```python
#Import drive
from google.colab import drive
dr = drive.mount('/content/drive')

# Data Manipulation
import pandas as pd
import numpy as np
import re

# Visualization
import matplotlib.pyplot as plt
import seaborn as sns

# Preprocessing
from sklearn.model_selection import train_test_split

# Machine Learning Models
from sklearn.linear_model import LinearRegression, Ridge, Lasso
from sklearn.tree import DecisionTreeRegressor

# Model Evaluation
from sklearn.metrics import mean_squared_error, r2_score

# Feature Selection
from sklearn.feature_selection import SelectKBest, chi2
from sklearn.metrics import accuracy_score, precision_score,
recall_score
# Cross-validation
from sklearn.model_selection import cross_val_score

# Hyperparameter Tuning
from sklearn.model_selection import GridSearchCV

#Intialize encoder
```

```
Drive already mounted at /content/drive; to attempt to forcibly
remount, call drive.mount("/content/drive", force_remount=True).
```

```python
drive_path = '/content/drive/MyDrive/Final Project Computer Science
2023/project/'
df_file = 'final_stock_file.csv'
df = pd.read_csv(drive_path+df_file)
df
```

```
         transaction_date  trade_date ticker
company_name  \
0     2022-01-12 16:53:26  2022-01-11   ADSK
Autodesk, Inc.
1     2022-01-11 19:26:43  2022-01-07   IBKR  Interactive Brokers
```

```
Group, Inc.
2     2022-01-03 10:01:05  2021-12-30    LLY                   Eli
Lilly & Co
3     2022-01-10 16:09:20  2022-01-07    HSY
Hershey Co
4     2022-01-31 16:15:08  2022-01-28   SAFE
Safehold Inc.
...                   ...         ...    ...
...
2057  2023-01-09 16:38:38  2023-01-06   HSKA
Heska Corp
2058  2023-01-13 16:20:21  2023-01-12   TEAM
Atlassian Corp
2059  2023-01-31 16:04:58  2023-01-27   FOXF         Fox Factory
Holding Corp
2060  2023-01-26 19:48:32  2023-01-25   TEAM
Atlassian Corp
2061  2023-01-19 16:39:34  2023-01-17    JBL
Jabil Inc

               owner_name                           Title
transaction_type  \
0         Hope Stephen W.    VP, Chief Accounting Officer         S -
Sale
1         Frank Thomas Aj                             CIO         S -
Sale
2     Lilly Endowment Inc                             10%         S -
Sale
3            Reiman Jason  SVP Chief Supply Chain Officer         S -
Sale
4              Istar Inc.                             10%     P -
Purchase
...                   ...                             ...
...
2057      Wilson Kevin S.                       CEO, Pres     P -
Purchase
2058       Farquhar Scott        Co-CEO, Co-Founder, 10%         S -
Sale
2059  Dennison Michael C.                             CEO         S -
Sale
2060       Farquhar Scott        Co-CEO, Co-Founder, 10%         S -
Sale
2061     Sansone Thomas A                             Dir         S -
Sale

      last_price      Qty  shares_held Owned        Value  stock_value
\
0         260.47     -197        3,755   -5%     -$51,313   270.630005

1          76.51  -32,897      394,861   -8%  -$2,516,911    76.679276
```

```
2           279.55   -3,614  107,463,810    0%  -$1,010,276   272.629761

3           196.45     -150       12,740   -1%     -$29,468   191.524307

4            59.09  +16,920   36,739,336    0%    +$999,859    57.652042

...            ...      ...          ...   ...          ...          ...

2057         58.62  +11,018      477,578   +2%    +$645,926    62.169998

2058        144.00   -8,614      465,156   -2%  -$1,240,432   146.479996

2059        115.00   -7,500       62,701  -11%    -$862,500   114.279999

2060        148.18   -8,614      396,244   -2%  -$1,276,438   151.929993

2061         78.75  -20,000    1,416,245   -1%  -$1,575,000    78.330002


      30_days_later
0        251.339996
1         72.449654
2        241.015518
3        198.301239
4         60.336269
...             ...
2057      88.480003
2058     172.229996
2059     112.139999
2060     170.630005
2061      84.089996

[2062 rows x 14 columns]
```

```
# Infer the data types of the columns
df = df.infer_objects()

# Check the data types of the columns
print(df.dtypes)
```

```
transaction_date     object
trade_date           object
ticker               object
company_name         object
owner_name           object
Title                object
transaction_type     object
```

```
last_price          float64
Qty                  object
shares_held          object
Owned                object
Value                object
stock_value         float64
30_days_later       float64
dtype: object
```

```
train_data, test_data = train_test_split(df, test_size=0.2)
```

```
train_data
```

```
         transaction_date  trade_date ticker  \
1336  2022-08-26 20:20:47  2022-08-25   CTLT
622   2022-04-28 21:46:49  2022-04-27   TSLA
1250  2022-08-04 16:24:34  2022-08-03    SAM
1718  2023-01-24 16:37:51  2023-01-23   AKAM
661   2022-04-05 16:33:53  2022-04-04    RMD
...                   ...         ...    ...
723   2022-04-27 18:23:32  2022-04-25   SMAR
1464  2022-09-08 14:09:34  2022-09-07    SXI
1015  2022-05-25 16:23:28  2022-05-24   IART
1259  2022-08-02 20:45:40  2022-07-19   CNXC
334   2022-01-06 18:07:57  2022-01-06    MAA

                                 company_name
owner_name  \
1336                           Catalent, Inc.           Maselli
Alessandro
622                               Tesla, Inc.                    Musk
Elon
1250                       Boston Beer Co Inc           O'Boyle
Carolyn L.
1718                  Akamai Technologies Inc           Leighton F
Thomson
661                                Resmed Inc              Pendarvis
David
...                                       ...
...
723                            Smartsheet Inc            Barker
Geoffrey T
1464           Standex International Corp/de/              Sarcevic
Ademir
1015      Integra Lifesciences Holdings Corp                   Evoli
Lisa
1259                           Concentrix Corp  Silver Star Developments
Ltd
334   Mid America Apartment Communities Inc.              Bolton H
Eric Jr
```

```
                             Title transaction_type  last_price
Qty  \
1336                     Pres, CEO         S - Sale      103.04    -
4,646
622                      CEO, