = train_df_mc.apply(corr_target, axis=1)
```

In [522…
```
train_df_mc['pairs'] = list(zip(train_df_mc.v1, train_df_mc.v2))

# drop level columns
train_df_mc.drop(columns=['index','v1', 'v2'], inplace = True)

# drop duplicates. This could be dangerous if you have variables perfectly corre
# for the sake of exercise, kept it in.
train_df_mc.drop_duplicates('corr', inplace=True)

# set index to pairs
train_df_mc.set_index(['pairs'], inplace = True)
```

In [523…
```
multicollinear = train_df_mc[(train_df_mc['corr'] > 0.7) & (train_df_mc['corr']
multicollinear
```

Out[523…

pairs	corr	v1_y_corr	v2_y_corr
(GarageCars, GarageArea)	0.882475	0.640409	0.623431
(YearBuilt, GarageYrBlt)	0.825667	0.522897	0.486362
(GrLivArea, TotRmsAbvGrd)	0.825489	0.708624	0.533723

pairs	corr	v1_y_corr	v2_y_corr
(1stFlrSF, TotalBsmtSF)	0.819530	0.605852	0.613581
(SalePrice, OverallQual)	0.790982	1.000000	0.790982
(SalePrice, GrLivArea)	0.708624	1.000000	0.708624

GaragesCars is more highly correlated with SalePrice than GarageArea, so GarageArea will be dropped.

YearBuilt is more highly correlated with SalePrice than GarageYrBlt, so GarageYrBlt will be dropped.

GrLivArea is more highly correlated with SalePrice than TotRmsAbvGrd, so TotRmsAbvGrd will be dropped.

TotBsmtSF is more highly correlated with SalePrice than 1stFlrSF, so 1stFlrSF will be dropped.

In [524…
```
# Dropping 'Id' column
train_df.drop('Id', axis=1, inplace=True)
```

In [525…
```
# Dropping predictors with too many null values
train_df.drop(['Alley', 'FireplaceQu', 'PoolQC', 'Fence', 'MiscFeature'], axis=1
```

In [526…
```
# Dropping multicollinear predictors
train_df.drop(['GarageArea', 'GarageYrBlt', 'TotRmsAbvGrd', '1stFlrSF'], axis=1,
```

In [527…
```
# Dropping low variance predictors, because they will have little effect on the
var = train_df.var().sort_values(ascending=True)
low_var = var[var <.1]
low_var = list(low_var.index)
train_df.drop(low_var, axis=1, inplace=True)
```

In [528…
```
# Dropping predictors not linearly related to the target
train_df.drop('MSSubClass', axis=1, inplace=True)
```

In [529…
```
# Dropping remaining null values
train_df.dropna(inplace=True)
```

In [530…
```
# Turning these predictors from categorical into numerical
map_function(train_df, ['ExterQual', 'ExterCond', 'BsmtQual', 'BsmtCond', 'Heati
```

In [531…
```
# Combining the weaker mid_var predictors to try and give them more predictive p
train_df['Bath_Fireplaces'] = train_df['Fireplaces'] + train_df['FullBath']
```

In [532…
```
train_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 1412 entries, 0 to 1459
Data columns (total 69 columns):
 #   Column           Non-Null Count  Dtype
---  ------           --------------  -----
 0   MSZoning         1412 non-null   object
```

```
1   LotFrontage      1412 non-null   float64
2   LotArea          1412 non-null   int64
3   Street           1412 non-null   object
4   LotShape         1412 non-null   object
5   LandContour      1412 non-null   object
6   Utilities        1412 non-null   object
7   LotConfig        1412 non-null   object
8   LandSlope        1412 non-null   object
9   Neighborhood     1412 non-null   object
10  Condition1       1412 non-null   object
11  Condition2       1412 non-null   object
12  BldgType         1412 non-null   object
13  HouseStyle       1412 non-null   object
14  OverallQual      1412 non-null   int64
15  OverallCond      1412 non-null   int64
16  YearBuilt        1412 non-null   int64
17  YearRemodAdd     1412 non-null   int64
18  RoofStyle        1412 non-null   object
19  RoofMatl         1412 non-null   object
20  Exterior1st      1412 non-null   object
21  Exterior2nd      1412 non-null   object
22  MasVnrType       1412 non-null   object
23  MasVnrArea       1412 non-null   float64
24  ExterQual        1412 non-null   int64
25  ExterCond        1412 non-null   int64
26  Foundation       1412 non-null   object
27  BsmtQual         1412 non-null   int64
28  BsmtCond         1412 non-null   int64
29  BsmtExposure     1412 non-null   object
30  BsmtFinType1     1412 non-null   object
31  BsmtFinSF1       1412 non-null   int64
32  BsmtFinType2     1412 non-null   object
33  BsmtFinSF2       1412 non-null   int64
34  BsmtUnfSF        1412 non-null   int64
35  TotalBsmtSF      1412 non-null   int64
36  Heating          1412 non-null   object
37  HeatingQC        1412 non-null   int64
38  CentralAir       1412 non-null   object
39  Electrical       1412 non-null   object
40  2ndFlrSF         1412 non-null   int64
41  LowQualFinSF     1412 non-null   int64
42  GrLivArea        1412 non-null   int64
43  BsmtFullBath     1412 non-null   int64
44  FullBath         1412 non-null   int64
45  HalfBath         1412 non-null   int64
46  BedroomAbvGr     1412 non-null   int64
47  KitchenQual      1412 non-null   int64
48  Functional       1412 non-null   object
49  Fireplaces       1412 non-null   int64
50  GarageType       1412 non-null   object
51  GarageFinish     1412 non-null   object
52  GarageCars       1412 non-null   int64
53  GarageQual       1412 non-null   object
54  GarageCond       1412 non-null   object
55  PavedDrive       1412 non-null   object
56  WoodDeckSF       1412 non-null   int64
57  OpenPorchSF      1412 non-null   int64
58  EnclosedPorch    1412 non-null   int64
59  3SsnPorch        1412 non-null   int64
60  ScreenPorch      1412 non-null   int64
61  PoolArea         1412 non-null   int64
62  MiscVal          1412 non-null   int64
63  MoSold           1412 non-null   int64
64  YrSold           1412 non-null   int64
65  SaleType         1412 non-null   object
```

```
 66  SaleCondition    1412 non-null   object
 67  SalePrice        1412 non-null   int64
 68  Bath_Fireplaces  1412 non-null   int64
dtypes: float64(2), int64(35), object(32)
memory usage: 772.2+ KB
```

In [533…
```
train_df.head()
```

Out[533…

	MSZoning	LotFrontage	LotArea	Street	LotShape	LandContour	Utilities	LotConfig	LandSlo
0	RL	65.0	8450	Pave	Reg	Lvl	AllPub	Inside	
1	RL	80.0	9600	Pave	Reg	Lvl	AllPub	FR2	
2	RL	68.0	11250	Pave	IR1	Lvl	AllPub	Inside	
3	RL	60.0	9550	Pave	IR1	Lvl	AllPub	Corner	
4	RL	84.0	14260	Pave	IR1	Lvl	AllPub	FR2	

5 rows × 69 columns

Modeling

Baseline Models

*disclaimer **

It is hard to say with any certainty how the values imputed to the lot frontage variable will effect the results of the models

Note: I am using recursive feature elimination prior to fitting

In [578…
```
x_train = train_df.drop(['SalePrice'], axis=1)
y_train = train_df['SalePrice']
```

In [579…
```
categorical_cols = x_train.select_dtypes('object')
numerical_cols = x_train.select_dtypes(exclude=['object'])

numerical_transformer = Pipeline(steps=[('ss', StandardScaler())])
categorical_transformer = Pipeline(steps=[('ohe', OneHotEncoder(handle_unknown='


transformer = ColumnTransformer(transformers=[('numerical', numerical_transforme
                                               ('categorical', categorical_transf
                                              ])

#cat_transformer = ColumnTransformer(transformers=[('categorical', categorical_t
```

In [580…
```
x_tr, x_val, y_tr, y_val = train_test_split(x_train, y_train, test_size=0.25, ra

# Transforming x_tr and x_val separately to avoid data leakage
x_tr = transformer.fit_transform(x_tr)
x_val = transformer.transform(x_val)
```

```
# Reducing Overfitting
rfe = RFE(LinearRegression(normalize=False), n_features_to_select=75)
x_tr = rfe.fit_transform(x_tr, y_tr)
x_val = rfe.transform(x_val)


# Instantiating and fitting model
linreg =  LinearRegression(normalize=False)
results = linreg.fit(x_tr, y_tr)


# Getting Predictions
y_tr_preds = results.predict(x_tr)
y_val_preds = results.predict(x_val)
```

In [581…
```
get_results_preds(y_tr, y_tr_preds, y_val, y_val_preds)
```

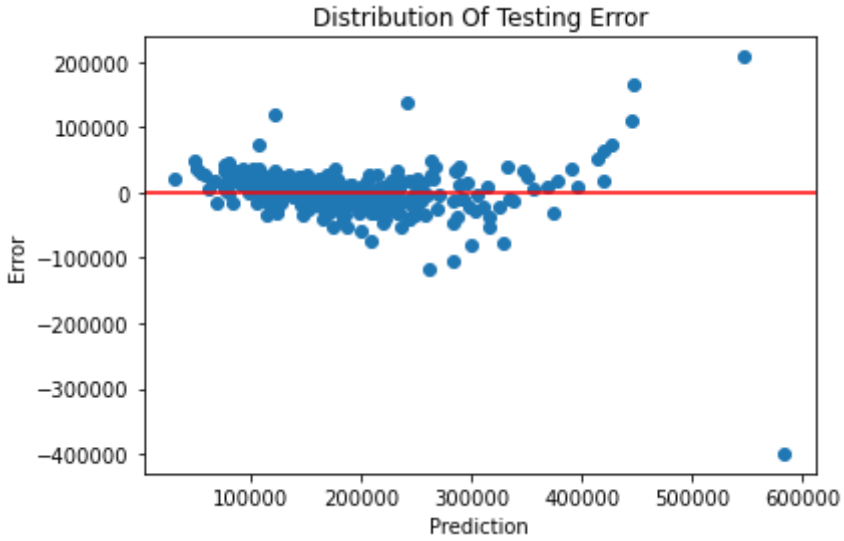
```
R-Squared score for the training data: 0.9011203723473886

R-Squared score for the testing data: 0.8108101837772864


Root Mean Squared Error for the training data: 24378.368158032215

Root Mean Squared Error for the testing data: 36611.07878134237
```

Analysis:

The baseline model using recursive feature elimination appears to have fit fairly well. I am going to check for homoskedasticity and then cross validate the model.

In [582…
```
train_error_distribution(y_tr, y_tr_preds)
```

In [583…
```
test_error_distribution(y_val, y_val_preds)
```



It appears that for the most part, the test residuals pass the check for homoscedasticity

In [584…
```
rfe = RFE(LinearRegression(normalize=False), n_features_to_select=75)
x_train = transformer.fit_transform(x_train)
x_train = rfe.fit_transform(x_train, y_train)
cv = cross_validate(linreg, x_train, y_train, scoring='r2', cv=5, return_train_s
get_cv_results(cv)
```

```
{'fit_time': array([0.03184414, 0.04104424, 0.03518486, 0.03032088, 0.0344800
9]), 'score_time': array([0.00073886, 0.00060964, 0.00075006, 0.00127196, 0.0005
3477]), 'test_score': array([0.87173715, 0.82297199, 0.80113393, 0.86038515, 0.6
8988316]), 'train_score': array([0.88614528, 0.89213888, 0.89983384, 0.89158741,
0.89097417])}

CV Train Scores: [0.88614528 0.89213888 0.89983384 0.89158741 0.89097417]

Mean CV Train Score: 0.8921359185194845

CV Test Scores: [0.87173715 0.82297199 0.80113393 0.86038515 0.68988316]

Mean CV Test Score: 0.8092222755302014
```

Linear Regression With l2 Regularization

In [481…
```
x_train = train_df.drop(['SalePrice'], axis=1)
y_train = train_df['SalePrice']
```

In [45]:
```
ridge_pipeline = Pipeline(steps=[('trans', transformer),
                                 ('rfe', RFE(LinearRegression(normalize=False),
                                 ('model', Ridge(random_state=42))])

ridge_grid = {'model__alpha': [10.0, 25.0, 50.0, 75.0],
              'model__normalize': [False],
              'model__max_iter': [500, 2000],
              'model__tol': [.001, .0001],
              'model__solver': ['auto']}

ridge_gs = GridSearchCV(ridge_pipeline,
                        ridge_grid,
                        scoring=['neg_root_mean_squared_error', 'r2'],
                        refit='neg_root_mean_squared_error',
                        cv=5,
```

```
                        verbose=3,
                        return_train_score=True)
```

In [46]:
```
results = ridge_gs.fit(x_train, y_train)
```

```
Fitting 5 folds for each of 16 candidates, totalling 80 fits
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.001
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[CV]  model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-31217.429, test=
-25914.247), r2=(train=0.849, test=0.879), total=  12.7s
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.001
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:   12.7s remaining:    0.0s
[CV]  model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-30524.788, test=
-33537.502), r2=(train=0.850, test=0.828), total=  13.5s
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.001
[Parallel(n_jobs=1)]: Done   2 out of   2 | elapsed:   26.3s remaining:    0.0s
[CV]  model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-30825.116, test=
-34914.931), r2=(train=0.840, test=0.839), total=  14.0s
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.001
[CV]  model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-31303.677, test=
-28989.172), r2=(train=0.850, test=0.838), total=  12.0s
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.001
[CV]  model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-27152.855, test=
-47557.427), r2=(train=0.882, test=0.650), total=  11.6s
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.0001
[CV]  model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-31203.493, test
=-25956.402), r2=(train=0.849, test=0.878), total=  12.2s
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.0001
[CV]  model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-30502.807, test
=-33546.749), r2=(train=0.850, test=0.828), total=  13.5s
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.0001
[CV]  model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-30816.955, test
=-34922.224), r2=(train=0.840, test=0.839), total=  13.9s
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.0001
[CV]  model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-31299.829, test
=-28984.641), r2=(train=0.850, test=0.838), total=  14.3s
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.0001
[CV]  model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-27137.097, test
=-47567.727), r2=(train=0.882, test=0.650), total=  12.5s
[CV] model__alpha=10.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.001
[CV]  model__alpha=10.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-31217.429, test
```

```
=-25914.247), r2=(train=0.849, test=0.879), total=  12.3s
[CV] model__alpha=10.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.001
[CV]  model__alpha=10.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-30524.788, test
=-33537.502), r2=(train=0.850, test=0.828), total=  14.5s
[CV] model__alpha=10.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.001
[CV]  model__alpha=10.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-30825.116, test
=-34914.931), r2=(train=0.840, test=0.839), total=  14.8s
[CV] model__alpha=10.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.001
[CV]  model__alpha=10.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-31303.677, test
=-28989.172), r2=(train=0.850, test=0.838), total=  12.2s
[CV] model__alpha=10.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.001
[CV]  model__alpha=10.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-27152.855, test
=-47557.427), r2=(train=0.882, test=0.650), total=  11.5s
[CV] model__alpha=10.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.0001
[CV]  model__alpha=10.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-31203.493, tes
t=-25956.402), r2=(train=0.849, test=0.878), total=  12.8s
[CV] model__alpha=10.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.0001
[CV]  model__alpha=10.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-30502.807, tes
t=-33546.749), r2=(train=0.850, test=0.828), total=  14.2s
[CV] model__alpha=10.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.0001
[CV]  model__alpha=10.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-30816.955, tes
t=-34922.224), r2=(train=0.840, test=0.839), total=  15.1s
[CV] model__alpha=10.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.0001
[CV]  model__alpha=10.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-31299.829, tes
t=-28984.641), r2=(train=0.850, test=0.838), total=  12.6s
[CV] model__alpha=10.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.0001
[CV]  model__alpha=10.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-27137.097, tes
t=-47567.727), r2=(train=0.882, test=0.650), total=  13.2s
[CV] model__alpha=25.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.001
[CV]  model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-32620.709, test=
-26404.022), r2=(train=0.835, test=0.874), total=  14.1s
[CV] model__alpha=25.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.001
[CV]  model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-31954.020, test=
-33696.401), r2=(train=0.836, test=0.827), total=  14.6s
[CV] model__alpha=25.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.001
[CV]  model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-32384.509, test=
-35787.114), r2=(train=0.824, test=0.831), total=  14.1s
[CV] model__alpha=25.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.001
[CV]  model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-32874.977, test=
```

```
-29214.511), r2=(train=0.835, test=0.836), total=  12.2s
[CV] model__alpha=25.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.001
[CV]  model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-28267.161, test=
-47972.894), r2=(train=0.872, test=0.644), total=  13.0s
[CV] model__alpha=25.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.0001
[CV]  model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-32612.837, test
=-26385.103), r2=(train=0.835, test=0.874), total=  13.0s
[CV] model__alpha=25.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.0001
[CV]  model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-31948.355, test
=-33695.402), r2=(train=0.836, test=0.827), total=  13.7s
[CV] model__alpha=25.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.0001
[CV]  model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-32378.537, test
=-35810.237), r2=(train=0.824, test=0.831), total=  14.1s
[CV] model__alpha=25.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.0001
[CV]  model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-32870.346, test
=-29208.105), r2=(train=0.835, test=0.836), total=  12.0s
[CV] model__alpha=25.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.0001
[CV]  model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-28258.292, test
=-48009.875), r2=(train=0.872, test=0.643), total=  12.3s
[CV] model__alpha=25.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.001
[CV]  model__alpha=25.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-32620.709, test
=-26404.022), r2=(train=0.835, test=0.874), total=  12.4s
[CV] model__alpha=25.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.001
[CV]  model__alpha=25.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-31954.020, test
=-33696.401), r2=(train=0.836, test=0.827), total=  13.6s
[CV] model__alpha=25.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.001
[CV]  model__alpha=25.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-32384.509, test
=-35787.114), r2=(train=0.824, test=0.831), total=  16.0s
[CV] model__alpha=25.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.001
[CV]  model__alpha=25.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-32874.977, test
=-29214.511), r2=(train=0.835, test=0.836), total=  13.6s
[CV] model__alpha=25.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.001
[CV]  model__alpha=25.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-28267.161, test
=-47972.894), r2=(train=0.872, test=0.644), total=  14.5s
[CV] model__alpha=25.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.0001
[CV]  model__alpha=25.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-32612.837, tes
t=-26385.103), r2=(train=0.835, test=0.874), total=  14.4s
[CV] model__alpha=25.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.0001
[CV]  model__alpha=25.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-31948.355, tes
```

```
t=-33695.402), r2=(train=0.836, test=0.827), total=  14.9s
[CV] model__alpha=25.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.0001
[CV]  model__alpha=25.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-32378.537, tes
t=-35810.237), r2=(train=0.824, test=0.831), total=  14.2s
[CV] model__alpha=25.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.0001
[CV]  model__alpha=25.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-32870.346, tes
t=-29208.105), r2=(train=0.835, test=0.836), total=  11.9s
[CV] model__alpha=25.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.0001
[CV]  model__alpha=25.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-28258.292, tes
t=-48009.875), r2=(train=0.872, test=0.643), total=  11.7s
[CV] model__alpha=50.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.001
[CV]  model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-33840.555, test=
-27109.357), r2=(train=0.823, test=0.867), total=  12.5s
[CV] model__alpha=50.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.001
[CV]  model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-33146.573, test=
-34070.566), r2=(train=0.823, test=0.823), total=  15.1s
[CV] model__alpha=50.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.001
[CV]  model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-33628.201, test=
-36957.953), r2=(train=0.810, test=0.820), total=  15.0s
[CV] model__alpha=50.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.001
[CV]  model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-34215.885, test=
-29744.047), r2=(train=0.821, test=0.830), total=  12.2s
[CV] model__alpha=50.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.001
[CV]  model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-29298.070, test=
-48484.510), r2=(train=0.862, test=0.636), total=  12.2s
[CV] model__alpha=50.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.0001
[CV]  model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-33832.205, test
=-27092.654), r2=(train=0.823, test=0.867), total=  12.5s
[CV] model__alpha=50.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.0001
[CV]  model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-33143.478, test
=-34074.794), r2=(train=0.823, test=0.823), total=  13.8s
[CV] model__alpha=50.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.0001
[CV]  model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-33626.272, test
=-36955.917), r2=(train=0.810, test=0.820), total=  13.9s
[CV] model__alpha=50.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.0001
[CV]  model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-34213.889, test
=-29739.909), r2=(train=0.821, test=0.830), total=  12.0s
[CV] model__alpha=50.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.0001
[CV]  model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-29289.614, test
```

```
=-48521.663), r2=(train=0.862, test=0.636), total=  11.5s
[CV] model__alpha=50.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.001
[CV]  model__alpha=50.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-33840.555, test
=-27109.357), r2=(train=0.823, test=0.867), total=  12.7s
[CV] model__alpha=50.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.001
[CV]  model__alpha=50.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-33146.573, test
=-34070.566), r2=(train=0.823, test=0.823), total=  14.7s
[CV] model__alpha=50.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.001
[CV]  model__alpha=50.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-33628.201, test
=-36957.953), r2=(train=0.810, test=0.820), total=  14.1s
[CV] model__alpha=50.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.001
[CV]  model__alpha=50.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-34215.885, test
=-29744.047), r2=(train=0.821, test=0.830), total=  12.5s
[CV] model__alpha=50.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.001
[CV]  model__alpha=50.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-29298.070, test
=-48484.510), r2=(train=0.862, test=0.636), total=  11.5s
[CV] model__alpha=50.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.0001
[CV]  model__alpha=50.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-33832.205, tes
t=-27092.654), r2=(train=0.823, test=0.867), total=  12.5s
[CV] model__alpha=50.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.0001
[CV]  model__alpha=50.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-33143.478, tes
t=-34074.794), r2=(train=0.823, test=0.823), total=  14.1s
[CV] model__alpha=50.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.0001
[CV]  model__alpha=50.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-33626.272, tes
t=-36955.917), r2=(train=0.810, test=0.820), total=  16.1s
[CV] model__alpha=50.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.0001
[CV]  model__alpha=50.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-34213.889, tes
t=-29739.909), r2=(train=0.821, test=0.830), total=  13.0s
[CV] model__alpha=50.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.0001
[CV]  model__alpha=50.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-29289.614, tes
t=-48521.663), r2=(train=0.862, test=0.636), total=  14.6s
[CV] model__alpha=75.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.001
[CV]  model__alpha=75.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-34601.366, test=
-27671.529), r2=(train=0.815, test=0.862), total=  14.3s
[CV] model__alpha=75.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.001
[CV]  model__alpha=75.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-33897.761, test=
-34410.237), r2=(train=0.815, test=0.819), total=  14.6s
[CV] model__alpha=75.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.001
[CV]  model__alpha=75.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-34388.950, test=
```

```
-37780.595), r2=(train=0.801, test=0.812), total=  13.9s
[CV] model__alpha=75.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.001
[CV]  model__alpha=75.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-35063.693, test=
-30192.320), r2=(train=0.812, test=0.824), total=  12.1s
[CV] model__alpha=75.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.001
[CV]  model__alpha=75.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-29971.263, test=
-48793.628), r2=(train=0.856, test=0.631), total=  11.6s
[CV] model__alpha=75.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.0001
[CV]  model__alpha=75.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-34599.893, test
=-27668.287), r2=(train=0.815, test=0.862), total=  12.4s
[CV] model__alpha=75.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.0001
[CV]  model__alpha=75.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-33894.278, test
=-34407.056), r2=(train=0.815, test=0.819), total=  13.7s
[CV] model__alpha=75.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.0001
[CV]  model__alpha=75.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-34387.190, test
=-37773.169), r2=(train=0.801, test=0.812), total=  14.8s
[CV] model__alpha=75.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.0001
[CV]  model__alpha=75.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-35062.161, test
=-30198.001), r2=(train=0.812, test=0.824), total=  12.0s
[CV] model__alpha=75.0, model__max_iter=500, model__normalize=False, model__solv
er=auto, model__tol=0.0001
[CV]  model__alpha=75.0, model__max_iter=500, model__normalize=False, model__sol
ver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-29969.651, test
=-48805.769), r2=(train=0.856, test=0.631), total=  11.6s
[CV] model__alpha=75.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.001
[CV]  model__alpha=75.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-34601.366, test
=-27671.529), r2=(train=0.815, test=0.862), total=  13.0s
[CV] model__alpha=75.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.001
[CV]  model__alpha=75.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-33897.761, test
=-34410.237), r2=(train=0.815, test=0.819), total=  17.3s
[CV] model__alpha=75.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.001
[CV]  model__alpha=75.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-34388.950, test
=-37780.595), r2=(train=0.801, test=0.812), total=  17.4s
[CV] model__alpha=75.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.001
[CV]  model__alpha=75.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-35063.693, test
=-30192.320), r2=(train=0.812, test=0.824), total=  14.0s
[CV] model__alpha=75.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.001
[CV]  model__alpha=75.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.001, neg_root_mean_squared_error=(train=-29971.263, test
=-48793.628), r2=(train=0.856, test=0.631), total=  11.5s
[CV] model__alpha=75.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.0001
[CV]  model__alpha=75.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-34599.893, tes
```

```
t=-27668.287), r2=(train=0.815, test=0.862), total=  14.3s
[CV] model__alpha=75.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.0001
[CV]  model__alpha=75.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-33894.278, tes
t=-34407.056), r2=(train=0.815, test=0.819), total=  13.7s
[CV] model__alpha=75.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.0001
[CV]  model__alpha=75.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-34387.190, tes
t=-37773.169), r2=(train=0.801, test=0.812), total=  14.3s
[CV] model__alpha=75.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.0001
[CV]  model__alpha=75.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-35062.161, tes
t=-30198.001), r2=(train=0.812, test=0.824), total=  14.1s
[CV] model__alpha=75.0, model__max_iter=2000, model__normalize=False, model__sol
ver=auto, model__tol=0.0001
[CV]  model__alpha=75.0, model__max_iter=2000, model__normalize=False, model__so
lver=auto, model__tol=0.0001, neg_root_mean_squared_error=(train=-29969.651, tes
t=-48805.769), r2=(train=0.856, test=0.631), total=  13.8s
[Parallel(n_jobs=1)]: Done  80 out of  80 | elapsed: 17.9min finished
```

In [47]:
```
results.best_params_
```

Out[47]:
```
{'model__alpha': 10.0,
 'model__max_iter': 500,
 'model__normalize': False,
 'model__solver': 'auto',
 'model__tol': 0.001}
```

In [48]:
```
results.best_score_
```

Out[48]:
```
-34182.65570655737
```

In [49]:
```
get_results(results)
```

```
The best model parameters produce a mean rmse score on train data of:
-30204.77303842335

The best model parameters produce a mean R-squared score on train data of:
0.8542529575044672

The best model parameters produce a mean rmse score on test data of:
-34182.65570655737

The best model parameters produce a mean R-squared score on test data of:
0.8068734112651119
```

Analysis:

The best parameters for this Ridge regression(linear regression with l2 regularization) were an alpha value of 10.0, maximum iterations of 500, and .001 tol, the default tolerance value.

The best model is slightly overfit to the training data with relation to the validation data, but not too overfit in the broad scope.

Linear Regressions With l1 Regularization

```
x_train = train_df.drop(['SalePrice'], axis=1)
```

In [53]:
```
y_train = train_df['SalePrice']
```

In [56]:
```
lasso_pipeline = Pipeline(steps=[('trans', transformer),
                                 ('rfe', RFE(LinearRegression(normalize=False),
                                 ('model', Lasso(random_state=62))])

lasso_grid = {'model__alpha': [10.0, 25.0, 50.0],
              'model__normalize': [False],
              'model__max_iter': [500, 1000],
              'model__tol': [.001, .0001],
              'model__selection': ['cyclic', 'random']}

lasso_gs = GridSearchCV(lasso_pipeline,
                        lasso_grid,
                        scoring=['neg_root_mean_squared_error', 'r2'],
                        refit='neg_root_mean_squared_error',
                        cv=5,
                        verbose=3,
                        return_train_score=True)
```

In [57]:
```
lasso_results = lasso_gs.fit(x_train, y_train)
```

```
Fitting 5 folds for each of 24 candidates, totalling 120 fits
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sele
ction=cyclic, model__tol=0.001
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[CV]  model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sel
ection=cyclic, model__tol=0.001, neg_root_mean_squared_error=(train=-26143.069,
test=-26060.877), r2=(train=0.894, test=0.877), total=  12.4s
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sele
ction=cyclic, model__tol=0.001
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:   12.4s remaining:    0.0s
[CV]  model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sel
ection=cyclic, model__tol=0.001, neg_root_mean_squared_error=(train=-25728.947,
test=-35061.192), r2=(train=0.893, test=0.812), total=  13.7s
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sele
ction=cyclic, model__tol=0.001
[Parallel(n_jobs=1)]: Done   2 out of   2 | elapsed:   26.2s remaining:    0.0s
[CV]  model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sel
ection=cyclic, model__tol=0.001, neg_root_mean_squared_error=(train=-23926.139,
test=-42020.850), r2=(train=0.904, test=0.767), total=  14.2s
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sele
ction=cyclic, model__tol=0.001
[CV]  model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sel
ection=cyclic, model__tol=0.001, neg_root_mean_squared_error=(train=-26299.722,
test=-29690.450), r2=(train=0.894, test=0.830), total=  12.1s
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sele
ction=cyclic, model__tol=0.001
[CV]  model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sel
ection=cyclic, model__tol=0.001, neg_root_mean_squared_error=(train=-25098.740,
test=-48333.786), r2=(train=0.899, test=0.638), total=  11.5s
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sele
ction=cyclic, model__tol=0.0001
[CV]  model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sel
ection=cyclic, model__tol=0.0001, neg_root_mean_squared_error=(train=-26143.174,
test=-26054.153), r2=(train=0.894, test=0.877), total=  12.4s
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sele
ction=cyclic, model__tol=0.0001
[CV]  model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sel
ection=cyclic, model__tol=0.0001, neg_root_mean_squared_error=(train=-25728.605,
test=-35063.254), r2=(train=0.893, test=0.812), total=  13.5s
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sele
```

ction=cyclic, model__tol=0.0001
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sel
ection=cyclic, model__tol=0.0001, neg_root_mean_squared_error=(train=-23925.210,
test=-42044.563), r2=(train=0.904, test=0.767), total= 13.9s
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sele
ction=cyclic, model__tol=0.0001
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sel
ection=cyclic, model__tol=0.0001, neg_root_mean_squared_error=(train=-26299.450,
test=-29683.108), r2=(train=0.894, test=0.830), total= 12.7s
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sele
ction=cyclic, model__tol=0.0001
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sel
ection=cyclic, model__tol=0.0001, neg_root_mean_squared_error=(train=-25097.907,
test=-48338.065), r2=(train=0.899, test=0.638), total= 12.9s
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sele
ction=random, model__tol=0.001
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sel
ection=random, model__tol=0.001, neg_root_mean_squared_error=(train=-26143.213,
test=-26060.646), r2=(train=0.894, test=0.877), total= 12.4s
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sele
ction=random, model__tol=0.001
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sel
ection=random, model__tol=0.001, neg_root_mean_squared_error=(train=-25729.028,
test=-35060.984), r2=(train=0.893, test=0.812), total= 13.8s
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sele
ction=random, model__tol=0.001
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sel
ection=random, model__tol=0.001, neg_root_mean_squared_error=(train=-23926.372,
test=-42017.930), r2=(train=0.904, test=0.767), total= 14.3s
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sele
ction=random, model__tol=0.001
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sel
ection=random, model__tol=0.001, neg_root_mean_squared_error=(train=-26298.771,
test=-29689.721), r2=(train=0.894, test=0.830), total= 12.2s
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sele
ction=random, model__tol=0.001
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sel
ection=random, model__tol=0.001, neg_root_mean_squared_error=(train=-25098.509,
test=-48336.513), r2=(train=0.899, test=0.638), total= 13.1s
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sele
ction=random, model__tol=0.0001
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sel
ection=random, model__tol=0.0001, neg_root_mean_squared_error=(train=-26143.205,
test=-26062.218), r2=(train=0.894, test=0.877), total= 12.8s
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sele
ction=random, model__tol=0.0001
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sel
ection=random, model__tol=0.0001, neg_root_mean_squared_error=(train=-25728.609,
test=-35063.260), r2=(train=0.893, test=0.812), total= 14.0s
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sele
ction=random, model__tol=0.0001
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sel
ection=random, model__tol=0.0001, neg_root_mean_squared_error=(train=-23925.481,
test=-42038.228), r2=(train=0.904, test=0.767), total= 14.2s
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sele
ction=random, model__tol=0.0001
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sel
ection=random, model__tol=0.0001, neg_root_mean_squared_error=(train=-26299.294,
test=-29682.467), r2=(train=0.894, test=0.830), total= 12.0s
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sele
ction=random, model__tol=0.0001
[CV] model__alpha=10.0, model__max_iter=500, model__normalize=False, model__sel
ection=random, model__tol=0.0001, neg_root_mean_squared_error=(train=-25097.888,
test=-48338.366), r2=(train=0.899, test=0.638), total= 11.7s
[CV] model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__sel

```
ection=cyclic, model__tol=0.001
[CV]  model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__se
lection=cyclic, model__tol=0.001, neg_root_mean_squared_error=(train=-26143.069,
test=-26060.877), r2=(train=0.894, test=0.877), total=  12.9s
[CV] model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__sel
ection=cyclic, model__tol=0.001
[CV]  model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__se
lection=cyclic, model__tol=0.001, neg_root_mean_squared_error=(train=-25728.947,
test=-35061.192), r2=(train=0.893, test=0.812), total=  13.7s
[CV] model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__sel
ection=cyclic, model__tol=0.001
[CV]  model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__se
lection=cyclic, model__tol=0.001, neg_root_mean_squared_error=(train=-23926.139,
test=-42020.850), r2=(train=0.904, test=0.767), total=  13.9s
[CV] model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__sel
ection=cyclic, model__tol=0.001
[CV]  model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__se
lection=cyclic, model__tol=0.001, neg_root_mean_squared_error=(train=-26299.722,
test=-29690.450), r2=(train=0.894, test=0.830), total=  11.9s
[CV] model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__sel
ection=cyclic, model__tol=0.001
[CV]  model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__se
lection=cyclic, model__tol=0.001, neg_root_mean_squared_error=(train=-25098.740,
test=-48333.786), r2=(train=0.899, test=0.638), total=  11.8s
[CV] model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__sel
ection=cyclic, model__tol=0.0001
[CV]  model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__se
lection=cyclic, model__tol=0.0001, neg_root_mean_squared_error=(train=-26143.17
4, test=-26054.153), r2=(train=0.894, test=0.877), total=  12.4s
[CV] model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__sel
ection=cyclic, model__tol=0.0001
[CV]  model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__se
lection=cyclic, model__tol=0.0001, neg_root_mean_squared_error=(train=-25728.60
5, test=-35063.254), r2=(train=0.893, test=0.812), total=  14.3s
[CV] model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__sel
ection=cyclic, model__tol=0.0001
[CV]  model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__se
lection=cyclic, model__tol=0.0001, neg_root_mean_squared_error=(train=-23925.21
0, test=-42044.563), r2=(train=0.904, test=0.767), total=  13.9s
[CV] model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__sel
ection=cyclic, model__tol=0.0001
[CV]  model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__se
lection=cyclic, model__tol=0.0001, neg_root_mean_squared_error=(train=-26299.45
0, test=-29683.108), r2=(train=0.894, test=0.830), total=  12.0s
[CV] model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__sel
ection=cyclic, model__tol=0.0001
[CV]  model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__se
lection=cyclic, model__tol=0.0001, neg_root_mean_squared_error=(train=-25097.90
7, test=-48338.065), r2=(train=0.899, test=0.638), total=  11.4s
[CV] model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__sel
ection=random, model__tol=0.001
[CV]  model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__se
lection=random, model__tol=0.001, neg_root_mean_squared_error=(train=-26143.213,
test=-26060.646), r2=(train=0.894, test=0.877), total=  12.6s
[CV] model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__sel
ection=random, model__tol=0.001
[CV]  model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__se
lection=random, model__tol=0.001, neg_root_mean_squared_error=(train=-25729.028,
test=-35060.984), r2=(train=0.893, test=0.812), total=  14.2s
[CV] model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__sel
ection=random, model__tol=0.001
[CV]  model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__se
lection=random, model__tol=0.001, neg_root_mean_squared_error=(train=-23926.372,
test=-42017.930), r2=(train=0.904, test=0.767), total=  14.6s
[CV] model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__sel
```

```
ection=random, model__tol=0.001
[CV]  model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__se
lection=random, model__tol=0.001, neg_root_mean_squared_error=(train=-26298.771,
test=-29689.721), r2=(train=0.894, test=0.830), total=  16.1s
[CV] model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__sel
ection=random, model__tol=0.001
[CV]  model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__se
lection=random, model__tol=0.001, neg_root_mean_squared_error=(train=-25098.509,
test=-48336.513), r2=(train=0.899, test=0.638), total=  13.4s
[CV] model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__sel
ection=random, model__tol=0.0001
[CV]  model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__se
lection=random, model__tol=0.0001, neg_root_mean_squared_error=(train=-26143.20
5, test=-26062.218), r2=(train=0.894, test=0.877), total=  15.2s
[CV] model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__sel
ection=random, model__tol=0.0001
[CV]  model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__se
lection=random, model__tol=0.0001, neg_root_mean_squared_error=(train=-25728.60
9, test=-35063.260), r2=(train=0.893, test=0.812), total=  15.7s
[CV] model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__sel
ection=random, model__tol=0.0001
[CV]  model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__se
lection=random, model__tol=0.0001, neg_root_mean_squared_error=(train=-23925.26
6, test=-42043.607), r2=(train=0.904, test=0.767), total=  14.4s
[CV] model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__sel
ection=random, model__tol=0.0001
[CV]  model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__se
lection=random, model__tol=0.0001, neg_root_mean_squared_error=(train=-26299.29
4, test=-29682.467), r2=(train=0.894, test=0.830), total=  12.1s
[CV] model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__sel
ection=random, model__tol=0.0001
[CV]  model__alpha=10.0, model__max_iter=1000, model__normalize=False, model__se
lection=random, model__tol=0.0001, neg_root_mean_squared_error=(train=-25097.88
8, test=-48338.366), r2=(train=0.899, test=0.638), total=  11.7s
[CV] model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sele
ction=cyclic, model__tol=0.001
[CV]  model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sel
ection=cyclic, model__tol=0.001, neg_root_mean_squared_error=(train=-26326.500,
test=-25852.840), r2=(train=0.893, test=0.879), total=  12.6s
[CV] model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sele
ction=cyclic, model__tol=0.001
[CV]  model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sel
ection=cyclic, model__tol=0.001, neg_root_mean_squared_error=(train=-25990.260,
test=-34785.669), r2=(train=0.891, test=0.815), total=  13.9s
[CV] model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sele
ction=cyclic, model__tol=0.001
[CV]  model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sel
ection=cyclic, model__tol=0.001, neg_root_mean_squared_error=(train=-24263.358,
test=-40039.880), r2=(train=0.901, test=0.789), total=  14.5s
[CV] model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sele
ction=cyclic, model__tol=0.001
[CV]  model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sel
ection=cyclic, model__tol=0.001, neg_root_mean_squared_error=(train=-26523.096,
test=-29271.486), r2=(train=0.892, test=0.835), total=  11.9s
[CV] model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sele
ction=cyclic, model__tol=0.001
[CV]  model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sel
ection=cyclic, model__tol=0.001, neg_root_mean_squared_error=(train=-25362.209,
test=-47987.312), r2=(train=0.897, test=0.644), total=  11.5s
[CV] model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sele
ction=cyclic, model__tol=0.0001
[CV]  model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sel
ection=cyclic, model__tol=0.0001, neg_root_mean_squared_error=(train=-26327.093,
test=-25841.132), r2=(train=0.893, test=0.879), total=  12.4s
[CV] model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sele
```

```
ction=cyclic, model__tol=0.0001
[CV]  model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sel
ection=cyclic, model__tol=0.0001, neg_root_mean_squared_error=(train=-25990.427,
test=-34787.336), r2=(train=0.891, test=0.815), total=  13.9s
[CV] model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sele
ction=cyclic, model__tol=0.0001
[CV]  model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sel
ection=cyclic, model__tol=0.0001, neg_root_mean_squared_error=(train=-24258.532,
test=-40076.212), r2=(train=0.901, test=0.788), total=  14.0s
[CV] model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sele
ction=cyclic, model__tol=0.0001
[CV]  model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sel
ection=cyclic, model__tol=0.0001, neg_root_mean_squared_error=(train=-26522.662,
test=-29272.273), r2=(train=0.892, test=0.835), total=  12.0s
[CV] model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sele
ction=cyclic, model__tol=0.0001
[CV]  model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sel
ection=cyclic, model__tol=0.0001, neg_root_mean_squared_error=(train=-25359.573,
test=-47994.448), r2=(train=0.897, test=0.643), total=  11.5s
[CV] model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sele
ction=random, model__tol=0.001
[CV]  model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sel
ection=random, model__tol=0.001, neg_root_mean_squared_error=(train=-26327.311,
test=-25836.390), r2=(train=0.893, test=0.879), total=  12.4s
[CV] model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sele
ction=random, model__tol=0.001
[CV]  model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sel
ection=random, model__tol=0.001, neg_root_mean_squared_error=(train=-25992.837,
test=-34789.476), r2=(train=0.891, test=0.815), total=  14.0s
[CV] model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sele
ction=random, model__tol=0.001
[CV]  model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sel
ection=random, model__tol=0.001, neg_root_mean_squared_error=(train=-24264.195,
test=-40035.464), r2=(train=0.901, test=0.789), total=  13.8s
[CV] model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sele
ction=random, model__tol=0.001
[CV]  model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sel
ection=random, model__tol=0.001, neg_root_mean_squared_error=(train=-26522.104,
test=-29270.425), r2=(train=0.892, test=0.835), total=  11.9s
[CV] model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sele
ction=random, model__tol=0.001
[CV]  model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sel
ection=random, model__tol=0.001, neg_root_mean_squared_error=(train=-25362.586,
test=-47985.344), r2=(train=0.897, test=0.644), total=  11.8s
[CV] model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sele
ction=random, model__tol=0.0001
[CV]  model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sel
ection=random, model__tol=0.0001, neg_root_mean_squared_error=(train=-26327.227,
test=-25838.865), r2=(train=0.893, test=0.879), total=  13.4s
[CV] model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sele
ction=random, model__tol=0.0001
[CV]  model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sel
ection=random, model__tol=0.0001, neg_root_mean_squared_error=(train=-25991.635,
test=-34786.937), r2=(train=0.891, test=0.815), total=  14.3s
[CV] model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sele
ction=random, model__tol=0.0001
[CV]  model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sel
ection=random, model__tol=0.0001, neg_root_mean_squared_error=(train=-24258.713,
test=-40075.207), r2=(train=0.901, test=0.788), total=  14.6s
[CV] model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sele
ction=random, model__tol=0.0001
[CV]  model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sel
ection=random, model__tol=0.0001, neg_root_mean_squared_error=(train=-26522.548,
test=-29271.768), r2=(train=0.892, test=0.835), total=  12.1s
[CV] model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sele
```

```
ction=random, model__tol=0.0001
[CV]  model__alpha=25.0, model__max_iter=500, model__normalize=False, model__sel
ection=random, model__tol=0.0001, neg_root_mean_squared_error=(train=-25359.605,
test=-47994.151), r2=(train=0.897, test=0.643), total=  11.5s
[CV] model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__sel
ection=cyclic, model__tol=0.001
[CV]  model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__se
lection=cyclic, model__tol=0.001, neg_root_mean_squared_error=(train=-26326.500,
test=-25852.840), r2=(train=0.893, test=0.879), total=  12.6s
[CV] model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__sel
ection=cyclic, model__tol=0.001
[CV]  model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__se
lection=cyclic, model__tol=0.001, neg_root_mean_squared_error=(train=-25990.260,
test=-34785.669), r2=(train=0.891, test=0.815), total=  13.7s
[CV] model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__sel
ection=cyclic, model__tol=0.001
[CV]  model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__se
lection=cyclic, model__tol=0.001, neg_root_mean_squared_error=(train=-24263.358,
test=-40039.880), r2=(train=0.901, test=0.789), total=  14.1s
[CV] model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__sel
ection=cyclic, model__tol=0.001
[CV]  model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__se
lection=cyclic, model__tol=0.001, neg_root_mean_squared_error=(train=-26523.096,
test=-29271.486), r2=(train=0.892, test=0.835), total=  11.9s
[CV] model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__sel
ection=cyclic, model__tol=0.001
[CV]  model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__se
lection=cyclic, model__tol=0.001, neg_root_mean_squared_error=(train=-25362.209,
test=-47987.312), r2=(train=0.897, test=0.644), total=  12.2s
[CV] model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__sel
ection=cyclic, model__tol=0.0001
[CV]  model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__se
lection=cyclic, model__tol=0.0001, neg_root_mean_squared_error=(train=-26327.09
3, test=-25841.132), r2=(train=0.893, test=0.879), total=  12.9s
[CV] model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__sel
ection=cyclic, model__tol=0.0001
[CV]  model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__se
lection=cyclic, model__tol=0.0001, neg_root_mean_squared_error=(train=-25990.42
7, test=-34787.336), r2=(train=0.891, test=0.815), total=  13.8s
[CV] model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__sel
ection=cyclic, model__tol=0.0001
[CV]  model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__se
lection=cyclic, model__tol=0.0001, neg_root_mean_squared_error=(train=-24258.53
2, test=-40076.212), r2=(train=0.901, test=0.788), total=  14.1s
[CV] model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__sel
ection=cyclic, model__tol=0.0001
[CV]  model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__se
lection=cyclic, model__tol=0.0001, neg_root_mean_squared_error=(train=-26522.66
2, test=-29272.273), r2=(train=0.892, test=0.835), total=  11.9s
[CV] model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__sel
ection=cyclic, model__tol=0.0001
[CV]  model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__se
lection=cyclic, model__tol=0.0001, neg_root_mean_squared_error=(train=-25359.57
3, test=-47994.448), r2=(train=0.897, test=0.643), total=  11.5s
[CV] model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__sel
ection=random, model__tol=0.001
[CV]  model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__se
lection=random, model__tol=0.001, neg_root_mean_squared_error=(train=-26327.311,
test=-25836.390), r2=(train=0.893, test=0.879), total=  12.3s
[CV] model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__sel
ection=random, model__tol=0.001
[CV]  model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__se
lection=random, model__tol=0.001, neg_root_mean_squared_error=(train=-25992.837,
test=-34789.476), r2=(train=0.891, test=0.815), total=  14.0s
[CV] model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__sel
```

```
ection=random, model__tol=0.001
[CV]  model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__se
lection=random, model__tol=0.001, neg_root_mean_squared_error=(train=-24264.195,
test=-40035.464), r2=(train=0.901, test=0.789), total=  14.7s
[CV] model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__sel
ection=random, model__tol=0.001
[CV]  model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__se
lection=random, model__tol=0.001, neg_root_mean_squared_error=(train=-26522.104,
test=-29270.425), r2=(train=0.892, test=0.835), total=  11.9s
[CV] model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__sel
ection=random, model__tol=0.001
[CV]  model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__se
lection=random, model__tol=0.001, neg_root_mean_squared_error=(train=-25362.586,
test=-47985.344), r2=(train=0.897, test=0.644), total=  11.4s
[CV] model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__sel
ection=random, model__tol=0.0001
[CV]  model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__se
lection=random, model__tol=0.0001, neg_root_mean_squared_error=(train=-26327.22
7, test=-25838.865), r2=(train=0.893, test=0.879), total=  12.5s
[CV] model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__sel
ection=random, model__tol=0.0001
[CV]  model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__se
lection=random, model__tol=0.0001, neg_root_mean_squared_error=(train=-25991.63
5, test=-34786.937), r2=(train=0.891, test=0.815), total=  13.8s
[CV] model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__sel
ection=random, model__tol=0.0001
[CV]  model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__se
lection=random, model__tol=0.0001, neg_root_mean_squared_error=(train=-24258.71
3, test=-40075.207), r2=(train=0.901, test=0.788), total=  14.1s
[CV] model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__sel
ection=random, model__tol=0.0001
[CV]  model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__se
lection=random, model__tol=0.0001, neg_root_mean_squared_error=(train=-26522.54
8, test=-29271.768), r2=(train=0.892, test=0.835), total=  12.0s
[CV] model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__sel
ection=random, model__tol=0.0001
[CV]  model__alpha=25.0, model__max_iter=1000, model__normalize=False, model__se
lection=random, model__tol=0.0001, neg_root_mean_squared_error=(train=-25359.60
5, test=-47994.151), r2=(train=0.897, test=0.643), total=  11.7s
[CV] model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sele
ction=cyclic, model__tol=0.001
[CV]  model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sel
ection=cyclic, model__tol=0.001, neg_root_mean_squared_error=(train=-26744.739,
test=-25533.631), r2=(train=0.889, test=0.882), total=  12.2s
[CV] model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sele
ction=cyclic, model__tol=0.001
[CV]  model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sel
ection=cyclic, model__tol=0.001, neg_root_mean_squared_error=(train=-26365.069,
test=-34389.061), r2=(train=0.888, test=0.820), total=  14.2s
[CV] model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sele
ction=cyclic, model__tol=0.001
[CV]  model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sel
ection=cyclic, model__tol=0.001, neg_root_mean_squared_error=(train=-24846.652,
test=-38022.554), r2=(train=0.896, test=0.809), total=  14.2s
[CV] model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sele
ction=cyclic, model__tol=0.001
[CV]  model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sel
ection=cyclic, model__tol=0.001, neg_root_mean_squared_error=(train=-26956.076,
test=-28929.463), r2=(train=0.889, test=0.839), total=  12.0s
[CV] model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sele
ction=cyclic, model__tol=0.001
[CV]  model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sel
ection=cyclic, model__tol=0.001, neg_root_mean_squared_error=(train=-25803.443,
test=-47533.410), r2=(train=0.893, test=0.650), total=  11.5s
[CV] model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sele
```

```
ction=cyclic, model__tol=0.0001
[CV]  model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sel
ection=cyclic, model__tol=0.0001, neg_root_mean_squared_error=(train=-26747.370,
test=-25516.496), r2=(train=0.889, test=0.882), total=  12.6s
[CV] model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sele
ction=cyclic, model__tol=0.0001
[CV]  model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sel
ection=cyclic, model__tol=0.0001, neg_root_mean_squared_error=(train=-26365.171,
test=-34389.347), r2=(train=0.888, test=0.820), total=  13.5s
[CV] model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sele
ction=cyclic, model__tol=0.0001
[CV]  model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sel
ection=cyclic, model__tol=0.0001, neg_root_mean_squared_error=(train=-24852.127,
test=-38001.387), r2=(train=0.896, test=0.810), total=  14.7s
[CV] model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sele
ction=cyclic, model__tol=0.0001
[CV]  model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sel
ection=cyclic, model__tol=0.0001, neg_root_mean_squared_error=(train=-26955.066,
test=-28931.009), r2=(train=0.889, test=0.839), total=  12.0s
[CV] model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sele
ction=cyclic, model__tol=0.0001
[CV]  model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sel
ection=cyclic, model__tol=0.0001, neg_root_mean_squared_error=(train=-25803.486,
test=-47535.761), r2=(train=0.893, test=0.650), total=  11.4s
[CV] model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sele
ction=random, model__tol=0.001
[CV]  model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sel
ection=random, model__tol=0.001, neg_root_mean_squared_error=(train=-26748.208,
test=-25510.998), r2=(train=0.889, test=0.882), total=  12.4s
[CV] model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sele
ction=random, model__tol=0.001
[CV]  model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sel
ection=random, model__tol=0.001, neg_root_mean_squared_error=(train=-26364.872,
test=-34391.098), r2=(train=0.888, test=0.819), total=  13.5s
[CV] model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sele
ction=random, model__tol=0.001
[CV]  model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sel
ection=random, model__tol=0.001, neg_root_mean_squared_error=(train=-24851.077,
test=-38008.070), r2=(train=0.896, test=0.810), total=  14.1s
[CV] model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sele
ction=random, model__tol=0.001
[CV]  model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sel
ection=random, model__tol=0.001, neg_root_mean_squared_error=(train=-26955.758,
test=-28930.160), r2=(train=0.889, test=0.839), total=  11.9s
[CV] model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sele
ction=random, model__tol=0.001
[CV]  model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sel
ection=random, model__tol=0.001, neg_root_mean_squared_error=(train=-25803.035,
test=-47533.475), r2=(train=0.893, test=0.650), total=  11.5s
[CV] model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sele
ction=random, model__tol=0.0001
[CV]  model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sel
ection=random, model__tol=0.0001, neg_root_mean_squared_error=(train=-26747.841,
test=-25513.718), r2=(train=0.889, test=0.882), total=  15.1s
[CV] model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sele
ction=random, model__tol=0.0001
[CV]  model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sel
ection=random, model__tol=0.0001, neg_root_mean_squared_error=(train=-26365.082,
test=-34389.961), r2=(train=0.888, test=0.820), total=  18.3s
[CV] model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sele
ction=random, model__tol=0.0001
[CV]  model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sel
ection=random, model__tol=0.0001, neg_root_mean_squared_error=(train=-24852.779,
test=-37999.384), r2=(train=0.896, test=0.810), total=  18.4s
[CV] model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sele
```

```
ction=random, model__tol=0.0001
[CV]  model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sel
ection=random, model__tol=0.0001, neg_root_mean_squared_error=(train=-26954.987,
test=-28931.094), r2=(train=0.889, test=0.839), total=  16.2s
[CV] model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sele
ction=random, model__tol=0.0001
[CV]  model__alpha=50.0, model__max_iter=500, model__normalize=False, model__sel
ection=random, model__tol=0.0001, neg_root_mean_squared_error=(train=-25803.306,
test=-47535.539), r2=(train=0.893, test=0.650), total=  15.6s
[CV] model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__sel
ection=cyclic, model__tol=0.001
[CV]  model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__se
lection=cyclic, model__tol=0.001, neg_root_mean_squared_error=(train=-26744.739,
test=-25533.631), r2=(train=0.889, test=0.882), total=  13.4s
[CV] model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__sel
ection=cyclic, model__tol=0.001
[CV]  model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__se
lection=cyclic, model__tol=0.001, neg_root_mean_squared_error=(train=-26365.069,
test=-34389.061), r2=(train=0.888, test=0.820), total=  13.5s
[CV] model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__sel
ection=cyclic, model__tol=0.001
[CV]  model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__se
lection=cyclic, model__tol=0.001, neg_root_mean_squared_error=(train=-24846.652,
test=-38022.554), r2=(train=0.896, test=0.809), total=  14.2s
[CV] model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__sel
ection=cyclic, model__tol=0.001
[CV]  model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__se
lection=cyclic, model__tol=0.001, neg_root_mean_squared_error=(train=-26956.076,
test=-28929.463), r2=(train=0.889, test=0.839), total=  12.0s
[CV] model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__sel
ection=cyclic, model__tol=0.001
[CV]  model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__se
lection=cyclic, model__tol=0.001, neg_root_mean_squared_error=(train=-25803.443,
test=-47533.410), r2=(train=0.893, test=0.650), total=  11.4s
[CV] model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__sel
ection=cyclic, model__tol=0.0001
[CV]  model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__se
lection=cyclic, model__tol=0.0001, neg_root_mean_squared_error=(train=-26747.37
0, test=-25516.496), r2=(train=0.889, test=0.882), total=  12.5s
[CV] model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__sel
ection=cyclic, model__tol=0.0001
[CV]  model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__se
lection=cyclic, model__tol=0.0001, neg_root_mean_squared_error=(train=-26365.17
1, test=-34389.347), r2=(train=0.888, test=0.820), total=  13.5s
[CV] model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__sel
ection=cyclic, model__tol=0.0001
[CV]  model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__se
lection=cyclic, model__tol=0.0001, neg_root_mean_squared_error=(train=-24852.12
7, test=-38001.387), r2=(train=0.896, test=0.810), total=  14.4s
[CV] model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__sel
ection=cyclic, model__tol=0.0001
[CV]  model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__se
lection=cyclic, model__tol=0.0001, neg_root_mean_squared_error=(train=-26955.06
6, test=-28931.009), r2=(train=0.889, test=0.839), total=  12.0s
[CV] model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__sel
ection=cyclic, model__tol=0.0001
[CV]  model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__se
lection=cyclic, model__tol=0.0001, neg_root_mean_squared_error=(train=-25803.48
6, test=-47535.761), r2=(train=0.893, test=0.650), total=  11.9s
[CV] model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__sel
ection=random, model__tol=0.001
[CV]  model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__se
lection=random, model__tol=0.001, neg_root_mean_squared_error=(train=-26748.208,
test=-25510.998), r2=(train=0.889, test=0.882), total=  12.5s
[CV] model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__sel
```

```
ection=random, model__tol=0.001
[CV]  model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__se
lection=random, model__tol=0.001, neg_root_mean_squared_error=(train=-26364.872,
test=-34391.098), r2=(train=0.888, test=0.819), total=  13.7s
[CV] model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__sel
ection=random, model__tol=0.001
[CV]  model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__se
lection=random, model__tol=0.001, neg_root_mean_squared_error=(train=-24851.077,
test=-38008.070), r2=(train=0.896, test=0.810), total=  13.9s
[CV] model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__sel
ection=random, model__tol=0.001
[CV]  model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__se
lection=random, model__tol=0.001, neg_root_mean_squared_error=(train=-26955.758,
test=-28930.160), r2=(train=0.889, test=0.839), total=  12.2s
[CV] model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__sel
ection=random, model__tol=0.001
[CV]  model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__se
lection=random, model__tol=0.001, neg_root_mean_squared_error=(train=-25803.035,
test=-47533.475), r2=(train=0.893, test=0.650), total=  11.4s
[CV] model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__sel
ection=random, model__tol=0.0001
[CV]  model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__se
lection=random, model__tol=0.0001, neg_root_mean_squared_error=(train=-26747.84
1, test=-25513.718), r2=(train=0.889, test=0.882), total=  12.7s
[CV] model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__sel
ection=random, model__tol=0.0001
[CV]  model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__se
lection=random, model__tol=0.0001, neg_root_mean_squared_error=(train=-26365.08
2, test=-34389.961), r2=(train=0.888, test=0.820), total=  13.5s
[CV] model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__sel
ection=random, model__tol=0.0001
[CV]  model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__se
lection=random, model__tol=0.0001, neg_root_mean_squared_error=(train=-24852.77
9, test=-37999.384), r2=(train=0.896, test=0.810), total=  16.6s
[CV] model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__sel
ection=random, model__tol=0.0001
[CV]  model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__se
lection=random, model__tol=0.0001, neg_root_mean_squared_error=(train=-26954.98
7, test=-28931.094), r2=(train=0.889, test=0.839), total=  16.1s
[CV] model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__sel
ection=random, model__tol=0.0001
[CV]  model__alpha=50.0, model__max_iter=1000, model__normalize=False, model__se
lection=random, model__tol=0.0001, neg_root_mean_squared_error=(train=-25803.30
6, test=-47535.539), r2=(train=0.893, test=0.650), total=  15.1s
[Parallel(n_jobs=1)]: Done 120 out of 120 | elapsed: 26.5min finished
```

In [58]:
```
lasso_results.best_params_
```

Out[58]:
```
{'model__alpha': 50.0,
 'model__max_iter': 500,
 'model__normalize': False,
 'model__selection': 'random',
 'model__tol': 0.0001}
```

In [59]:
```
get_results(lasso_results)
```

```
The best model parameters produce a mean rmse score on train data of:
-26144.798791128233

The best model parameters produce a mean R-squared score on train data of:
0.8911157755585011

The best model parameters produce a mean rmse score on test data of:
-34873.93932767444
```

```
The best model parameters produce a mean R-squared score on test data of:
0.8001131523090838
```

Analysis:

The best parameters for this Lasso regression(linear regression with l1 regularization) were an alpha value of 50.0, maximum iterations of 500, and a tolerance of .0001 tol.

The best model is fairly overfit to the training data with relation to the validation data, though only slightly overfit broadly.

Note: I tested an elasticnet regression in a scratch notebook and it performed terribly, so I am not running it here. If you want to see the results, please reference the other notebook.

Decision Tree Regression

In [60]:
```
x_train = train_df.drop(['SalePrice'], axis=1)
y_train = train_df['SalePrice']
```

In [61]:
```
dt_pipeline = Pipeline(steps=[('trans', transformer),
                              ('rfe', RFE(LinearRegression(normalize=False), n_f
                              ('model', DecisionTreeRegressor(random_state=92))]

dt_grid = {'model__criterion': ['mse', 'mae'],
           'model__splitter': ['best'],
           'model__max_depth': [None, 10],
           'model__min_samples_split': [2, 12],
           'model__min_samples_leaf': [1, 3],
           'model__max_features': ['auto']}

dt_gs = GridSearchCV(dt_pipeline,
                     dt_grid,
                     scoring=['neg_root_mean_squared_error', 'r2'],
                     refit='neg_root_mean_squared_error',
                     cv=5,
                     verbose=3,
                     return_train_score=True)
```

In [62]:
```
dt_results = dt_gs.fit(x_train, y_train)
```

```
Fitting 5 folds for each of 16 candidates, totalling 80 fits
[CV] model__criterion=mse, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=1, model__min_samples_split=2, model__splitter=best
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[CV]  model__criterion=mse, model__max_depth=None, model__max_features=auto, mod
el__min_samples_leaf=1, model__min_samples_split=2, model__splitter=best, neg_ro
ot_mean_squared_error=(train=-268.614, test=-39189.359), r2=(train=1.000, test=
0.723), total=  13.9s
[CV] model__criterion=mse, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=1, model__min_samples_split=2, model__splitter=best
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:   13.9s remaining:    0.0s
[CV]  model__criterion=mse, model__max_depth=None, model__max_features=auto, mod
el__min_samples_leaf=1, model__min_samples_split=2, model__splitter=best, neg_ro
ot_mean_squared_error=(train=-685.506, test=-51339.711), r2=(train=1.000, test=
```

```
0.598), total=  13.6s
[CV] model__criterion=mse, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=1, model__min_samples_split=2, model__splitter=best
[Parallel(n_jobs=1)]: Done   2 out of   2 | elapsed:   27.5s remaining:    0.0s
[CV]  model__criterion=mse, model__max_depth=None, model__max_features=auto, mod
el__min_samples_leaf=1, model__min_samples_split=2, model__splitter=best, neg_ro
ot_mean_squared_error=(train=-374.662, test=-38833.158), r2=(train=1.000, test=
0.801), total=  14.1s
[CV] model__criterion=mse, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=1, model__min_samples_split=2, model__splitter=best
[CV]  model__criterion=mse, model__max_depth=None, model__max_features=auto, mod
el__min_samples_leaf=1, model__min_samples_split=2, model__splitter=best, neg_ro
ot_mean_squared_error=(train=-655.318, test=-41827.826), r2=(train=1.000, test=
0.663), total=  12.1s
[CV] model__criterion=mse, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=1, model__min_samples_split=2, model__splitter=best
[CV]  model__criterion=mse, model__max_depth=None, model__max_features=auto, mod
el__min_samples_leaf=1, model__min_samples_split=2, model__splitter=best, neg_ro
ot_mean_squared_error=(train=-605.718, test=-56617.386), r2=(train=1.000, test=
0.504), total=  11.5s
[CV] model__criterion=mse, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=1, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mse, model__max_depth=None, model__max_features=auto, mod
el__min_samples_leaf=1, model__min_samples_split=12, model__splitter=best, neg_r
oot_mean_squared_error=(train=-16897.171, test=-38655.641), r2=(train=0.956, tes
t=0.730), total=  12.5s
[CV] model__criterion=mse, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=1, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mse, model__max_depth=None, model__max_features=auto, mod
el__min_samples_leaf=1, model__min_samples_split=12, model__splitter=best, neg_r
oot_mean_squared_error=(train=-19294.295, test=-44372.054), r2=(train=0.940, tes
t=0.700), total=  13.9s
[CV] model__criterion=mse, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=1, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mse, model__max_depth=None, model__max_features=auto, mod
el__min_samples_leaf=1, model__min_samples_split=12, model__splitter=best, neg_r
oot_mean_squared_error=(train=-17581.143, test=-37328.735), r2=(train=0.948, tes
t=0.816), total=  13.8s
[CV] model__criterion=mse, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=1, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mse, model__max_depth=None, model__max_features=auto, mod
el__min_samples_leaf=1, model__min_samples_split=12, model__splitter=best, neg_r
oot_mean_squared_error=(train=-20526.827, test=-31975.034), r2=(train=0.936, tes
t=0.803), total=  12.1s
[CV] model__criterion=mse, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=1, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mse, model__max_depth=None, model__max_features=auto, mod
el__min_samples_leaf=1, model__min_samples_split=12, model__splitter=best, neg_r
oot_mean_squared_error=(train=-16447.341, test=-50909.918), r2=(train=0.957, tes
t=0.599), total=  11.5s
[CV] model__criterion=mse, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=3, model__min_samples_split=2, model__splitter=best
[CV]  model__criterion=mse, model__max_depth=None, model__max_features=auto, mod
el__min_samples_leaf=3, model__min_samples_split=2, model__splitter=best, neg_ro
ot_mean_squared_error=(train=-17082.124, test=-37210.774), r2=(train=0.955, test
=0.750), total=  12.5s
[CV] model__criterion=mse, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=3, model__min_samples_split=2, model__splitter=best
[CV]  model__criterion=mse, model__max_depth=None, model__max_features=auto, mod
el__min_samples_leaf=3, model__min_samples_split=2, model__splitter=best, neg_ro
ot_mean_squared_error=(train=-19451.157, test=-39397.445), r2=(train=0.939, test
=0.763), total=  13.4s
[CV] model__criterion=mse, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=3, model__min_samples_split=2, model__splitter=best
[CV]  model__criterion=mse, model__max_depth=None, model__max_features=auto, mod
```

```
el__min_samples_leaf=3, model__min_samples_split=2, model__splitter=best, neg_ro
ot_mean_squared_error=(train=-19029.962, test=-46838.185), r2=(train=0.939, test
=0.711), total=  14.3s
[CV] model__criterion=mse, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=3, model__min_samples_split=2, model__splitter=best
[CV]  model__criterion=mse, model__max_depth=None, model__max_features=auto, mod
el__min_samples_leaf=3, model__min_samples_split=2, model__splitter=best, neg_ro
ot_mean_squared_error=(train=-21792.433, test=-33652.965), r2=(train=0.927, test
=0.782), total=  11.8s
[CV] model__criterion=mse, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=3, model__min_samples_split=2, model__splitter=best
[CV]  model__criterion=mse, model__max_depth=None, model__max_features=auto, mod
el__min_samples_leaf=3, model__min_samples_split=2, model__splitter=best, neg_ro
ot_mean_squared_error=(train=-18500.033, test=-43924.474), r2=(train=0.945, test
=0.701), total=  12.3s
[CV] model__criterion=mse, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=3, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mse, model__max_depth=None, model__max_features=auto, mod
el__min_samples_leaf=3, model__min_samples_split=12, model__splitter=best, neg_r
oot_mean_squared_error=(train=-20120.453, test=-37626.285), r2=(train=0.937, tes
t=0.744), total=  12.5s
[CV] model__criterion=mse, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=3, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mse, model__max_depth=None, model__max_features=auto, mod
el__min_samples_leaf=3, model__min_samples_split=12, model__splitter=best, neg_r
oot_mean_squared_error=(train=-22534.753, test=-40769.342), r2=(train=0.918, tes
t=0.746), total=  13.7s
[CV] model__criterion=mse, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=3, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mse, model__max_depth=None, model__max_features=auto, mod
el__min_samples_leaf=3, model__min_samples_split=12, model__splitter=best, neg_r
oot_mean_squared_error=(train=-22839.347, test=-42528.074), r2=(train=0.912, tes
t=0.762), total=  14.2s
[CV] model__criterion=mse, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=3, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mse, model__max_depth=None, model__max_features=auto, mod
el__min_samples_leaf=3, model__min_samples_split=12, model__splitter=best, neg_r
oot_mean_squared_error=(train=-24728.612, test=-31939.485), r2=(train=0.906, tes
t=0.804), total=  12.1s
[CV] model__criterion=mse, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=3, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mse, model__max_depth=None, model__max_features=auto, mod
el__min_samples_leaf=3, model__min_samples_split=12, model__splitter=best, neg_r
oot_mean_squared_error=(train=-22614.464, test=-40793.551), r2=(train=0.918, tes
t=0.742), total=  11.8s
[CV] model__criterion=mse, model__max_depth=10, model__max_features=auto, model_
_min_samples_leaf=1, model__min_samples_split=2, model__splitter=best
[CV]  model__criterion=mse, model__max_depth=10, model__max_features=auto, model
__min_samples_leaf=1, model__min_samples_split=2, model__splitter=best, neg_root
_mean_squared_error=(train=-12654.920, test=-39350.907), r2=(train=0.975, test=
0.720), total=  12.5s
[CV] model__criterion=mse, model__max_depth=10, model__max_features=auto, model_
_min_samples_leaf=1, model__min_samples_split=2, model__splitter=best
[CV]  model__criterion=mse, model__max_depth=10, model__max_features=auto, model
__min_samples_leaf=1, model__min_samples_split=2, model__splitter=best, neg_root
_mean_squared_error=(train=-11509.210, test=-34199.546), r2=(train=0.979, test=
0.821), total=  14.0s
[CV] model__criterion=mse, model__max_depth=10, model__max_features=auto, model_
_min_samples_leaf=1, model__min_samples_split=2, model__splitter=best
[CV]  model__criterion=mse, model__max_depth=10, model__max_features=auto, model
__min_samples_leaf=1, model__min_samples_split=2, model__splitter=best, neg_root
_mean_squared_error=(train=-14161.032, test=-35240.820), r2=(train=0.966, test=
0.836), total=  14.2s
[CV] model__criterion=mse, model__max_depth=10, model__max_features=auto, model_
_min_samples_leaf=1, model__min_samples_split=2, model__splitter=best
```

```
[CV]  model__criterion=mse, model__max_depth=10, model__max_features=auto, model
__min_samples_leaf=1, model__min_samples_split=2, model__splitter=best, neg_root
_mean_squared_error=(train=-14538.939, test=-39911.464), r2=(train=0.968, test=
0.693), total=  12.0s
[CV] model__criterion=mse, model__max_depth=10, model__max_features=auto, model_
_min_samples_leaf=1, model__min_samples_split=2, model__splitter=best
[CV]  model__criterion=mse, model__max_depth=10, model__max_features=auto, model
__min_samples_leaf=1, model__min_samples_split=2, model__splitter=best, neg_root
_mean_squared_error=(train=-12270.395, test=-57138.510), r2=(train=0.976, test=
0.495), total=  11.5s
[CV] model__criterion=mse, model__max_depth=10, model__max_features=auto, model_
_min_samples_leaf=1, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mse, model__max_depth=10, model__max_features=auto, model
__min_samples_leaf=1, model__min_samples_split=12, model__splitter=best, neg_roo
t_mean_squared_error=(train=-19206.010, test=-39133.680), r2=(train=0.943, test=
0.724), total=  12.6s
[CV] model__criterion=mse, model__max_depth=10, model__max_features=auto, model_
_min_samples_leaf=1, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mse, model__max_depth=10, model__max_features=auto, model
__min_samples_leaf=1, model__min_samples_split=12, model__splitter=best, neg_roo
t_mean_squared_error=(train=-20349.445, test=-38210.319), r2=(train=0.933, test=
0.777), total=  13.7s
[CV] model__criterion=mse, model__max_depth=10, model__max_features=auto, model_
_min_samples_leaf=1, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mse, model__max_depth=10, model__max_features=auto, model
__min_samples_leaf=1, model__min_samples_split=12, model__splitter=best, neg_roo
t_mean_squared_error=(train=-20058.445, test=-36595.657), r2=(train=0.932, test=
0.823), total=  14.0s
[CV] model__criterion=mse, model__max_depth=10, model__max_features=auto, model_
_min_samples_leaf=1, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mse, model__max_depth=10, model__max_features=auto, model
__min_samples_leaf=1, model__min_samples_split=12, model__splitter=best, neg_roo
t_mean_squared_error=(train=-22556.534, test=-31208.700), r2=(train=0.922, test=
0.812), total=  12.2s
[CV] model__criterion=mse, model__max_depth=10, model__max_features=auto, model_
_min_samples_leaf=1, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mse, model__max_depth=10, model__max_features=auto, model
__min_samples_leaf=1, model__min_samples_split=12, model__splitter=best, neg_roo
t_mean_squared_error=(train=-18707.109, test=-52859.165), r2=(train=0.944, test=
0.567), total=  13.3s
[CV] model__criterion=mse, model__max_depth=10, model__max_features=auto, model_
_min_samples_leaf=3, model__min_samples_split=2, model__splitter=best
[CV]  model__criterion=mse, model__max_depth=10, model__max_features=auto, model
__min_samples_leaf=3, model__min_samples_split=2, model__splitter=best, neg_root
_mean_squared_error=(train=-19248.384, test=-37119.892), r2=(train=0.943, test=
0.751), total=  15.2s
[CV] model__criterion=mse, model__max_depth=10, model__max_features=auto, model_
_min_samples_leaf=3, model__min_samples_split=2, model__splitter=best
[CV]  model__criterion=mse, model__max_depth=10, model__max_features=auto, model
__min_samples_leaf=3, model__min_samples_split=2, model__splitter=best, neg_root
_mean_squared_error=(train=-20474.230, test=-39082.633), r2=(train=0.932, test=
0.767), total=  15.6s
[CV] model__criterion=mse, model__max_depth=10, model__max_features=auto, model_
_min_samples_leaf=3, model__min_samples_split=2, model__splitter=best
[CV]  model__criterion=mse, model__max_depth=10, model__max_features=auto, model
__min_samples_leaf=3, model__min_samples_split=2, model__splitter=best, neg_root
_mean_squared_error=(train=-21212.785, test=-46116.268), r2=(train=0.924, test=
0.720), total=  14.0s
[CV] model__criterion=mse, model__max_depth=10, model__max_features=auto, model_
_min_samples_leaf=3, model__min_samples_split=2, model__splitter=best
[CV]  model__criterion=mse, model__max_depth=10, model__max_features=auto, model
__min_samples_leaf=3, model__min_samples_split=2, model__splitter=best, neg_root
_mean_squared_error=(train=-23230.077, test=-32776.497), r2=(train=0.917, test=
0.793), total=  12.0s
[CV] model__criterion=mse, model__max_depth=10, model__max_features=auto, model_
```

```
_min_samples_leaf=3, model__min_samples_split=2, model__splitter=best
[CV]  model__criterion=mse, model__max_depth=10, model__max_features=auto, model
__min_samples_leaf=3, model__min_samples_split=2, model__splitter=best, neg_root
_mean_squared_error=(train=-20612.698, test=-44143.395), r2=(train=0.932, test=
0.698), total=  11.4s
[CV] model__criterion=mse, model__max_depth=10, model__max_features=auto, model_
_min_samples_leaf=3, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mse, model__max_depth=10, model__max_features=auto, model
__min_samples_leaf=3, model__min_samples_split=12, model__splitter=best, neg_roo
t_mean_squared_error=(train=-21470.631, test=-37594.772), r2=(train=0.929, test=
0.745), total=  12.4s
[CV] model__criterion=mse, model__max_depth=10, model__max_features=auto, model_
_min_samples_leaf=3, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mse, model__max_depth=10, model__max_features=auto, model
__min_samples_leaf=3, model__min_samples_split=12, model__splitter=best, neg_roo
t_mean_squared_error=(train=-23072.598, test=-40556.881), r2=(train=0.914, test=
0.749), total=  14.1s
[CV] model__criterion=mse, model__max_depth=10, model__max_features=auto, model_
_min_samples_leaf=3, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mse, model__max_depth=10, model__max_features=auto, model
__min_samples_leaf=3, model__min_samples_split=12, model__splitter=best, neg_roo
t_mean_squared_error=(train=-23959.443, test=-42316.949), r2=(train=0.904, test=
0.764), total=  14.1s
[CV] model__criterion=mse, model__max_depth=10, model__max_features=auto, model_
_min_samples_leaf=3, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mse, model__max_depth=10, model__max_features=auto, model
__min_samples_leaf=3, model__min_samples_split=12, model__splitter=best, neg_roo
t_mean_squared_error=(train=-25359.081, test=-31742.432), r2=(train=0.902, test=
0.806), total=  11.9s
[CV] model__criterion=mse, model__max_depth=10, model__max_features=auto, model_
_min_samples_leaf=3, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mse, model__max_depth=10, model__max_features=auto, model
__min_samples_leaf=3, model__min_samples_split=12, model__splitter=best, neg_roo
t_mean_squared_error=(train=-23555.594, test=-41047.435), r2=(train=0.911, test=
0.739), total=  11.7s
[CV] model__criterion=mae, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=1, model__min_samples_split=2, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=None, model__max_features=auto, mod
el__min_samples_leaf=1, model__min_samples_split=2, model__splitter=best, neg_ro
ot_mean_squared_error=(train=-268.614, test=-36905.484), r2=(train=1.000, test=
0.754), total=  12.8s
[CV] model__criterion=mae, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=1, model__min_samples_split=2, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=None, model__max_features=auto, mod
el__min_samples_leaf=1, model__min_samples_split=2, model__splitter=best, neg_ro
ot_mean_squared_error=(train=-685.680, test=-48507.701), r2=(train=1.000, test=
0.641), total=  14.1s
[CV] model__criterion=mae, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=1, model__min_samples_split=2, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=None, model__max_features=auto, mod
el__min_samples_leaf=1, model__min_samples_split=2, model__splitter=best, neg_ro
ot_mean_squared_error=(train=-374.662, test=-41113.049), r2=(train=1.000, test=
0.777), total=  14.4s
[CV] model__criterion=mae, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=1, model__min_samples_split=2, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=None, model__max_features=auto, mod
el__min_samples_leaf=1, model__min_samples_split=2, model__splitter=best, neg_ro
ot_mean_squared_error=(train=-655.318, test=-42771.555), r2=(train=1.000, test=
0.648), total=  12.0s
[CV] model__criterion=mae, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=1, model__min_samples_split=2, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=None, model__max_features=auto, mod
el__min_samples_leaf=1, model__min_samples_split=2, model__splitter=best, neg_ro
ot_mean_squared_error=(train=-605.915, test=-49040.064), r2=(train=1.000, test=
0.628), total=  11.7s
```

```
[CV] model__criterion=mae, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=1, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=None, model__max_features=auto, mod
el__min_samples_leaf=1, model__min_samples_split=12, model__splitter=best, neg_r
oot_mean_squared_error=(train=-16200.312, test=-35114.747), r2=(train=0.959, tes
t=0.777), total=  12.6s
[CV] model__criterion=mae, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=1, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=None, model__max_features=auto, mod
el__min_samples_leaf=1, model__min_samples_split=12, model__splitter=best, neg_r
oot_mean_squared_error=(train=-24722.516, test=-43457.551), r2=(train=0.902, tes
t=0.712), total=  14.3s
[CV] model__criterion=mae, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=1, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=None, model__max_features=auto, mod
el__min_samples_leaf=1, model__min_samples_split=12, model__splitter=best, neg_r
oot_mean_squared_error=(train=-16303.975, test=-37601.338), r2=(train=0.955, tes
t=0.814), total=  14.3s
[CV] model__criterion=mae, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=1, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=None, model__max_features=auto, mod
el__min_samples_leaf=1, model__min_samples_split=12, model__splitter=best, neg_r
oot_mean_squared_error=(train=-19335.905, test=-39594.299), r2=(train=0.943, tes
t=0.698), total=  12.4s
[CV] model__criterion=mae, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=1, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=None, model__max_features=auto, mod
el__min_samples_leaf=1, model__min_samples_split=12, model__splitter=best, neg_r
oot_mean_squared_error=(train=-17547.685, test=-50793.669), r2=(train=0.951, tes
t=0.601), total=  11.8s
[CV] model__criterion=mae, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=3, model__min_samples_split=2, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=None, model__max_features=auto, mod
el__min_samples_leaf=3, model__min_samples_split=2, model__splitter=best, neg_ro
ot_mean_squared_error=(train=-19122.664, test=-35359.731), r2=(train=0.943, test
=0.774), total=  13.1s
[CV] model__criterion=mae, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=3, model__min_samples_split=2, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=None, model__max_features=auto, mod
el__min_samples_leaf=3, model__min_samples_split=2, model__splitter=best, neg_ro
ot_mean_squared_error=(train=-21858.345, test=-43346.192), r2=(train=0.923, test
=0.713), total=  14.8s
[CV] model__criterion=mae, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=3, model__min_samples_split=2, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=None, model__max_features=auto, mod
el__min_samples_leaf=3, model__min_samples_split=2, model__splitter=best, neg_ro
ot_mean_squared_error=(train=-22921.096, test=-37193.963), r2=(train=0.912, test
=0.818), total=  14.1s
[CV] model__criterion=mae, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=3, model__min_samples_split=2, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=None, model__max_features=auto, mod
el__min_samples_leaf=3, model__min_samples_split=2, model__splitter=best, neg_ro
ot_mean_squared_error=(train=-24559.197, test=-34501.102), r2=(train=0.908, test
=0.771), total=  12.2s
[CV] model__criterion=mae, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=3, model__min_samples_split=2, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=None, model__max_features=auto, mod
el__min_samples_leaf=3, model__min_samples_split=2, model__splitter=best, neg_ro
ot_mean_squared_error=(train=-21878.217, test=-43961.956), r2=(train=0.923, test
=0.701), total=  11.7s
[CV] model__criterion=mae, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=3, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=None, model__max_features=auto, mod
el__min_samples_leaf=3, model__min_samples_split=12, model__splitter=best, neg_r
oot_mean_squared_error=(train=-23099.149, test=-36077.442), r2=(train=0.917, tes
```

```
t=0.765), total=  12.6s
[CV] model__criterion=mae, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=3, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=None, model__max_features=auto, mod
el__min_samples_leaf=3, model__min_samples_split=12, model__splitter=best, neg_r
oot_mean_squared_error=(train=-27217.420, test=-44428.154), r2=(train=0.881, tes
t=0.699), total=  14.6s
[CV] model__criterion=mae, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=3, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=None, model__max_features=auto, mod
el__min_samples_leaf=3, model__min_samples_split=12, model__splitter=best, neg_r
oot_mean_squared_error=(train=-25492.010, test=-37569.146), r2=(train=0.891, tes
t=0.814), total=  14.3s
[CV] model__criterion=mae, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=3, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=None, model__max_features=auto, mod
el__min_samples_leaf=3, model__min_samples_split=12, model__splitter=best, neg_r
oot_mean_squared_error=(train=-26987.509, test=-31767.958), r2=(train=0.889, tes
t=0.806), total=  12.3s
[CV] model__criterion=mae, model__max_depth=None, model__max_features=auto, mode
l__min_samples_leaf=3, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=None, model__max_features=auto, mod
el__min_samples_leaf=3, model__min_samples_split=12, model__splitter=best, neg_r
oot_mean_squared_error=(train=-24494.714, test=-43834.373), r2=(train=0.904, tes
t=0.703), total=  11.6s
[CV] model__criterion=mae, model__max_depth=10, model__max_features=auto, model_
_min_samples_leaf=1, model__min_samples_split=2, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=10, model__max_features=auto, model
__min_samples_leaf=1, model__min_samples_split=2, model__splitter=best, neg_root
_mean_squared_error=(train=-13235.625, test=-35708.576), r2=(train=0.973, test=
0.770), total=  12.6s
[CV] model__criterion=mae, model__max_depth=10, model__max_features=auto, model_
_min_samples_leaf=1, model__min_samples_split=2, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=10, model__max_features=auto, model
__min_samples_leaf=1, model__min_samples_split=2, model__splitter=best, neg_root
_mean_squared_error=(train=-13564.490, test=-47797.070), r2=(train=0.970, test=
0.651), total=  13.7s
[CV] model__criterion=mae, model__max_depth=10, model__max_features=auto, model_
_min_samples_leaf=1, model__min_samples_split=2, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=10, model__max_features=auto, model
__min_samples_leaf=1, model__min_samples_split=2, model__splitter=best, neg_root
_mean_squared_error=(train=-13472.008, test=-41550.677), r2=(train=0.969, test=
0.772), total=  14.1s
[CV] model__criterion=mae, model__max_depth=10, model__max_features=auto, model_
_min_samples_leaf=1, model__min_samples_split=2, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=10, model__max_features=auto, model
__min_samples_leaf=1, model__min_samples_split=2, model__splitter=best, neg_root
_mean_squared_error=(train=-15729.373, test=-39939.546), r2=(train=0.962, test=
0.693), total=  12.8s
[CV] model__criterion=mae, model__max_depth=10, model__max_features=auto, model_
_min_samples_leaf=1, model__min_samples_split=2, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=10, model__max_features=auto, model
__min_samples_leaf=1, model__min_samples_split=2, model__splitter=best, neg_root
_mean_squared_error=(train=-11336.987, test=-53198.489), r2=(train=0.979, test=
0.562), total=  11.6s
[CV] model__criterion=mae, model__max_depth=10, model__max_features=auto, model_
_min_samples_leaf=1, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=10, model__max_features=auto, model
__min_samples_leaf=1, model__min_samples_split=12, model__splitter=best, neg_roo
t_mean_squared_error=(train=-18260.636, test=-35074.244), r2=(train=0.948, test=
0.778), total=  13.2s
[CV] model__criterion=mae, model__max_depth=10, model__max_features=auto, model_
_min_samples_leaf=1, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=10, model__max_features=auto, model
__min_samples_leaf=1, model__min_samples_split=12, model__splitter=best, neg_roo
```

```
t_mean_squared_error=(train=-25846.097, test=-43945.715), r2=(train=0.892, test=
0.705), total=  13.8s
[CV] model__criterion=mae, model__max_depth=10, model__max_features=auto, model_
_min_samples_leaf=1, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=10, model__max_features=auto, model
__min_samples_leaf=1, model__min_samples_split=12, model__splitter=best, neg_roo
t_mean_squared_error=(train=-18261.467, test=-40078.888), r2=(train=0.944, test=
0.788), total=  14.7s
[CV] model__criterion=mae, model__max_depth=10, model__max_features=auto, model_
_min_samples_leaf=1, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=10, model__max_features=auto, model
__min_samples_leaf=1, model__min_samples_split=12, model__splitter=best, neg_roo
t_mean_squared_error=(train=-21494.413, test=-29255.943), r2=(train=0.929, test=
0.835), total=  12.1s
[CV] model__criterion=mae, model__max_depth=10, model__max_features=auto, model_
_min_samples_leaf=1, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=10, model__max_features=auto, model
__min_samples_leaf=1, model__min_samples_split=12, model__splitter=best, neg_roo
t_mean_squared_error=(train=-18957.222, test=-45161.272), r2=(train=0.942, test=
0.684), total=  11.6s
[CV] model__criterion=mae, model__max_depth=10, model__max_features=auto, model_
_min_samples_leaf=3, model__min_samples_split=2, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=10, model__max_features=auto, model
__min_samples_leaf=3, model__min_samples_split=2, model__splitter=best, neg_root
_mean_squared_error=(train=-20818.099, test=-35243.752), r2=(train=0.933, test=
0.776), total=  13.1s
[CV] model__criterion=mae, model__max_depth=10, model__max_features=auto, model_
_min_samples_leaf=3, model__min_samples_split=2, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=10, model__max_features=auto, model
__min_samples_leaf=3, model__min_samples_split=2, model__splitter=best, neg_root
_mean_squared_error=(train=-22896.704, test=-40233.315), r2=(train=0.916, test=
0.753), total=  13.7s
[CV] model__criterion=mae, model__max_depth=10, model__max_features=auto, model_
_min_samples_leaf=3, model__min_samples_split=2, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=10, model__max_features=auto, model
__min_samples_leaf=3, model__min_samples_split=2, model__splitter=best, neg_root
_mean_squared_error=(train=-21673.612, test=-42089.457), r2=(train=0.921, test=
0.766), total=  14.2s
[CV] model__criterion=mae, model__max_depth=10, model__max_features=auto, model_
_min_samples_leaf=3, model__min_samples_split=2, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=10, model__max_features=auto, model
__min_samples_leaf=3, model__min_samples_split=2, model__splitter=best, neg_root
_mean_squared_error=(train=-25722.951, test=-33871.515), r2=(train=0.899, test=
0.779), total=  12.4s
[CV] model__criterion=mae, model__max_depth=10, model__max_features=auto, model_
_min_samples_leaf=3, model__min_samples_split=2, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=10, model__max_features=auto, model
__min_samples_leaf=3, model__min_samples_split=2, model__splitter=best, neg_root
_mean_squared_error=(train=-22390.049, test=-43851.070), r2=(train=0.920, test=
0.702), total=  11.8s
[CV] model__criterion=mae, model__max_depth=10, model__max_features=auto, model_
_min_samples_leaf=3, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=10, model__max_features=auto, model
__min_samples_leaf=3, model__min_samples_split=12, model__splitter=best, neg_roo
t_mean_squared_error=(train=-24253.818, test=-36529.481), r2=(train=0.909, test=
0.759), total=  12.6s
[CV] model__criterion=mae, model__max_depth=10, model__max_features=auto, model_
_min_samples_leaf=3, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=10, model__max_features=auto, model
__min_samples_leaf=3, model__min_samples_split=12, model__splitter=best, neg_roo
t_mean_squared_error=(train=-27661.317, test=-44063.981), r2=(train=0.877, test=
0.704), total=  13.9s
[CV] model__criterion=mae, model__max_depth=10, model__max_features=auto, model_
_min_samples_leaf=3, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=10, model__max_features=auto, model
```

```
__min_samples_leaf=3, model__min_samples_split=12, model__splitter=best, neg_roo
t_mean_squared_error=(train=-23805.672, test=-42068.093), r2=(train=0.905, test=
0.767), total=  14.1s
[CV] model__criterion=mae, model__max_depth=10, model__max_features=auto, model_
_min_samples_leaf=3, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=10, model__max_features=auto, model
__min_samples_leaf=3, model__min_samples_split=12, model__splitter=best, neg_roo
t_mean_squared_error=(train=-27556.247, test=-31039.179), r2=(train=0.884, test=
0.814), total=  12.1s
[CV] model__criterion=mae, model__max_depth=10, model__max_features=auto, model_
_min_samples_leaf=3, model__min_samples_split=12, model__splitter=best
[CV]  model__criterion=mae, model__max_depth=10, model__max_features=auto, model
__min_samples_leaf=3, model__min_samples_split=12, model__splitter=best, neg_roo
t_mean_squared_error=(train=-24761.479, test=-43766.967), r2=(train=0.902, test=
0.703), total=  11.5s
[Parallel(n_jobs=1)]: Done  80 out of  80 | elapsed: 17.4min finished
```

In [63]:
```
dt_results.best_params_
```

Out[63]:
```
{'model__criterion': 'mse',
 'model__max_depth': 10,
 'model__max_features': 'auto',
 'model__min_samples_leaf': 3,
 'model__min_samples_split': 12,
 'model__splitter': 'best'}
```

In [64]:
```
get_results(dt_results)
```

```
The best model parameters produce a mean rmse score on train data of:
-23483.469430541732

The best model parameters produce a mean R-squared score on train data of:
0.9118110885672543

The best model parameters produce a mean rmse score on test data of:
-38651.694073440085

The best model parameters produce a mean R-squared score on test data of:
0.760553933795492
```

Analysis:

The best parameters for the decision tree regressor were the absolute error for split criterion, a max model depth set to 10(could be interesting to play with this value in the future), a min samples leaf value of 3, a min samples split value of 12, and the 'best' splitter method.

The best model in the grid is considerably overfit to the training data both relative to the validation data as well as to the train set.

Random Forest Regression

In [65]:
```
x_train = train_df.drop(['SalePrice'], axis=1)
y_train = train_df['SalePrice']
```

In [66]:
```
rf_pipeline = Pipeline(steps=[('trans', transformer),
                              ('rfe', RFE(LinearRegression(normalize=False), n_f
                              ('model', RandomForestRegressor(random_state=100))

rf_grid = {'model__n_estimators': [50, 250],
```

```
            'model__criterion': ['mse', 'mae'],
            'model__max_depth': [None, 10],
            'model__min_samples_split': [2],
            'model__min_samples_leaf': [1, 3],
            'model__max_features': ['auto'],
            'model__ccp_alpha': [0.0]}

rf_gs = GridSearchCV(rf_pipeline,
                     rf_grid,
                     scoring=['neg_root_mean_squared_error', 'r2'],
                     refit='neg_root_mean_squared_error',
                     cv=5,
                     verbose=3,
                     return_train_score=True)
```

In [67]:
```
rf_results = rf_gs.fit(x_train, y_train)
```

```
Fitting 5 folds for each of 16 candidates, totalling 80 fits
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__m
ax_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__
n_estimators=50
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model_
_n_estimators=50, neg_root_mean_squared_error=(train=-13053.776, test=-28794.84
6), r2=(train=0.974, test=0.850), total=  13.3s
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__m
ax_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__
n_estimators=50
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:   13.3s remaining:    0.0s
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model_
_n_estimators=50, neg_root_mean_squared_error=(train=-12898.673, test=-34218.85
9), r2=(train=0.973, test=0.821), total=  15.2s
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__m
ax_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__
n_estimators=50
[Parallel(n_jobs=1)]: Done   2 out of   2 | elapsed:   28.6s remaining:    0.0s
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model_
_n_estimators=50, neg_root_mean_squared_error=(train=-12090.817, test=-32258.99
0), r2=(train=0.975, test=0.863), total=  14.8s
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__m
ax_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__
n_estimators=50
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model_
_n_estimators=50, neg_root_mean_squared_error=(train=-13196.930, test=-28953.46
1), r2=(train=0.973, test=0.839), total=  12.7s
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__m
ax_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__
n_estimators=50
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model_
_n_estimators=50, neg_root_mean_squared_error=(train=-12035.625, test=-34972.12
7), r2=(train=0.977, test=0.811), total=  12.3s
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__m
ax_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__
n_estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model_
_n_estimators=250, neg_root_mean_squared_error=(train=-11933.347, test=-28135.09
```

```
2), r2=(train=0.978, test=0.857), total=  16.3s
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__m
ax_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__
n_estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model_
_n_estimators=250, neg_root_mean_squared_error=(train=-12060.652, test=-33325.39
7), r2=(train=0.977, test=0.831), total=  17.4s
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__m
ax_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__
n_estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model_
_n_estimators=250, neg_root_mean_squared_error=(train=-11805.580, test=-32655.19
5), r2=(train=0.977, test=0.859), total=  19.6s
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__m
ax_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__
n_estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model_
_n_estimators=250, neg_root_mean_squared_error=(train=-13150.288, test=-27538.99
8), r2=(train=0.974, test=0.854), total=  15.3s
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__m
ax_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__
n_estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model_
_n_estimators=250, neg_root_mean_squared_error=(train=-11626.999, test=-35925.27
0), r2=(train=0.978, test=0.800), total=  16.0s
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__m
ax_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__
n_estimators=50
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model_
_n_estimators=50, neg_root_mean_squared_error=(train=-19501.586, test=-28678.57
0), r2=(train=0.941, test=0.852), total=  12.8s
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__m
ax_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__
n_estimators=50
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model_
_n_estimators=50, neg_root_mean_squared_error=(train=-21069.331, test=-32705.67
2), r2=(train=0.929, test=0.837), total=  14.0s
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__m
ax_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__
n_estimators=50
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model_
_n_estimators=50, neg_root_mean_squared_error=(train=-20337.424, test=-34745.50
4), r2=(train=0.930, test=0.841), total=  14.5s
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__m
ax_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__
n_estimators=50
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model_
_n_estimators=50, neg_root_mean_squared_error=(train=-21639.219, test=-28484.22
6), r2=(train=0.928, test=0.844), total=  12.3s
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__m
ax_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__
n_estimators=50
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model_
_n_estimators=50, neg_root_mean_squared_error=(train=-19080.700, test=-37724.87
8), r2=(train=0.942, test=0.780), total=  12.0s
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__m
```

```
ax_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__
n_estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model_
_n_estimators=250, neg_root_mean_squared_error=(train=-19029.074, test=-28505.68
4), r2=(train=0.944, test=0.853), total=  15.1s
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__m
ax_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__
n_estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model_
_n_estimators=250, neg_root_mean_squared_error=(train=-20568.004, test=-31943.14
0), r2=(train=0.932, test=0.844), total=  16.1s
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__m
ax_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__
n_estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model_
_n_estimators=250, neg_root_mean_squared_error=(train=-20158.626, test=-34650.24
0), r2=(train=0.932, test=0.842), total=  16.8s
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__m
ax_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__
n_estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model_
_n_estimators=250, neg_root_mean_squared_error=(train=-21788.077, test=-27464.63
4), r2=(train=0.927, test=0.855), total=  14.2s
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__m
ax_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__
n_estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model_
_n_estimators=250, neg_root_mean_squared_error=(train=-18973.704, test=-37809.84
2), r2=(train=0.942, test=0.779), total=  14.1s
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n_
estimators=50
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__ma
x_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n
_estimators=50, neg_root_mean_squared_error=(train=-14494.685, test=-28821.967),
r2=(train=0.968, test=0.850), total=  14.1s
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n_
estimators=50
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__ma
x_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n
_estimators=50, neg_root_mean_squared_error=(train=-15066.044, test=-33871.321),
r2=(train=0.963, test=0.825), total=  14.7s
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n_
estimators=50
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__ma
x_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n
_estimators=50, neg_root_mean_squared_error=(train=-14781.597, test=-32132.680),
r2=(train=0.963, test=0.864), total=  14.8s
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n_
estimators=50
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__ma
x_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n
_estimators=50, neg_root_mean_squared_error=(train=-16649.886, test=-27858.450),
r2=(train=0.958, test=0.851), total=  12.8s
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n_
estimators=50
```

```
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__ma
x_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n
_estimators=50, neg_root_mean_squared_error=(train=-13750.722, test=-35050.225),
r2=(train=0.970, test=0.810), total=  12.2s
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n_
estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__ma
x_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n
_estimators=250, neg_root_mean_squared_error=(train=-13903.088, test=-28282.79
4), r2=(train=0.970, test=0.856), total=  15.4s
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n_
estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__ma
x_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n
_estimators=250, neg_root_mean_squared_error=(train=-14469.399, test=-33573.90
5), r2=(train=0.966, test=0.828), total=  16.3s
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n_
estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__ma
x_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n
_estimators=250, neg_root_mean_squared_error=(train=-14495.528, test=-32509.98
6), r2=(train=0.965, test=0.861), total=  17.5s
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n_
estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__ma
x_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n
_estimators=250, neg_root_mean_squared_error=(train=-16374.884, test=-27794.86
1), r2=(train=0.959, test=0.851), total=  14.4s
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n_
estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__ma
x_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n
_estimators=250, neg_root_mean_squared_error=(train=-13473.241, test=-36334.98
2), r2=(train=0.971, test=0.796), total=  14.1s
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n_
estimators=50
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__ma
x_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n
_estimators=50, neg_root_mean_squared_error=(train=-20013.641, test=-28796.974),
r2=(train=0.938, test=0.850), total=  13.0s
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n_
estimators=50
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__ma
x_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n
_estimators=50, neg_root_mean_squared_error=(train=-21481.747, test=-32548.265),
r2=(train=0.926, test=0.838), total=  14.7s
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n_
estimators=50
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__ma
x_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n
_estimators=50, neg_root_mean_squared_error=(train=-20879.407, test=-34765.291),
r2=(train=0.927, test=0.841), total=  14.7s
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n_
estimators=50
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__ma
x_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n
```

```
_estimators=50, neg_root_mean_squared_error=(train=-22327.635, test=-28514.286),
r2=(train=0.924, test=0.843), total=  12.6s
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n_
estimators=50
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__ma
x_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n
_estimators=50, neg_root_mean_squared_error=(train=-19589.528, test=-37879.484),
r2=(train=0.938, test=0.778), total=  13.7s
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n_
estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__ma
x_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n
_estimators=250, neg_root_mean_squared_error=(train=-19520.491, test=-28573.18
4), r2=(train=0.941, test=0.853), total=  18.9s
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n_
estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__ma
x_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n
_estimators=250, neg_root_mean_squared_error=(train=-21080.181, test=-31978.23
2), r2=(train=0.928, test=0.844), total=  17.2s
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n_
estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__ma
x_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n
_estimators=250, neg_root_mean_squared_error=(train=-20694.568, test=-34644.05
1), r2=(train=0.928, test=0.842), total=  16.9s
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n_
estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__ma
x_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n
_estimators=250, neg_root_mean_squared_error=(train=-22418.412, test=-27515.14
9), r2=(train=0.923, test=0.854), total=  13.9s
[CV] model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n_
estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mse, model__max_depth=10, model__ma
x_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n
_estimators=250, neg_root_mean_squared_error=(train=-19503.741, test=-37885.66
4), r2=(train=0.939, test=0.778), total=  13.6s
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__m
ax_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__
n_estimators=50
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model_
_n_estimators=50, neg_root_mean_squared_error=(train=-12581.325, test=-27555.37
2), r2=(train=0.976, test=0.863), total=  17.9s
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__m
ax_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__
n_estimators=50
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model_
_n_estimators=50, neg_root_mean_squared_error=(train=-13225.974, test=-34658.94
5), r2=(train=0.972, test=0.817), total=  19.0s
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__m
ax_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__
n_estimators=50
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model_
_n_estimators=50, neg_root_mean_squared_error=(train=-11855.276, test=-32928.24
8), r2=(train=0.976, test=0.857), total=  19.2s
```

```
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__m
ax_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__
n_estimators=50
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model_
_n_estimators=50, neg_root_mean_squared_error=(train=-13252.168, test=-27311.85
8), r2=(train=0.973, test=0.856), total=  16.8s
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__m
ax_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__
n_estimators=50
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model_
_n_estimators=50, neg_root_mean_squared_error=(train=-12188.972, test=-35133.04
9), r2=(train=0.976, test=0.809), total=  17.4s
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__m
ax_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__
n_estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model_
_n_estimators=250, neg_root_mean_squared_error=(train=-11834.073, test=-27496.95
2), r2=(train=0.978, test=0.863), total=  41.5s
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__m
ax_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__
n_estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model_
_n_estimators=250, neg_root_mean_squared_error=(train=-12097.399, test=-34659.49
8), r2=(train=0.976, test=0.817), total=  38.1s
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__m
ax_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__
n_estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model_
_n_estimators=250, neg_root_mean_squared_error=(train=-11663.391, test=-32850.08
8), r2=(train=0.977, test=0.858), total=  40.5s
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__m
ax_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__
n_estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model_
_n_estimators=250, neg_root_mean_squared_error=(train=-12938.387, test=-27254.85
0), r2=(train=0.974, test=0.857), total=  36.4s
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__m
ax_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__
n_estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model_
_n_estimators=250, neg_root_mean_squared_error=(train=-11444.003, test=-35465.48
0), r2=(train=0.979, test=0.805), total=  39.0s
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__m
ax_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__
n_estimators=50
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model_
_n_estimators=50, neg_root_mean_squared_error=(train=-21428.185, test=-28129.94
0), r2=(train=0.929, test=0.857), total=  16.1s
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__m
ax_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__
n_estimators=50
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model_
_n_estimators=50, neg_root_mean_squared_error=(train=-23047.210, test=-33425.37
9), r2=(train=0.914, test=0.829), total=  16.9s
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__m
ax_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__
```

```
n_estimators=50
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model_
_n_estimators=50, neg_root_mean_squared_error=(train=-22246.370, test=-35421.25
8), r2=(train=0.917, test=0.835), total=  17.8s
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__m
ax_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__
n_estimators=50
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model_
_n_estimators=50, neg_root_mean_squared_error=(train=-23312.237, test=-27807.58
2), r2=(train=0.917, test=0.851), total=  15.0s
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__m
ax_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__
n_estimators=50
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model_
_n_estimators=50, neg_root_mean_squared_error=(train=-21491.761, test=-39003.89
0), r2=(train=0.926, test=0.764), total=  15.5s
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__m
ax_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__
n_estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model_
_n_estimators=250, neg_root_mean_squared_error=(train=-21170.936, test=-28208.87
5), r2=(train=0.931, test=0.856), total=  31.8s
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__m
ax_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__
n_estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model_
_n_estimators=250, neg_root_mean_squared_error=(train=-22554.080, test=-33328.07
8), r2=(train=0.918, test=0.830), total=  31.3s
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__m
ax_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__
n_estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model_
_n_estimators=250, neg_root_mean_squared_error=(train=-22206.331, test=-35031.05
7), r2=(train=0.917, test=0.838), total=  36.6s
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__m
ax_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__
n_estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model_
_n_estimators=250, neg_root_mean_squared_error=(train=-23643.043, test=-27481.48
1), r2=(train=0.914, test=0.855), total=  30.0s
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__m
ax_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__
n_estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=None, model__
max_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model_
_n_estimators=250, neg_root_mean_squared_error=(train=-21331.989, test=-38797.07
4), r2=(train=0.927, test=0.767), total=  31.0s
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n_
estimators=50
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__ma
x_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n
_estimators=50, neg_root_mean_squared_error=(train=-15185.236, test=-27337.380),
r2=(train=0.964, test=0.865), total=  17.8s
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n_
estimators=50
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__ma
```

```
x_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n
_estimators=50, neg_root_mean_squared_error=(train=-15849.084, test=-36270.354),
r2=(train=0.960, test=0.799), total=  18.2s
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n_
estimators=50
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__ma
x_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n
_estimators=50, neg_root_mean_squared_error=(train=-15308.987, test=-33488.724),
r2=(train=0.961, test=0.852), total=  19.2s
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n_
estimators=50
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__ma
x_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n
_estimators=50, neg_root_mean_squared_error=(train=-17272.544, test=-27039.323),
r2=(train=0.954, test=0.859), total=  16.2s
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n_
estimators=50
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__ma
x_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n
_estimators=50, neg_root_mean_squared_error=(train=-14615.569, test=-35021.067),
r2=(train=0.966, test=0.810), total=  17.0s
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n_
estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__ma
x_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n
_estimators=250, neg_root_mean_squared_error=(train=-14551.582, test=-27639.03
6), r2=(train=0.967, test=0.862), total=  37.6s
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n_
estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__ma
x_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n
_estimators=250, neg_root_mean_squared_error=(train=-15127.339, test=-35652.35
7), r2=(train=0.963, test=0.806), total=  36.0s
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n_
estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__ma
x_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n
_estimators=250, neg_root_mean_squared_error=(train=-15101.177, test=-32914.74
5), r2=(train=0.962, test=0.857), total=  38.2s
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n_
estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__ma
x_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n
_estimators=250, neg_root_mean_squared_error=(train=-17073.712, test=-27274.56
6), r2=(train=0.955, test=0.857), total=  34.1s
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n_
estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__ma
x_features=auto, model__min_samples_leaf=1, model__min_samples_split=2, model__n
_estimators=250, neg_root_mean_squared_error=(train=-14129.350, test=-34652.67
0), r2=(train=0.968, test=0.814), total=  37.0s
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n_
estimators=50
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__ma
x_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n
_estimators=50, neg_root_mean_squared_error=(train=-21837.966, test=-27921.260),
```

```
r2=(train=0.926, test=0.859), total=  16.2s
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n_
estimators=50
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__ma
x_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n
_estimators=50, neg_root_mean_squared_error=(train=-23680.137, test=-33531.146),
r2=(train=0.910, test=0.828), total=  17.1s
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n_
estimators=50
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__ma
x_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n
_estimators=50, neg_root_mean_squared_error=(train=-22867.524, test=-36052.744),
r2=(train=0.912, test=0.829), total=  17.7s
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n_
estimators=50
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__ma
x_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n
_estimators=50, neg_root_mean_squared_error=(train=-23842.483, test=-27552.987),
r2=(train=0.913, test=0.854), total=  15.3s
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n_
estimators=50
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__ma
x_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n
_estimators=50, neg_root_mean_squared_error=(train=-21829.599, test=-38593.023),
r2=(train=0.924, test=0.769), total=  15.4s
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n_
estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__ma
x_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n
_estimators=250, neg_root_mean_squared_error=(train=-21444.929, test=-28187.94
3), r2=(train=0.929, test=0.857), total=  30.5s
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n_
estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__ma
x_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n
_estimators=250, neg_root_mean_squared_error=(train=-22959.647, test=-33472.41
5), r2=(train=0.915, test=0.829), total=  29.8s
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n_
estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__ma
x_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n
_estimators=250, neg_root_mean_squared_error=(train=-22711.235, test=-35283.68
2), r2=(train=0.913, test=0.836), total=  31.4s
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n_
estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__ma
x_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n
_estimators=250, neg_root_mean_squared_error=(train=-24296.121, test=-27403.76
5), r2=(train=0.910, test=0.855), total=  26.8s
[CV] model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__max
_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n_
estimators=250
[CV]  model__ccp_alpha=0.0, model__criterion=mae, model__max_depth=10, model__ma
x_features=auto, model__min_samples_leaf=3, model__min_samples_split=2, model__n
_estimators=250, neg_root_mean_squared_error=(train=-21681.142, test=-38695.62
5), r2=(train=0.925, test=0.768), total=  30.9s
[Parallel(n_jobs=1)]: Done  80 out of  80 | elapsed: 27.1min finished
```

It seems that as the model iterates through more candidates, it is beginning to overfit less.

However, it appears that there is at least one fold per candidate that returns an r-squared value below .08. This could potentially be caused by model overfitting on the outliers.

The 'poisson' criteria seems to be resulting in significant overfitting as the train r-squared scores are ~.96 while the validation r-squared scores are between 0.8 and 0.6 for the most part.

In [70]:
```
rf_results.best_params_
```

Out[70]:
```
{'model__ccp_alpha': 0.0,
 'model__criterion': 'mse',
 'model__max_depth': None,
 'model__max_features': 'auto',
 'model__min_samples_leaf': 1,
 'model__min_samples_split': 2,
 'model__n_estimators': 250}
```

In [71]:
```
get_results(rf_results)
```

```
The best model parameters produce a mean rmse score on train data of:
-12115.373235799616

The best model parameters produce a mean R-squared score on train data of:
0.9765943742612325

The best model parameters produce a mean rmse score on test data of:
-31515.990302817292

The best model parameters produce a mean R-squared score on test data of:
0.8402221513439431
```

Analysis:

The best parameters for the random forest regressor were the absolute error for split criterion, a max model depth of none, a min samples leaf value of 1, a min samples split value of 2, and n_estimators 150.

The best model in the grid is significantly overfit to the training data both relative to the validation data, and more broadly.

XGBoost Regressor

In [149…
```
x_train = train_df.drop(['SalePrice'], axis=1)
y_train = train_df['SalePrice']
```

In [150…
```
xgb_pipeline = Pipeline(steps=[('trans', transformer),
                               ('rfe', RFE(LinearRegression(normalize=False), n_
                               ('model', XGBRegressor(random_state=42))])

xgb_grid = {'model__n_estimators': [250, ],
            'model__max_depth': [None, 10],
            'model__booster' : ['gbtree', 'gblinear', 'dart'],
            'model__reg_alpha' : [.01, 1.0],
            'model__reg_lambda' : [75.0, 100.0]}
```

```
xgb_gs = GridSearchCV(xgb_pipeline,
                      xgb_grid,
                      scoring=['neg_root_mean_squared_error', 'r2'],
                      refit='neg_root_mean_squared_error',
                      cv=5,
                      verbose=3,
                      return_train_score=True)
```

In [151…

```
xgb_results = xgb_gs.fit(x_train, y_train)
```

```
Fitting 5 folds for each of 24 candidates, totalling 120 fits
[CV] model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mode
l__reg_alpha=0.01, model__reg_lambda=75.0
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[CV]  model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mod
el__reg_alpha=0.01, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-
8806.488, test=-27474.891), r2=(train=0.988, test=0.864), total=  13.0s
[CV] model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mode
l__reg_alpha=0.01, model__reg_lambda=75.0
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:   13.0s remaining:    0.0s
[CV]  model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mod
el__reg_alpha=0.01, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-
10309.400, test=-36896.248), r2=(train=0.983, test=0.792), total=  13.8s
[CV] model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mode
l__reg_alpha=0.01, model__reg_lambda=75.0
[Parallel(n_jobs=1)]: Done   2 out of   2 | elapsed:   26.8s remaining:    0.0s
[CV]  model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mod
el__reg_alpha=0.01, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-
10069.150, test=-32738.183), r2=(train=0.983, test=0.859), total=  14.8s
[CV] model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mode
l__reg_alpha=0.01, model__reg_lambda=75.0
[CV]  model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mod
el__reg_alpha=0.01, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-
12213.353, test=-31401.668), r2=(train=0.977, test=0.810), total=  12.2s
[CV] model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mode
l__reg_alpha=0.01, model__reg_lambda=75.0
[CV]  model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mod
el__reg_alpha=0.01, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-
9046.607, test=-33581.869), r2=(train=0.987, test=0.825), total=  11.8s
[CV] model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mode
l__reg_alpha=0.01, model__reg_lambda=100.0
[CV]  model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mod
el__reg_alpha=0.01, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=
-9604.448, test=-27768.220), r2=(train=0.986, test=0.861), total=  13.1s
[CV] model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mode
l__reg_alpha=0.01, model__reg_lambda=100.0
[CV]  model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mod
el__reg_alpha=0.01, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=
-11147.286, test=-37431.024), r2=(train=0.980, test=0.786), total=  13.8s
[CV] model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mode
l__reg_alpha=0.01, model__reg_lambda=100.0
[CV]  model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mod
el__reg_alpha=0.01, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=
-11250.766, test=-34035.292), r2=(train=0.979, test=0.847), total=  14.3s
[CV] model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mode
l__reg_alpha=0.01, model__reg_lambda=100.0
[CV]  model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mod
el__reg_alpha=0.01, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=
-13326.933, test=-32262.225), r2=(train=0.973, test=0.800), total=  12.3s
[CV] model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mode
l__reg_alpha=0.01, model__reg_lambda=100.0
[CV]  model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mod
el__reg_alpha=0.01, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=
```

```
-10188.210, test=-32835.886), r2=(train=0.983, test=0.833), total=  11.8s
[CV] model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mode
l__reg_alpha=1.0, model__reg_lambda=75.0
[CV]  model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mod
el__reg_alpha=1.0, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-8
806.520, test=-27474.893), r2=(train=0.988, test=0.864), total=  12.7s
[CV] model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mode
l__reg_alpha=1.0, model__reg_lambda=75.0
[CV]  model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mod
el__reg_alpha=1.0, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-1
0309.434, test=-36896.251), r2=(train=0.983, test=0.792), total=  13.9s
[CV] model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mode
l__reg_alpha=1.0, model__reg_lambda=75.0
[CV]  model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mod
el__reg_alpha=1.0, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-1
0049.473, test=-32755.754), r2=(train=0.983, test=0.859), total=  14.2s
[CV] model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mode
l__reg_alpha=1.0, model__reg_lambda=75.0
[CV]  model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mod
el__reg_alpha=1.0, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-1
2163.796, test=-31403.873), r2=(train=0.977, test=0.810), total=  12.2s
[CV] model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mode
l__reg_alpha=1.0, model__reg_lambda=75.0
[CV]  model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mod
el__reg_alpha=1.0, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-9
046.643, test=-33581.872), r2=(train=0.987, test=0.825), total=  12.3s
[CV] model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mode
l__reg_alpha=1.0, model__reg_lambda=100.0
[CV]  model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mod
el__reg_alpha=1.0, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-
9667.991, test=-27676.161), r2=(train=0.986, test=0.862), total=  12.7s
[CV] model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mode
l__reg_alpha=1.0, model__reg_lambda=100.0
[CV]  model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mod
el__reg_alpha=1.0, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-
11264.316, test=-37340.020), r2=(train=0.980, test=0.787), total=  13.9s
[CV] model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mode
l__reg_alpha=1.0, model__reg_lambda=100.0
[CV]  model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mod
el__reg_alpha=1.0, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-
11250.799, test=-34035.294), r2=(train=0.979, test=0.847), total=  14.2s
[CV] model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mode
l__reg_alpha=1.0, model__reg_lambda=100.0
[CV]  model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mod
el__reg_alpha=1.0, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-
13326.964, test=-32262.237), r2=(train=0.973, test=0.800), total=  12.1s
[CV] model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mode
l__reg_alpha=1.0, model__reg_lambda=100.0
[CV]  model__booster=gbtree, model__max_depth=None, model__n_estimators=250, mod
el__reg_alpha=1.0, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-
10188.240, test=-32835.885), r2=(train=0.983, test=0.833), total=  11.8s
[CV] model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model_
_reg_alpha=0.01, model__reg_lambda=75.0
[CV]  model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model
__reg_alpha=0.01, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-43
18.153, test=-28053.307), r2=(train=0.997, test=0.858), total=  14.8s
[CV] model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model_
_reg_alpha=0.01, model__reg_lambda=75.0
[CV]  model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model
__reg_alpha=0.01, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-47
65.918, test=-37704.731), r2=(train=0.996, test=0.783), total=  14.3s
[CV] model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model_
_reg_alpha=0.01, model__reg_lambda=75.0
[CV]  model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model
__reg_alpha=0.01, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-53
```

```
55.634, test=-34379.027), r2=(train=0.995, test=0.844), total=  14.5s
[CV] model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model_
_reg_alpha=0.01, model__reg_lambda=75.0
[CV]  model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model
__reg_alpha=0.01, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-71
45.747, test=-30769.288), r2=(train=0.992, test=0.818), total=  13.5s
[CV] model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model_
_reg_alpha=0.01, model__reg_lambda=75.0
[CV]  model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model
__reg_alpha=0.01, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-45
42.508, test=-32082.633), r2=(train=0.997, test=0.841), total=  12.1s
[CV] model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model_
_reg_alpha=0.01, model__reg_lambda=100.0
[CV]  model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model
__reg_alpha=0.01, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-5
234.111, test=-27447.337), r2=(train=0.996, test=0.864), total=  12.9s
[CV] model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model_
_reg_alpha=0.01, model__reg_lambda=100.0
[CV]  model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model
__reg_alpha=0.01, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-6
013.058, test=-38313.744), r2=(train=0.994, test=0.776), total=  14.1s
[CV] model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model_
_reg_alpha=0.01, model__reg_lambda=100.0
[CV]  model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model
__reg_alpha=0.01, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-6
340.638, test=-34658.426), r2=(train=0.993, test=0.842), total=  14.3s
[CV] model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model_
_reg_alpha=0.01, model__reg_lambda=100.0
[CV]  model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model
__reg_alpha=0.01, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-8
481.706, test=-31231.379), r2=(train=0.989, test=0.812), total=  12.4s
[CV] model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model_
_reg_alpha=0.01, model__reg_lambda=100.0
[CV]  model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model
__reg_alpha=0.01, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-5
797.885, test=-32289.007), r2=(train=0.995, test=0.839), total=  12.0s
[CV] model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model_
_reg_alpha=1.0, model__reg_lambda=75.0
[CV]  model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model
__reg_alpha=1.0, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-428
1.361, test=-28064.510), r2=(train=0.997, test=0.858), total=  12.9s
[CV] model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model_
_reg_alpha=1.0, model__reg_lambda=75.0
[CV]  model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model
__reg_alpha=1.0, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-455
9.824, test=-37990.685), r2=(train=0.997, test=0.780), total=  14.2s
[CV] model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model_
_reg_alpha=1.0, model__reg_lambda=75.0
[CV]  model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model
__reg_alpha=1.0, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-535
4.173, test=-34380.065), r2=(train=0.995, test=0.844), total=  14.5s
[CV] model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model_
_reg_alpha=1.0, model__reg_lambda=75.0
[CV]  model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model
__reg_alpha=1.0, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-714
5.813, test=-30769.292), r2=(train=0.992, test=0.818), total=  12.4s
[CV] model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model_
_reg_alpha=1.0, model__reg_lambda=75.0
[CV]  model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model
__reg_alpha=1.0, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-455
6.403, test=-32100.514), r2=(train=0.997, test=0.840), total=  11.9s
[CV] model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model_
_reg_alpha=1.0, model__reg_lambda=100.0
[CV]  model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model
__reg_alpha=1.0, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-52
```

```
72.246, test=-27450.336), r2=(train=0.996, test=0.864), total=  13.1s
[CV] model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model_
_reg_alpha=1.0, model__reg_lambda=100.0
[CV]  model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model
__reg_alpha=1.0, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-60
51.036, test=-38317.130), r2=(train=0.994, test=0.776), total=  13.9s
[CV] model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model_
_reg_alpha=1.0, model__reg_lambda=100.0
[CV]  model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model
__reg_alpha=1.0, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-63
40.688, test=-34658.416), r2=(train=0.993, test=0.842), total=  14.5s
[CV] model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model_
_reg_alpha=1.0, model__reg_lambda=100.0
[CV]  model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model
__reg_alpha=1.0, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-84
81.761, test=-31231.382), r2=(train=0.989, test=0.812), total=  12.8s
[CV] model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model_
_reg_alpha=1.0, model__reg_lambda=100.0
[CV]  model__booster=gbtree, model__max_depth=10, model__n_estimators=250, model
__reg_alpha=1.0, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-57
99.663, test=-32294.582), r2=(train=0.995, test=0.839), total=  12.0s
[CV] model__booster=gblinear, model__max_depth=None, model__n_estimators=250, mo
del__reg_alpha=0.01, model__reg_lambda=75.0
[CV]  model__booster=gblinear, model__max_depth=None, model__n_estimators=250, m
odel__reg_alpha=0.01, model__reg_lambda=75.0, neg_root_mean_squared_error=(train
=-77886.814, test=-71955.583), r2=(train=0.062, test=0.065), total=  12.6s
[CV] model__booster=gblinear, model__max_depth=None, model__n_estimators=250, mo
del__reg_alpha=0.01, model__reg_lambda=75.0
[CV]  model__booster=gblinear, model__max_depth=None, model__n_estimators=250, m
odel__reg_alpha=0.01, model__reg_lambda=75.0, neg_root_mean_squared_error=(train
=-77196.715, test=-79267.032), r2=(train=0.040, test=0.041), total=  13.9s
[CV] model__booster=gblinear, model__max_depth=None, model__n_estimators=250, mo
del__reg_alpha=0.01, model__reg_lambda=75.0
[CV]  model__booster=gblinear, model__max_depth=None, model__n_estimators=250, m
odel__reg_alpha=0.01, model__reg_lambda=75.0, neg_root_mean_squared_error=(train
=-75352.127, test=-85392.357), r2=(train=0.046, test=0.039), total=  14.1s
[CV] model__booster=gblinear, model__max_depth=None, model__n_estimators=250, mo
del__reg_alpha=0.01, model__reg_lambda=75.0
[CV]  model__booster=gblinear, model__max_depth=None, model__n_estimators=250, m
odel__reg_alpha=0.01, model__reg_lambda=75.0, neg_root_mean_squared_error=(train
=-79444.148, test=-71301.893), r2=(train=0.034, test=0.021), total=  12.0s
[CV] model__booster=gblinear, model__max_depth=None, model__n_estimators=250, mo
del__reg_alpha=0.01, model__reg_lambda=75.0
[CV]  model__booster=gblinear, model__max_depth=None, model__n_estimators=250, m
odel__reg_alpha=0.01, model__reg_lambda=75.0, neg_root_mean_squared_error=(train
=-76833.239, test=-78274.477), r2=(train=0.053, test=0.052), total=  11.6s
[CV] model__booster=gblinear, model__max_depth=None, model__n_estimators=250, mo
del__reg_alpha=0.01, model__reg_lambda=100.0
[CV]  model__booster=gblinear, model__max_depth=None, model__n_estimators=250, m
odel__reg_alpha=0.01, model__reg_lambda=100.0, neg_root_mean_squared_error=(trai
n=-78493.561, test=-72554.669), r2=(train=0.047, test=0.050), total=  12.9s
[CV] model__booster=gblinear, model__max_depth=None, model__n_estimators=250, mo
del__reg_alpha=0.01, model__reg_lambda=100.0
[CV]  model__booster=gblinear, model__max_depth=None, model__n_estimators=250, m
odel__reg_alpha=0.01, model__reg_lambda=100.0, neg_root_mean_squared_error=(trai
n=-77588.811, test=-79686.156), r2=(train=0.031, test=0.031), total=  13.8s
[CV] model__booster=gblinear, model__max_depth=None, model__n_estimators=250, mo
del__reg_alpha=0.01, model__reg_lambda=100.0
[CV]  model__booster=gblinear, model__max_depth=None, model__n_estimators=250, m
odel__reg_alpha=0.01, model__reg_lambda=100.0, neg_root_mean_squared_error=(trai
n=-75785.023, test=-85836.512), r2=(train=0.035, test=0.029), total=  14.0s
[CV] model__booster=gblinear, model__max_depth=None, model__n_estimators=250, mo
del__reg_alpha=0.01, model__reg_lambda=100.0
[CV]  model__booster=gblinear, model__max_depth=None, model__n_estimators=250, m
odel__reg_alpha=0.01, model__reg_lambda=100.0, neg_root_mean_squared_error=(trai
```

```
n=-79785.446, test=-71624.083), r2=(train=0.026, test=0.012), total=  12.6s
[CV] model__booster=gblinear, model__max_depth=None, model__n_estimators=250, mo
del__reg_alpha=0.01, model__reg_lambda=100.0
[CV]  model__booster=gblinear, model__max_depth=None, model__n_estimators=250, m
odel__reg_alpha=0.01, model__reg_lambda=100.0, neg_root_mean_squared_error=(trai
n=-77349.343, test=-78782.240), r2=(train=0.040, test=0.039), total=  12.2s
[CV] model__booster=gblinear, model__max_depth=None, model__n_estimators=250, mo
del__reg_alpha=1.0, model__reg_lambda=75.0
[CV]  model__booster=gblinear, model__max_depth=None, model__n_estimators=250, m
odel__reg_alpha=1.0, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=
-77886.879, test=-71955.647), r2=(train=0.062, test=0.065), total=  12.8s
[CV] model__booster=gblinear, model__max_depth=None, model__n_estimators=250, mo
del__reg_alpha=1.0, model__reg_lambda=75.0
[CV]  model__booster=gblinear, model__max_depth=None, model__n_estimators=250, m
odel__reg_alpha=1.0, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=
-77196.757, test=-79267.077), r2=(train=0.040, test=0.041), total=  13.9s
[CV] model__booster=gblinear, model__max_depth=None, model__n_estimators=250, mo
del__reg_alpha=1.0, model__reg_lambda=75.0
[CV]  model__booster=gblinear, model__max_depth=None, model__n_estimators=250, m
odel__reg_alpha=1.0, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=
-75352.175, test=-85392.406), r2=(train=0.046, test=0.039), total=  14.1s
[CV] model__booster=gblinear, model__max_depth=None, model__n_estimators=250, mo
del__reg_alpha=1.0, model__reg_lambda=75.0
[CV]  model__booster=gblinear, model__max_depth=None, model__n_estimators=250, m
odel__reg_alpha=1.0, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=
-79444.182, test=-71301.924), r2=(train=0.034, test=0.021), total=  12.1s
[CV] model__booster=gblinear, model__max_depth=None, model__n_estimators=250, mo
del__reg_alpha=1.0, model__reg_lambda=75.0
[CV]  model__booster=gblinear, model__max_depth=None, model__n_estimators=250, m
odel__reg_alpha=1.0, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=
-76833.294, test=-78274.529), r2=(train=0.053, test=0.052), total=  12.2s
[CV] model__booster=gblinear, model__max_depth=None, model__n_estimators=250, mo
del__reg_alpha=1.0, model__reg_lambda=100.0
[CV]  model__booster=gblinear, model__max_depth=None, model__n_estimators=250, m
odel__reg_alpha=1.0, model__reg_lambda=100.0, neg_root_mean_squared_error=(train
=-78493.610, test=-72554.714), r2=(train=0.047, test=0.050), total=  12.4s
[CV] model__booster=gblinear, model__max_depth=None, model__n_estimators=250, mo
del__reg_alpha=1.0, model__reg_lambda=100.0
[CV]  model__booster=gblinear, model__max_depth=None, model__n_estimators=250, m
odel__reg_alpha=1.0, model__reg_lambda=100.0, neg_root_mean_squared_error=(train
=-77588.850, test=-79686.196), r2=(train=0.031, test=0.031), total=  13.7s
[CV] model__booster=gblinear, model__max_depth=None, model__n_estimators=250, mo
del__reg_alpha=1.0, model__reg_lambda=100.0
[CV]  model__booster=gblinear, model__max_depth=None, model__n_estimators=250, m
odel__reg_alpha=1.0, model__reg_lambda=100.0, neg_root_mean_squared_error=(train
=-75785.061, test=-85836.549), r2=(train=0.035, test=0.029), total=  14.0s
[CV] model__booster=gblinear, model__max_depth=None, model__n_estimators=250, mo
del__reg_alpha=1.0, model__reg_lambda=100.0
[CV]  model__booster=gblinear, model__max_depth=None, model__n_estimators=250, m
odel__reg_alpha=1.0, model__reg_lambda=100.0, neg_root_mean_squared_error=(train
=-79785.470, test=-71624.104), r2=(train=0.026, test=0.012), total=  12.0s
[CV] model__booster=gblinear, model__max_depth=None, model__n_estimators=250, mo
del__reg_alpha=1.0, model__reg_lambda=100.0
[CV]  model__booster=gblinear, model__max_depth=None, model__n_estimators=250, m
odel__reg_alpha=1.0, model__reg_lambda=100.0, neg_root_mean_squared_error=(train
=-77349.384, test=-78782.276), r2=(train=0.040, test=0.039), total=  11.8s
[CV] model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mode
l__reg_alpha=0.01, model__reg_lambda=75.0
[01:44:38] WARNING: /Users/runner/miniforge3/conda-bld/xgboost_1598185652448/wor
k/src/learner.cc:516:
Parameters: { max_depth } might not be used.

  This may not be accurate due to some parameters are only used in language bind
ings but
  passed down to XGBoost core.  Or some parameters are not used but slip through
```

```
this
  verification. Please open an issue if you find above cases.


[CV]  model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mod
el__reg_alpha=0.01, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-
77886.814, test=-71955.583), r2=(train=0.062, test=0.065), total=  12.8s
[CV] model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mode
l__reg_alpha=0.01, model__reg_lambda=75.0
[01:44:51] WARNING: /Users/runner/miniforge3/conda-bld/xgboost_1598185652448/wor
k/src/learner.cc:516:
Parameters: { max_depth } might not be used.

  This may not be accurate due to some parameters are only used in language bind
ings but
  passed down to XGBoost core.  Or some parameters are not used but slip through
this
  verification. Please open an issue if you find above cases.


[CV]  model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mod
el__reg_alpha=0.01, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-
77196.715, test=-79267.032), r2=(train=0.040, test=0.041), total=  13.6s
[CV] model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mode
l__reg_alpha=0.01, model__reg_lambda=75.0
[01:45:05] WARNING: /Users/runner/miniforge3/conda-bld/xgboost_1598185652448/wor
k/src/learner.cc:516:
Parameters: { max_depth } might not be used.

  This may not be accurate due to some parameters are only used in language bind
ings but
  passed down to XGBoost core.  Or some parameters are not used but slip through
this
  verification. Please open an issue if you find above cases.


[CV]  model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mod
el__reg_alpha=0.01, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-
75352.127, test=-85392.357), r2=(train=0.046, test=0.039), total=  14.0s
[CV] model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mode
l__reg_alpha=0.01, model__reg_lambda=75.0
[01:45:18] WARNING: /Users/runner/miniforge3/conda-bld/xgboost_1598185652448/wor
k/src/learner.cc:516:
Parameters: { max_depth } might not be used.

  This may not be accurate due to some parameters are only used in language bind
ings but
  passed down to XGBoost core.  Or some parameters are not used but slip through
this
  verification. Please open an issue if you find above cases.


[CV]  model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mod
el__reg_alpha=0.01, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-
79444.148, test=-71301.893), r2=(train=0.034, test=0.021), total=  12.2s
[CV] model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mode
l__reg_alpha=0.01, model__reg_lambda=75.0
[01:45:29] WARNING: /Users/runner/miniforge3/conda-bld/xgboost_1598185652448/wor
k/src/learner.cc:516:
Parameters: { max_depth } might not be used.

  This may not be accurate due to some parameters are only used in language bind
ings but
  passed down to XGBoost core.  Or some parameters are not used but slip through
this
```

```
  verification. Please open an issue if you find above cases.


[CV]  model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mod
el__reg_alpha=0.01, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-
76833.239, test=-78274.477), r2=(train=0.053, test=0.052), total=  11.6s
[CV] model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mode
l__reg_alpha=0.01, model__reg_lambda=100.0
[01:45:42] WARNING: /Users/runner/miniforge3/conda-bld/xgboost_1598185652448/wor
k/src/learner.cc:516:
Parameters: { max_depth } might not be used.

  This may not be accurate due to some parameters are only used in language bind
ings but
  passed down to XGBoost core.  Or some parameters are not used but slip through
this
  verification. Please open an issue if you find above cases.


[CV]  model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mod
el__reg_alpha=0.01, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=
-78493.561, test=-72554.669), r2=(train=0.047, test=0.050), total=  12.8s
[CV] model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mode
l__reg_alpha=0.01, model__reg_lambda=100.0
[01:45:56] WARNING: /Users/runner/miniforge3/conda-bld/xgboost_1598185652448/wor
k/src/learner.cc:516:
Parameters: { max_depth } might not be used.

  This may not be accurate due to some parameters are only used in language bind
ings but
  passed down to XGBoost core.  Or some parameters are not used but slip through
this
  verification. Please open an issue if you find above cases.


[CV]  model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mod
el__reg_alpha=0.01, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=
-77588.811, test=-79686.156), r2=(train=0.031, test=0.031), total=  13.9s
[CV] model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mode
l__reg_alpha=0.01, model__reg_lambda=100.0
[01:46:10] WARNING: /Users/runner/miniforge3/conda-bld/xgboost_1598185652448/wor
k/src/learner.cc:516:
Parameters: { max_depth } might not be used.

  This may not be accurate due to some parameters are only used in language bind
ings but
  passed down to XGBoost core.  Or some parameters are not used but slip through
this
  verification. Please open an issue if you find above cases.


[CV]  model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mod
el__reg_alpha=0.01, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=
-75785.023, test=-85836.512), r2=(train=0.035, test=0.029), total=  14.1s
[CV] model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mode
l__reg_alpha=0.01, model__reg_lambda=100.0
[01:46:22] WARNING: /Users/runner/miniforge3/conda-bld/xgboost_1598185652448/wor
k/src/learner.cc:516:
Parameters: { max_depth } might not be used.

  This may not be accurate due to some parameters are only used in language bind
ings but
  passed down to XGBoost core.  Or some parameters are not used but slip through
this
  verification. Please open an issue if you find above cases.
```

```
[CV]  model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mod
el__reg_alpha=0.01, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=
-79785.446, test=-71624.083), r2=(train=0.026, test=0.012), total=  12.1s
[CV] model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mode
l__reg_alpha=0.01, model__reg_lambda=100.0
[01:46:34] WARNING: /Users/runner/miniforge3/conda-bld/xgboost_1598185652448/wor
k/src/learner.cc:516:
Parameters: { max_depth } might not be used.

  This may not be accurate due to some parameters are only used in language bind
ings but
  passed down to XGBoost core.  Or some parameters are not used but slip through
this
  verification. Please open an issue if you find above cases.


[CV]  model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mod
el__reg_alpha=0.01, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=
-77349.343, test=-78782.240), r2=(train=0.040, test=0.039), total=  11.6s
[CV] model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mode
l__reg_alpha=1.0, model__reg_lambda=75.0
[01:46:47] WARNING: /Users/runner/miniforge3/conda-bld/xgboost_1598185652448/wor
k/src/learner.cc:516:
Parameters: { max_depth } might not be used.

  This may not be accurate due to some parameters are only used in language bind
ings but
  passed down to XGBoost core.  Or some parameters are not used but slip through
this
  verification. Please open an issue if you find above cases.


[CV]  model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mod
el__reg_alpha=1.0, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-7
7886.879, test=-71955.647), r2=(train=0.062, test=0.065), total=  12.6s
[CV] model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mode
l__reg_alpha=1.0, model__reg_lambda=75.0
[01:47:01] WARNING: /Users/runner/miniforge3/conda-bld/xgboost_1598185652448/wor
k/src/learner.cc:516:
Parameters: { max_depth } might not be used.

  This may not be accurate due to some parameters are only used in language bind
ings but
  passed down to XGBoost core.  Or some parameters are not used but slip through
this
  verification. Please open an issue if you find above cases.


[CV]  model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mod
el__reg_alpha=1.0, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-7
7196.757, test=-79267.077), r2=(train=0.040, test=0.041), total=  14.7s
[CV] model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mode
l__reg_alpha=1.0, model__reg_lambda=75.0
[01:47:17] WARNING: /Users/runner/miniforge3/conda-bld/xgboost_1598185652448/wor
k/src/learner.cc:516:
Parameters: { max_depth } might not be used.

  This may not be accurate due to some parameters are only used in language bind
ings but
  passed down to XGBoost core.  Or some parameters are not used but slip through
this
  verification. Please open an issue if you find above cases.
```

```
[CV]  model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mod
el__reg_alpha=1.0, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-7
5352.175, test=-85392.406), r2=(train=0.046, test=0.039), total=  16.1s
[CV] model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mode
l__reg_alpha=1.0, model__reg_lambda=75.0
[01:47:30] WARNING: /Users/runner/miniforge3/conda-bld/xgboost_1598185652448/wor
k/src/learner.cc:516:
Parameters: { max_depth } might not be used.

  This may not be accurate due to some parameters are only used in language bind
ings but
  passed down to XGBoost core.  Or some parameters are not used but slip through
this
  verification. Please open an issue if you find above cases.


[CV]  model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mod
el__reg_alpha=1.0, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-7
9444.182, test=-71301.924), r2=(train=0.034, test=0.021), total=  12.0s
[CV] model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mode
l__reg_alpha=1.0, model__reg_lambda=75.0
[01:47:41] WARNING: /Users/runner/miniforge3/conda-bld/xgboost_1598185652448/wor
k/src/learner.cc:516:
Parameters: { max_depth } might not be used.

  This may not be accurate due to some parameters are only used in language bind
ings but
  passed down to XGBoost core.  Or some parameters are not used but slip through
this
  verification. Please open an issue if you find above cases.


[CV]  model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mod
el__reg_alpha=1.0, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-7
6833.294, test=-78274.529), r2=(train=0.053, test=0.052), total=  11.6s
[CV] model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mode
l__reg_alpha=1.0, model__reg_lambda=100.0
[01:47:54] WARNING: /Users/runner/miniforge3/conda-bld/xgboost_1598185652448/wor
k/src/learner.cc:516:
Parameters: { max_depth } might not be used.

  This may not be accurate due to some parameters are only used in language bind
ings but
  passed down to XGBoost core.  Or some parameters are not used but slip through
this
  verification. Please open an issue if you find above cases.


[CV]  model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mod
el__reg_alpha=1.0, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-
78493.610, test=-72554.714), r2=(train=0.047, test=0.050), total=  12.7s
[CV] model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mode
l__reg_alpha=1.0, model__reg_lambda=100.0
[01:48:07] WARNING: /Users/runner/miniforge3/conda-bld/xgboost_1598185652448/wor
k/src/learner.cc:516:
Parameters: { max_depth } might not be used.

  This may not be accurate due to some parameters are only used in language bind
ings but
  passed down to XGBoost core.  Or some parameters are not used but slip through
this
  verification. Please open an issue if you find above cases.
```

```
[CV]  model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mod
el__reg_alpha=1.0, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-
77588.850, test=-79686.196), r2=(train=0.031, test=0.031), total=  13.5s
[CV] model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mode
l__reg_alpha=1.0, model__reg_lambda=100.0
[01:48:22] WARNING: /Users/runner/miniforge3/conda-bld/xgboost_1598185652448/wor
k/src/learner.cc:516:
Parameters: { max_depth } might not be used.

  This may not be accurate due to some parameters are only used in language bind
ings but
  passed down to XGBoost core.  Or some parameters are not used but slip through
this
  verification. Please open an issue if you find above cases.


[CV]  model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mod
el__reg_alpha=1.0, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-
75785.061, test=-85836.549), r2=(train=0.035, test=0.029), total=  14.2s
[CV] model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mode
l__reg_alpha=1.0, model__reg_lambda=100.0
[01:48:34] WARNING: /Users/runner/miniforge3/conda-bld/xgboost_1598185652448/wor
k/src/learner.cc:516:
Parameters: { max_depth } might not be used.

  This may not be accurate due to some parameters are only used in language bind
ings but
  passed down to XGBoost core.  Or some parameters are not used but slip through
this
  verification. Please open an issue if you find above cases.


[CV]  model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mod
el__reg_alpha=1.0, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-
79785.470, test=-71624.104), r2=(train=0.026, test=0.012), total=  12.6s
[CV] model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mode
l__reg_alpha=1.0, model__reg_lambda=100.0
[01:48:46] WARNING: /Users/runner/miniforge3/conda-bld/xgboost_1598185652448/wor
k/src/learner.cc:516:
Parameters: { max_depth } might not be used.

  This may not be accurate due to some parameters are only used in language bind
ings but
  passed down to XGBoost core.  Or some parameters are not used but slip through
this
  verification. Please open an issue if you find above cases.


[CV]  model__booster=gblinear, model__max_depth=10, model__n_estimators=250, mod
el__reg_alpha=1.0, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-
77349.384, test=-78782.276), r2=(train=0.040, test=0.039), total=  12.1s
[CV] model__booster=dart, model__max_depth=None, model__n_estimators=250, model_
_reg_alpha=0.01, model__reg_lambda=75.0
[CV]  model__booster=dart, model__max_depth=None, model__n_estimators=250, model
__reg_alpha=0.01, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-88
06.488, test=-27474.891), r2=(train=0.988, test=0.864), total=  13.4s
[CV] model__booster=dart, model__max_depth=None, model__n_estimators=250, model_
_reg_alpha=0.01, model__reg_lambda=75.0
[CV]  model__booster=dart, model__max_depth=None, model__n_estimators=250, model
__reg_alpha=0.01, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-10
309.400, test=-36896.248), r2=(train=0.983, test=0.792), total=  14.5s
[CV] model__booster=dart, model__max_depth=None, model__n_estimators=250, model_
_reg_alpha=0.01, model__reg_lambda=75.0
[CV]  model__booster=dart, model__max_depth=None, model__n_estimators=250, model
__reg_alpha=0.01, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-10
```

```
069.150, test=-32738.183), r2=(train=0.983, test=0.859), total=  15.0s
[CV] model__booster=dart, model__max_depth=None, model__n_estimators=250, model_
_reg_alpha=0.01, model__reg_lambda=75.0
[CV]  model__booster=dart, model__max_depth=None, model__n_estimators=250, model
__reg_alpha=0.01, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-12
213.353, test=-31401.668), r2=(train=0.977, test=0.810), total=  13.1s
[CV] model__booster=dart, model__max_depth=None, model__n_estimators=250, model_
_reg_alpha=0.01, model__reg_lambda=75.0
[CV]  model__booster=dart, model__max_depth=None, model__n_estimators=250, model
__reg_alpha=0.01, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-90
46.607, test=-33581.870), r2=(train=0.987, test=0.825), total=  12.4s
[CV] model__booster=dart, model__max_depth=None, model__n_estimators=250, model_
_reg_alpha=0.01, model__reg_lambda=100.0
[CV]  model__booster=dart, model__max_depth=None, model__n_estimators=250, model
__reg_alpha=0.01, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-9
604.448, test=-27768.220), r2=(train=0.986, test=0.861), total=  13.1s
[CV] model__booster=dart, model__max_depth=None, model__n_estimators=250, model_
_reg_alpha=0.01, model__reg_lambda=100.0
[CV]  model__booster=dart, model__max_depth=None, model__n_estimators=250, model
__reg_alpha=0.01, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-1
1147.286, test=-37431.024), r2=(train=0.980, test=0.786), total=  14.5s
[CV] model__booster=dart, model__max_depth=None, model__n_estimators=250, model_
_reg_alpha=0.01, model__reg_lambda=100.0
[CV]  model__booster=dart, model__max_depth=None, model__n_estimators=250, model
__reg_alpha=0.01, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-1
1250.766, test=-34035.292), r2=(train=0.979, test=0.847), total=  17.8s
[CV] model__booster=dart, model__max_depth=None, model__n_estimators=250, model_
_reg_alpha=0.01, model__reg_lambda=100.0
[CV]  model__booster=dart, model__max_depth=None, model__n_estimators=250, model
__reg_alpha=0.01, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-1
3326.933, test=-32262.225), r2=(train=0.973, test=0.800), total=  13.1s
[CV] model__booster=dart, model__max_depth=None, model__n_estimators=250, model_
_reg_alpha=0.01, model__reg_lambda=100.0
[CV]  model__booster=dart, model__max_depth=None, model__n_estimators=250, model
__reg_alpha=0.01, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-1
0188.210, test=-32835.886), r2=(train=0.983, test=0.833), total=  12.6s
[CV] model__booster=dart, model__max_depth=None, model__n_estimators=250, model_
_reg_alpha=1.0, model__reg_lambda=75.0
[CV]  model__booster=dart, model__max_depth=None, model__n_estimators=250, model
__reg_alpha=1.0, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-877
8.349, test=-27510.387), r2=(train=0.988, test=0.863), total=  13.3s
[CV] model__booster=dart, model__max_depth=None, model__n_estimators=250, model_
_reg_alpha=1.0, model__reg_lambda=75.0
[CV]  model__booster=dart, model__max_depth=None, model__n_estimators=250, model
__reg_alpha=1.0, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-103
09.434, test=-36896.251), r2=(train=0.983, test=0.792), total=  14.5s
[CV] model__booster=dart, model__max_depth=None, model__n_estimators=250, model_
_reg_alpha=1.0, model__reg_lambda=75.0
[CV]  model__booster=dart, model__max_depth=None, model__n_estimators=250, model
__reg_alpha=1.0, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-100
49.473, test=-32755.754), r2=(train=0.983, test=0.859), total=  14.9s
[CV] model__booster=dart, model__max_depth=None, model__n_estimators=250, model_
_reg_alpha=1.0, model__reg_lambda=75.0
[CV]  model__booster=dart, model__max_depth=None, model__n_estimators=250, model
__reg_alpha=1.0, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-121
63.796, test=-31403.873), r2=(train=0.977, test=0.810), total=  13.4s
[CV] model__booster=dart, model__max_depth=None, model__n_estimators=250, model_
_reg_alpha=1.0, model__reg_lambda=75.0
[CV]  model__booster=dart, model__max_depth=None, model__n_estimators=250, model
__reg_alpha=1.0, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-904
6.643, test=-33581.872), r2=(train=0.987, test=0.825), total=  12.5s
[CV] model__booster=dart, model__max_depth=None, model__n_estimators=250, model_
_reg_alpha=1.0, model__reg_lambda=100.0
[CV]  model__booster=dart, model__max_depth=None, model__n_estimators=250, model
__reg_alpha=1.0, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-96
```

```
67.991, test=-27676.161), r2=(train=0.986, test=0.862), total=  13.5s
[CV] model__booster=dart, model__max_depth=None, model__n_estimators=250, model_
_reg_alpha=1.0, model__reg_lambda=100.0
[CV]  model__booster=dart, model__max_depth=None, model__n_estimators=250, model
__reg_alpha=1.0, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-11
264.316, test=-37340.020), r2=(train=0.980, test=0.787), total=  14.7s
[CV] model__booster=dart, model__max_depth=None, model__n_estimators=250, model_
_reg_alpha=1.0, model__reg_lambda=100.0
[CV]  model__booster=dart, model__max_depth=None, model__n_estimators=250, model
__reg_alpha=1.0, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-11
250.799, test=-34035.294), r2=(train=0.979, test=0.847), total=  16.6s
[CV] model__booster=dart, model__max_depth=None, model__n_estimators=250, model_
_reg_alpha=1.0, model__reg_lambda=100.0
[CV]  model__booster=dart, model__max_depth=None, model__n_estimators=250, model
__reg_alpha=1.0, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-13
326.964, test=-32262.238), r2=(train=0.973, test=0.800), total=  13.0s
[CV] model__booster=dart, model__max_depth=None, model__n_estimators=250, model_
_reg_alpha=1.0, model__reg_lambda=100.0
[CV]  model__booster=dart, model__max_depth=None, model__n_estimators=250, model
__reg_alpha=1.0, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-10
188.240, test=-32835.885), r2=(train=0.983, test=0.833), total=  12.4s
[CV] model__booster=dart, model__max_depth=10, model__n_estimators=250, model__r
eg_alpha=0.01, model__reg_lambda=75.0
[CV]  model__booster=dart, model__max_depth=10, model__n_estimators=250, model__
reg_alpha=0.01, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-431
8.153, test=-28053.307), r2=(train=0.997, test=0.858), total=  14.2s
[CV] model__booster=dart, model__max_depth=10, model__n_estimators=250, model__r
eg_alpha=0.01, model__reg_lambda=75.0
[CV]  model__booster=dart, model__max_depth=10, model__n_estimators=250, model__
reg_alpha=0.01, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-476
5.918, test=-37704.731), r2=(train=0.996, test=0.783), total=  15.1s
[CV] model__booster=dart, model__max_depth=10, model__n_estimators=250, model__r
eg_alpha=0.01, model__reg_lambda=75.0
[CV]  model__booster=dart, model__max_depth=10, model__n_estimators=250, model__
reg_alpha=0.01, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-535
5.634, test=-34379.027), r2=(train=0.995, test=0.844), total=  16.2s
[CV] model__booster=dart, model__max_depth=10, model__n_estimators=250, model__r
eg_alpha=0.01, model__reg_lambda=75.0
[CV]  model__booster=dart, model__max_depth=10, model__n_estimators=250, model__
reg_alpha=0.01, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-714
5.747, test=-30769.288), r2=(train=0.992, test=0.818), total=  14.0s
[CV] model__booster=dart, model__max_depth=10, model__n_estimators=250, model__r
eg_alpha=0.01, model__reg_lambda=75.0
[CV]  model__booster=dart, model__max_depth=10, model__n_estimators=250, model__
reg_alpha=0.01, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-454
2.508, test=-32082.633), r2=(train=0.997, test=0.841), total=  13.3s
[CV] model__booster=dart, model__max_depth=10, model__n_estimators=250, model__r
eg_alpha=0.01, model__reg_lambda=100.0
[CV]  model__booster=dart, model__max_depth=10, model__n_estimators=250, model__
reg_alpha=0.01, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-523
4.111, test=-27447.337), r2=(train=0.996, test=0.864), total=  14.0s
[CV] model__booster=dart, model__max_depth=10, model__n_estimators=250, model__r
eg_alpha=0.01, model__reg_lambda=100.0
[CV]  model__booster=dart, model__max_depth=10, model__n_estimators=250, model__
reg_alpha=0.01, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-601
3.058, test=-38313.744), r2=(train=0.994, test=0.776), total=  15.4s
[CV] model__booster=dart, model__max_depth=10, model__n_estimators=250, model__r
eg_alpha=0.01, model__reg_lambda=100.0
[CV]  model__booster=dart, model__max_depth=10, model__n_estimators=250, model__
reg_alpha=0.01, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-634
0.638, test=-34658.426), r2=(train=0.993, test=0.842), total=  15.6s
[CV] model__booster=dart, model__max_depth=10, model__n_estimators=250, model__r
eg_alpha=0.01, model__reg_lambda=100.0
[CV]  model__booster=dart, model__max_depth=10, model__n_estimators=250, model__
reg_alpha=0.01, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-848
```

```
1.706, test=-31231.379), r2=(train=0.989, test=0.812), total=  13.7s
[CV] model__booster=dart, model__max_depth=10, model__n_estimators=250, model__r
eg_alpha=0.01, model__reg_lambda=100.0
[CV]  model__booster=dart, model__max_depth=10, model__n_estimators=250, model__
reg_alpha=0.01, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-579
7.885, test=-32289.007), r2=(train=0.995, test=0.839), total=  13.5s
[CV] model__booster=dart, model__max_depth=10, model__n_estimators=250, model__r
eg_alpha=1.0, model__reg_lambda=75.0
[CV]  model__booster=dart, model__max_depth=10, model__n_estimators=250, model__
reg_alpha=1.0, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-4281.
361, test=-28064.510), r2=(train=0.997, test=0.858), total=  14.3s
[CV] model__booster=dart, model__max_depth=10, model__n_estimators=250, model__r
eg_alpha=1.0, model__reg_lambda=75.0
[CV]  model__booster=dart, model__max_depth=10, model__n_estimators=250, model__
reg_alpha=1.0, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-4559.
824, test=-37990.685), r2=(train=0.997, test=0.780), total=  15.2s
[CV] model__booster=dart, model__max_depth=10, model__n_estimators=250, model__r
eg_alpha=1.0, model__reg_lambda=75.0
[CV]  model__booster=dart, model__max_depth=10, model__n_estimators=250, model__
reg_alpha=1.0, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-5354.
173, test=-34380.065), r2=(train=0.995, test=0.844), total=  15.8s
[CV] model__booster=dart, model__max_depth=10, model__n_estimators=250, model__r
eg_alpha=1.0, model__reg_lambda=75.0
[CV]  model__booster=dart, model__max_depth=10, model__n_estimators=250, model__
reg_alpha=1.0, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-7145.
813, test=-30769.292), r2=(train=0.992, test=0.818), total=  13.6s
[CV] model__booster=dart, model__max_depth=10, model__n_estimators=250, model__r
eg_alpha=1.0, model__reg_lambda=75.0
[CV]  model__booster=dart, model__max_depth=10, model__n_estimators=250, model__
reg_alpha=1.0, model__reg_lambda=75.0, neg_root_mean_squared_error=(train=-4556.
403, test=-32100.514), r2=(train=0.997, test=0.840), total=  14.2s
[CV] model__booster=dart, model__max_depth=10, model__n_estimators=250, model__r
eg_alpha=1.0, model__reg_lambda=100.0
[CV]  model__booster=dart, model__max_depth=10, model__n_estimators=250, model__
reg_alpha=1.0, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-527
2.245, test=-27450.335), r2=(train=0.996, test=0.864), total=  14.3s
[CV] model__booster=dart, model__max_depth=10, model__n_estimators=250, model__r
eg_alpha=1.0, model__reg_lambda=100.0
[CV]  model__booster=dart, model__max_depth=10, model__n_estimators=250, model__
reg_alpha=1.0, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-605
1.036, test=-38317.130), r2=(train=0.994, test=0.776), total=  15.2s
[CV] model__booster=dart, model__max_depth=10, model__n_estimators=250, model__r
eg_alpha=1.0, model__reg_lambda=100.0
[CV]  model__booster=dart, model__max_depth=10, model__n_estimators=250, model__
reg_alpha=1.0, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-634
0.688, test=-34658.416), r2=(train=0.993, test=0.842), total=  15.7s
[CV] model__booster=dart, model__max_depth=10, model__n_estimators=250, model__r
eg_alpha=1.0, model__reg_lambda=100.0
[CV]  model__booster=dart, model__max_depth=10, model__n_estimators=250, model__
reg_alpha=1.0, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-848
1.761, test=-31231.382), r2=(train=0.989, test=0.812), total=  13.8s
[CV] model__booster=dart, model__max_depth=10, model__n_estimators=250, model__r
eg_alpha=1.0, model__reg_lambda=100.0
[CV]  model__booster=dart, model__max_depth=10, model__n_estimators=250, model__
reg_alpha=1.0, model__reg_lambda=100.0, neg_root_mean_squared_error=(train=-579
9.663, test=-32294.582), r2=(train=0.995, test=0.839), total=  13.3s
[Parallel(n_jobs=1)]: Done 120 out of 120 | elapsed: 27.0min finished
```

In [152…

```
xgb_results.best_params_
```

Out[152…

```
{'model__booster': 'gbtree',
 'model__max_depth': None,
 'model__n_estimators': 250,
```

```
 'model__reg_alpha': 0.01,
 'model__reg_lambda': 75.0}
```

In [153…
```
get_results(xgb_results)
```

```
The best model parameters produce a mean rmse score on train data of:
-10088.99973543373

The best model parameters produce a mean R-squared score on train data of:
0.9835781039433739

The best model parameters produce a mean rmse score on test data of:
-32418.571807187243

The best model parameters produce a mean R-squared score on test data of:
0.830023355678742
```

Analysis:

The best parameters for the XGboost regressor were 'dart' for the booster parameter, a max model depth of none, 250 n_estimators, a reg_alpha of 1.0, and a reg_labmda of 50.0

The best model in the grid is more overfit to the training data relative to the validation data and the whole set than any of ther other regressions I have fit thus far.

Generally, it does not appear that recursive feature elimination was that helpful in reducing overfitting of the models.

Of the four models I trained using GridSearchCV, the Ridge Regression appeared to have the best fit in regard to the bias-variance trade-off, so I am going to train another using the best features from the grid search and messing around with the n_features_to_select parameter of the recursive feature elimination object.

Experimenting With Neural Networks

In [437…
```
x_train = train_df.drop(['SalePrice'], axis=1)
y_train = train_df['SalePrice']
```

In [438…
```
categorical_cols = x_train.select_dtypes('object')
numerical_cols = x_train.select_dtypes(exclude=['object'])

numerical_transformer = Pipeline(steps=[('ss', StandardScaler())])
ordinal_transformer = Pipeline(steps=[('oe', OrdinalEncoder())])


oe_transformer = ColumnTransformer(transformers=[('categorical', ordinal_transfo

num_transformer = ColumnTransformer(transformers=[('numerical', numerical_transf
```

In [454…
```
x_train = train_df.drop(['SalePrice'], axis=1)
y_train = train_df['SalePrice']

# Transforming categorical variables
x_train = oe_transformer.fit_transform(x_train)

x_tr, x_val, y_tr, y_val = train_test_split(x_train, y_train, test_size=0.25, ra
```

```
# Selecting features using recursive feature elimination
rfe = RFE(LinearRegression(), n_features_to_select=40)
x_tr = rfe.fit_transform(x_tr, y_tr)
x_val = rfe.transform(x_val)


# Building the model
model = models.Sequential()

model.add(layers.Dense(40, activation='tanh', input_shape=(40,)))

model.add(layers.Dense(80, activation='tanh', kernel_regularizer=l2(l2=0.001)))

model.add(Dropout(0.5))

model.add(layers.Dense(160, activation='tanh', kernel_regularizer=l2(l2=0.001)))

model.add(Dropout(0.5))

model.add(layers.Dense(40, activation='tanh', kernel_regularizer=l2(l2=0.001)))

model.add(Dropout(0.25))

model.add(layers.Dense(10, activation='tanh', kernel_regularizer=l2(l2=0.001)))

model.add(Dropout(0.25))

model.add(layers.Dense(5, activation='tanh', kernel_regularizer=l2(l2=0.01)))

model.add(Dropout(0.2))

model.add(layers.Dense(1, activation='linear'))


# Compiling the model
model.compile(optimizer='SGD',
              loss='mse',
              metrics=['mse'])

# Fitting The Model
history  = model.fit(x_tr,
                     y_tr,
                     batch_size=50,
                     epochs=100,
                     steps_per_epoch=20,
                     verbose=2,
                     validation_data=(x_val, y_val),
                     validation_steps=7,
                     validation_batch_size=50
                     )
```

```
Epoch 1/100
20/20 - 0s - loss: 26188328960.0000 - mse: 26187814912.0000 - val_loss: 10096229
376.0000 - val_mse: 10095594496.0000
Epoch 2/100
20/20 - 0s - loss: 15509465088.0000 - mse: 15508811776.0000 - val_loss: 81803683
84.0000 - val_mse: 8179692544.0000
Epoch 3/100
20/20 - 0s - loss: 11891102720.0000 - mse: 11890400256.0000 - val_loss: 68646369
28.0000 - val_mse: 6863880192.0000
```

```
Epoch 4/100
20/20 - 0s - loss: 10040206336.0000 - mse: 10039446528.0000 - val_loss: 64428702
72.0000 - val_mse: 6442105856.0000
Epoch 5/100
20/20 - 0s - loss: 7692273152.0000 - mse: 7691509760.0000 - val_loss: 618827776
0.0000 - val_mse: 6187516416.0000
Epoch 6/100
20/20 - 0s - loss: 7615449600.0000 - mse: 7050882048.0000 - val_loss: 751194368
0.0000 - val_mse: 5968963072.0000
Epoch 7/100
20/20 - 0s - loss: 8353430016.0000 - mse: 6816254464.0000 - val_loss: 752938240
0.0000 - val_mse: 5998694912.0000
Epoch 8/100
20/20 - 0s - loss: 8565298176.0000 - mse: 7040318976.0000 - val_loss: 748888780
8.0000 - val_mse: 5970394624.0000
Epoch 9/100
20/20 - 0s - loss: 7885812736.0000 - mse: 6372931584.0000 - val_loss: 746390681
6.0000 - val_mse: 5957510144.0000
Epoch 10/100
20/20 - 0s - loss: 8180767232.0000 - mse: 6678356480.0000 - val_loss: 746505830
4.0000 - val_mse: 5965921280.0000
Epoch 11/100
20/20 - 0s - loss: 8167787008.0000 - mse: 6634845184.0000 - val_loss: 748715673
6.0000 - val_mse: 5947059200.0000
Epoch 12/100
20/20 - 0s - loss: 8124568064.0000 - mse: 6590308864.0000 - val_loss: 747505612
8.0000 - val_mse: 5947229696.0000
Epoch 13/100
20/20 - 0s - loss: 8184435200.0000 - mse: 6662620160.0000 - val_loss: 750015232
0.0000 - val_mse: 5984497152.0000
Epoch 14/100
20/20 - 0s - loss: 7859954176.0000 - mse: 6350211072.0000 - val_loss: 745282304
0.0000 - val_mse: 5949243392.0000
Epoch 15/100
20/20 - 0s - loss: 7453519872.0000 - mse: 5955752448.0000 - val_loss: 743942656
0.0000 - val_mse: 5947825152.0000
Epoch 16/100
20/20 - 0s - loss: 8274885120.0000 - mse: 6789000192.0000 - val_loss: 742720153
6.0000 - val_mse: 5947483648.0000
Epoch 17/100
20/20 - 0s - loss: 7911601664.0000 - mse: 6437503488.0000 - val_loss: 741499596
8.0000 - val_mse: 5947066880.0000
Epoch 18/100
20/20 - 0s - loss: 7211947520.0000 - mse: 5749543424.0000 - val_loss: 741179033
6.0000 - val_mse: 5955556352.0000
Epoch 19/100
20/20 - 0s - loss: 8643514368.0000 - mse: 7192710656.0000 - val_loss: 739222272
0.0000 - val_mse: 5947590144.0000
Epoch 20/100
20/20 - 0s - loss: 7724259840.0000 - mse: 6284965888.0000 - val_loss: 738035353
6.0000 - val_mse: 5947228160.0000
Epoch 21/100
20/20 - 0s - loss: 7828993024.0000 - mse: 6401115136.0000 - val_loss: 736892979
2.0000 - val_mse: 5947222016.0000
Epoch 22/100
20/20 - 0s - loss: 7775602176.0000 - mse: 6359054336.0000 - val_loss: 741342105
6.0000 - val_mse: 6003039744.0000
Epoch 23/100
20/20 - 0s - loss: 7707425280.0000 - mse: 6302205440.0000 - val_loss: 736582860
8.0000 - val_mse: 5966074368.0000
Epoch 24/100
20/20 - 0s - loss: 8188403712.0000 - mse: 6794154496.0000 - val_loss: 733552691
2.0000 - val_mse: 5946923520.0000
Epoch 25/100
20/20 - 0s - loss: 6961206784.0000 - mse: 5578019328.0000 - val_loss: 733373593
```

```
6.0000 - val_mse: 5956194304.0000
Epoch 26/100
20/20 - 0s - loss: 7450252288.0000 - mse: 6078037504.0000 - val_loss: 733619712
0.0000 - val_mse: 5969630208.0000
Epoch 27/100
20/20 - 0s - loss: 8455199232.0000 - mse: 7093867520.0000 - val_loss: 730856550
4.0000 - val_mse: 5952885248.0000
Epoch 28/100
20/20 - 0s - loss: 7584183808.0000 - mse: 6233652736.0000 - val_loss: 729377638
4.0000 - val_mse: 5948896768.0000
Epoch 29/100
20/20 - 0s - loss: 7916024320.0000 - mse: 6576206336.0000 - val_loss: 728514048
0.0000 - val_mse: 5950974976.0000
Epoch 30/100
20/20 - 0s - loss: 7779212800.0000 - mse: 6450022912.0000 - val_loss: 727197132
8.0000 - val_mse: 5948434432.0000
Epoch 31/100
20/20 - 0s - loss: 7803129344.0000 - mse: 6484484608.0000 - val_loss: 726683392
0.0000 - val_mse: 5953841152.0000
Epoch 32/100
20/20 - 0s - loss: 7830039552.0000 - mse: 6521862656.0000 - val_loss: 725115494
4.0000 - val_mse: 5948631040.0000
Epoch 33/100
20/20 - 0s - loss: 7745680896.0000 - mse: 6447884800.0000 - val_loss: 724364083
2.0000 - val_mse: 5951495168.0000
Epoch 34/100
20/20 - 0s - loss: 7574787584.0000 - mse: 6231597056.0000 - val_loss: 734066739
2.0000 - val_mse: 5947177984.0000
Epoch 35/100
20/20 - 0s - loss: 8225057792.0000 - mse: 6837051392.0000 - val_loss: 733694412
8.0000 - val_mse: 5954556416.0000
Epoch 36/100
20/20 - 0s - loss: 6910556672.0000 - mse: 5533560320.0000 - val_loss: 732272128
0.0000 - val_mse: 5951347200.0000
Epoch 37/100
20/20 - 0s - loss: 8766458880.0000 - mse: 7400384512.0000 - val_loss: 731705446
4.0000 - val_mse: 5956604416.0000
Epoch 38/100
20/20 - 0s - loss: 7433861120.0000 - mse: 6078626304.0000 - val_loss: 729651916
8.0000 - val_mse: 5946907136.0000
Epoch 39/100
20/20 - 0s - loss: 8123907072.0000 - mse: 6779421184.0000 - val_loss: 728578304
0.0000 - val_mse: 5946924032.0000
Epoch 40/100
20/20 - 0s - loss: 7369131008.0000 - mse: 6035310592.0000 - val_loss: 729695795
2.0000 - val_mse: 5968765440.0000
Epoch 41/100
20/20 - 0s - loss: 7951337472.0000 - mse: 6627951104.0000 - val_loss: 727731200
0.0000 - val_mse: 5958281216.0000
Epoch 42/100
20/20 - 0s - loss: 7674714112.0000 - mse: 6360557568.0000 - val_loss: 725676390
4.0000 - val_mse: 5948240384.0000
Epoch 43/100
20/20 - 0s - loss: 7380514816.0000 - mse: 6076774400.0000 - val_loss: 727313868
8.0000 - val_mse: 5975029760.0000
Epoch 44/100
20/20 - 0s - loss: 7934078976.0000 - mse: 6640679936.0000 - val_loss: 723736832
0.0000 - val_mse: 5949600768.0000
Epoch 45/100
20/20 - 0s - loss: 7746375168.0000 - mse: 6463487488.0000 - val_loss: 722481664
0.0000 - val_mse: 5947309056.0000
Epoch 46/100
20/20 - 0s - loss: 7398269440.0000 - mse: 6125786624.0000 - val_loss: 721486182
4.0000 - val_mse: 5947531776.0000
Epoch 47/100
```

```
20/20 - 0s - loss: 7771188736.0000 - mse: 6508801536.0000 - val_loss: 720423219
2.0000 - val_mse: 5946997248.0000
Epoch 48/100
20/20 - 0s - loss: 8040433152.0000 - mse: 6788059648.0000 - val_loss: 719411046
4.0000 - val_mse: 5946891776.0000
Epoch 49/100
20/20 - 0s - loss: 7799008256.0000 - mse: 6556568064.0000 - val_loss: 718763110
4.0000 - val_mse: 5950348288.0000
Epoch 50/100
20/20 - 0s - loss: 6789713408.0000 - mse: 5557129728.0000 - val_loss: 718834124
8.0000 - val_mse: 5960915456.0000
Epoch 51/100
20/20 - 0s - loss: 8638150656.0000 - mse: 7415344128.0000 - val_loss: 716987187
2.0000 - val_mse: 5952224256.0000
Epoch 52/100
20/20 - 0s - loss: 7518482432.0000 - mse: 6305369600.0000 - val_loss: 716874547
2.0000 - val_mse: 5960777216.0000
Epoch 53/100
20/20 - 0s - loss: 7619158016.0000 - mse: 6415654400.0000 - val_loss: 714757785
6.0000 - val_mse: 5949232128.0000
Epoch 54/100
20/20 - 0s - loss: 7115548160.0000 - mse: 5921592320.0000 - val_loss: 713780889
6.0000 - val_mse: 5949010432.0000
Epoch 55/100
20/20 - 0s - loss: 7737314304.0000 - mse: 6552828928.0000 - val_loss: 713842585
6.0000 - val_mse: 5959098368.0000
Epoch 56/100
20/20 - 0s - loss: 7752824832.0000 - mse: 6577965568.0000 - val_loss: 711890380
8.0000 - val_mse: 5948970496.0000
Epoch 57/100
20/20 - 0s - loss: 6827664384.0000 - mse: 5662334464.0000 - val_loss: 711072921
6.0000 - val_mse: 5950116864.0000
Epoch 58/100
20/20 - 0s - loss: 7868745728.0000 - mse: 6712658944.0000 - val_loss: 709830912
0.0000 - val_mse: 5946941440.0000
Epoch 59/100
20/20 - 0s - loss: 7694989824.0000 - mse: 6548073984.0000 - val_loss: 708953036
8.0000 - val_mse: 5947335168.0000
Epoch 60/100
20/20 - 0s - loss: 7888617472.0000 - mse: 6750798848.0000 - val_loss: 708241356
8.0000 - val_mse: 5949317632.0000
Epoch 61/100
20/20 - 0s - loss: 7577272832.0000 - mse: 6448479232.0000 - val_loss: 708034457
6.0000 - val_mse: 5956275200.0000
Epoch 62/100
20/20 - 0s - loss: 7607144960.0000 - mse: 6487306240.0000 - val_loss: 706200678
4.0000 - val_mse: 5946892288.0000
Epoch 63/100
20/20 - 0s - loss: 7285133312.0000 - mse: 6174176256.0000 - val_loss: 705524684
8.0000 - val_mse: 5949015552.0000
Epoch 64/100
20/20 - 0s - loss: 7563953152.0000 - mse: 6461809152.0000 - val_loss: 704459520
0.0000 - val_mse: 5947175424.0000
Epoch 65/100
20/20 - 0s - loss: 7256065536.0000 - mse: 6162664960.0000 - val_loss: 703857561
6.0000 - val_mse: 5949898240.0000
Epoch 66/100
20/20 - 0s - loss: 7699049984.0000 - mse: 6614322688.0000 - val_loss: 702875238
4.0000 - val_mse: 5948748800.0000
Epoch 67/100
20/20 - 0s - loss: 7461968896.0000 - mse: 6386058752.0000 - val_loss: 703003545
6.0000 - val_mse: 5958635008.0000
Epoch 68/100
20/20 - 0s - loss: 7751564800.0000 - mse: 6684379136.0000 - val_loss: 702504140
8.0000 - val_mse: 5962175488.0000
```

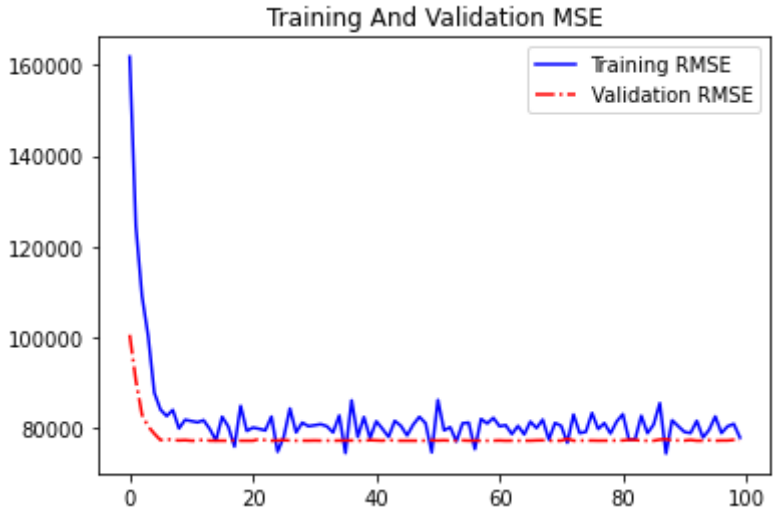
```
Epoch 69/100
20/20 - 0s - loss: 7048855040.0000 - mse: 5986472960.0000 - val_loss: 701906278
4.0000 - val_mse: 5947124736.0000
Epoch 70/100
20/20 - 0s - loss: 7632611840.0000 - mse: 6564819456.0000 - val_loss: 701307238
4.0000 - val_mse: 5949673984.0000
Epoch 71/100
20/20 - 0s - loss: 7523956736.0000 - mse: 6464632320.0000 - val_loss: 700387276
8.0000 - val_mse: 5948945408.0000
Epoch 72/100
20/20 - 0s - loss: 6928394240.0000 - mse: 5877460992.0000 - val_loss: 706189875
2.0000 - val_mse: 6015158272.0000
Epoch 73/100
20/20 - 0s - loss: 7915719680.0000 - mse: 6872370176.0000 - val_loss: 698634803
2.0000 - val_mse: 5947149312.0000
Epoch 74/100
20/20 - 0s - loss: 7246109184.0000 - mse: 6210787328.0000 - val_loss: 698470912
0.0000 - val_mse: 5953789440.0000
Epoch 75/100
20/20 - 0s - loss: 7279534080.0000 - mse: 6252423680.0000 - val_loss: 697234483
2.0000 - val_mse: 5949637120.0000
Epoch 76/100
20/20 - 0s - loss: 7945454592.0000 - mse: 6926490624.0000 - val_loss: 696881664
0.0000 - val_mse: 5954256384.0000
Epoch 77/100
20/20 - 0s - loss: 7364380160.0000 - mse: 6353499648.0000 - val_loss: 695488460
8.0000 - val_mse: 5948405248.0000
Epoch 78/100
20/20 - 0s - loss: 7563870720.0000 - mse: 6561189376.0000 - val_loss: 694878003
2.0000 - val_mse: 5950292480.0000
Epoch 79/100
20/20 - 0s - loss: 7189685760.0000 - mse: 6195126784.0000 - val_loss: 693957939
2.0000 - val_mse: 5949045760.0000
Epoch 80/100
20/20 - 0s - loss: 7603304448.0000 - mse: 6616634368.0000 - val_loss: 693921740
8.0000 - val_mse: 5956574720.0000
Epoch 81/100
20/20 - 0s - loss: 7862440448.0000 - mse: 6883596800.0000 - val_loss: 693191884
8.0000 - val_mse: 5957104128.0000
Epoch 82/100
20/20 - 0s - loss: 6949983744.0000 - mse: 5978904576.0000 - val_loss: 694701056
0.0000 - val_mse: 5979960832.0000
Epoch 83/100
20/20 - 0s - loss: 6962670080.0000 - mse: 5999291904.0000 - val_loss: 693148364
8.0000 - val_mse: 5972137472.0000
Epoch 84/100
20/20 - 0s - loss: 7782282240.0000 - mse: 6826545664.0000 - val_loss: 690333440
0.0000 - val_mse: 5951629824.0000
Epoch 85/100
20/20 - 0s - loss: 7155589120.0000 - mse: 6207434752.0000 - val_loss: 689114931
2.0000 - val_mse: 5947025920.0000
Epoch 86/100
20/20 - 0s - loss: 7448748544.0000 - mse: 6508114944.0000 - val_loss: 688401664
0.0000 - val_mse: 5947413504.0000
Epoch 87/100
20/20 - 0s - loss: 8228761088.0000 - mse: 7295587328.0000 - val_loss: 691341004
8.0000 - val_mse: 5984267776.0000
Epoch 88/100
20/20 - 0s - loss: 6443811840.0000 - mse: 5518040576.0000 - val_loss: 692207206
4.0000 - val_mse: 6000331776.0000
Epoch 89/100
20/20 - 0s - loss: 7580481536.0000 - mse: 6662232576.0000 - val_loss: 686694144
0.0000 - val_mse: 5952543744.0000
Epoch 90/100
20/20 - 0s - loss: 7359698944.0000 - mse: 6448898048.0000 - val_loss: 686529382
```

```
4.0000 - val_mse: 5958179840.0000
Epoch 91/100
20/20 - 0s - loss: 7152232960.0000 - mse: 6248655872.0000 - val_loss: 685215078
4.0000 - val_mse: 5952261632.0000
Epoch 92/100
20/20 - 0s - loss: 7108498944.0000 - mse: 6212088320.0000 - val_loss: 686622412
8.0000 - val_mse: 5973504000.0000
Epoch 93/100
20/20 - 0s - loss: 7532124160.0000 - mse: 6642824704.0000 - val_loss: 683304704
0.0000 - val_mse: 5947438080.0000
Epoch 94/100
20/20 - 0s - loss: 6939122176.0000 - mse: 6056875008.0000 - val_loss: 682544640
0.0000 - val_mse: 5946891264.0000
Epoch 95/100
20/20 - 0s - loss: 7196422144.0000 - mse: 6321172480.0000 - val_loss: 683754444
8.0000 - val_mse: 5965988352.0000
Epoch 96/100
20/20 - 0s - loss: 7669862400.0000 - mse: 6801556480.0000 - val_loss: 681156556
8.0000 - val_mse: 5946951168.0000
Epoch 97/100
20/20 - 0s - loss: 7070863872.0000 - mse: 6209444864.0000 - val_loss: 681297152
0.0000 - val_mse: 5955244544.0000
Epoch 98/100
20/20 - 0s - loss: 7302370816.0000 - mse: 6447784448.0000 - val_loss: 680583782
4.0000 - val_mse: 5954943488.0000
Epoch 99/100
20/20 - 0s - loss: 7379338752.0000 - mse: 6531531776.0000 - val_loss: 682063360
0.0000 - val_mse: 5976516096.0000
Epoch 100/100
20/20 - 0s - loss: 6895243776.0000 - mse: 6054325248.0000 - val_loss: 679524864
0.0000 - val_mse: 5957855744.0000
```

In [455…

```
visualize_nn(history, model, x_tr, y_tr, x_val, y_val)
```

```
Training Evaluation:
11/11 [==============================] - 0s 2ms/step - loss: 7245062144.0000 - m
se: 6407669248.0000

Validation Evaluation:
8/8 [==============================] - 0s 1ms/step - loss: 6757675520.0000 - ms
e: 5920282624.0000

Train Evaluation RMSE: 80047.9184488891

Validation Evaluation RMSE: 76943.37284003088
```




```
<Figure size 1152x576 with 0 Axes>
```

Testing Best Fit Model

In [585…
```
x_train = train_df.drop(['SalePrice'], axis=1)
y_train = train_df['SalePrice']
```

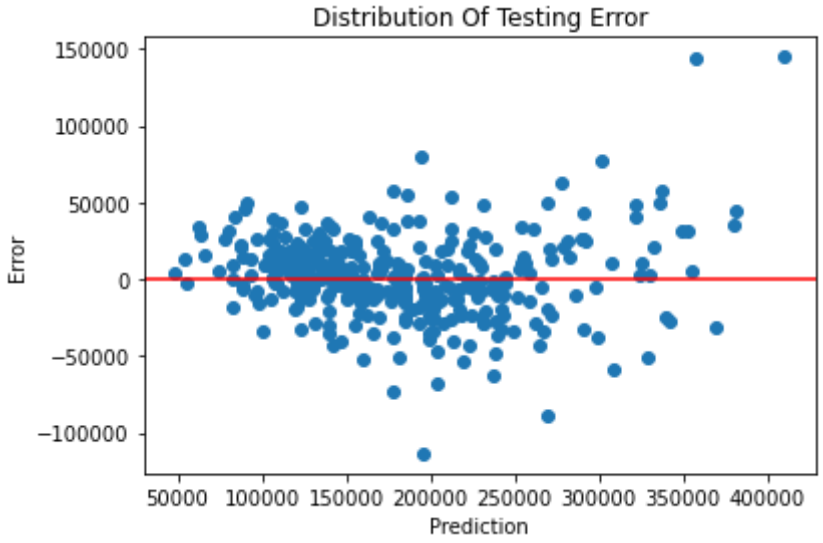
In [586…
```
x_tr, x_val, y_tr, y_val = train_test_split(x_train, y_train, test_size=0.25, ra

x_tr = transformer.fit_transform(x_tr)
x_val = transformer.transform(x_val)

rfe = RFE(LinearRegression(normalize=False), n_features_to_select=80)
x_tr = rfe.fit_transform(x_tr, y_tr)
x_val = rfe.transform(x_val)

# Fitting Model
model = Ridge(alpha=10.0, max_iter=500, random_state=1000)
results = model.fit(x_tr, y_tr)

# Getting Predictions
y_tr_preds = results.predict(x_tr)
y_val_preds = results.predict(x_val)
```

In [587…
```
get_results_preds(y_tr, y_tr_preds, y_val, y_val_preds)
```

```
R-Squared score for the training data: 0.8443560551411233

R-Squared score for the testing data: 0.8625669061039603


Root Mean Squared Error for the training data: 32014.381493841953

Root Mean Squared Error for the testing data: 27146.66162434128
```

In [588…
```
train_error_distribution(y_tr, y_tr_preds)
```

In [589…
```
test_error_distribution(y_val, y_val_preds)
```



Results

After using grid search to cross validate simple linear regressors, ridge regressors, lasso regressors, decision tree regressors, random forest regressors, and fully connected dense neural networks, the model that appeared to have the best fit in regard to the bias-variance tradeoff was a ridge regressor with alpha = 10.0 and max iterations = 500 as parameters. This model returned an r-squared score on the training data of ~0.844 and a root mean squared error score of ~32,014. On the test set, the model returned an r-squared score of ~0.863 and a root mean squared error score of ~27,146.

Note:

Because the test set does not contain a column for sale price, as competitors in the kaggle competition submit their final predictions for scoring, I will not be testing the best model on the test set. However, I've included the code I would use if I was testing the holdout set:

In [553…
```
test_df = pd.read_csv('data/test.csv')
```

In [554…
```
test_df = test_df.apply(impute_lot_frontage, axis=1)
```

In [555…
```
replace_NaN(test_df, ['GarageType', 'GarageFinish', 'GarageQual', 'GarageCond'],
```

In [556…
```
test_df.drop('Id', axis=1, inplace=True)
```

In [557…
```
test_df.drop(['Alley', 'FireplaceQu', 'PoolQC', 'Fence', 'MiscFeature'], axis=1,
```

In [558…
```
test_df.drop(['GarageArea', 'GarageYrBlt', 'TotRmsAbvGrd', '1stFlrSF'], axis=1,
```

In [559…
```
test_df.drop(low_var, axis=1, inplace=True)
```

In [560…
```
test_df.drop('MSSubClass', axis=1, inplace=True)
```

In [561…
```
test_df.dropna(inplace=True)
```

In [562…
```
map_function(test_df, ['ExterQual', 'ExterCond', 'BsmtQual', 'BsmtCond', 'Heatin
```

In [563…
```
test_df['Bath_Fireplaces'] = test_df['Fireplaces'] + test_df['FullBath']
```

In [568…
```
x_train = train_df.drop(['SalePrice'], axis=1)
y_train = train_df['SalePrice']
```

In [566…
```
x_test = test_df
```

In [570…
```
x_train = transformer.fit_transform(x_train)
x_test = transformer.transform(x_test)

rfe = RFE(LinearRegression(normalize=False), n_features_to_select=80)
x_train = rfe.fit_transform(x_train, y_train)
x_test = rfe.transform(x_test)

# Fitting Best Model
model = Ridge(alpha=10.0, max_iter=500, random_state=1000)
results = model.fit(x_train, y_train)

# Getting Predictions
y_train_preds = results.predict(x_train)
y_test_preds = results.predict(x_test)
```

In [574…
```
get_results_preds(y_train, y_train_preds, y_test, y_test_preds)
```

```
R-Squared score for the training data: 0.8509148503685335

Root Mean Squared Error for the training data: 30596.69300007709
```

In [ ]:
```
train_error_distribution(y_train, y_train_preds)
```

In [ ]:
```
test_error_distribution(y_test, y_test_preds)
```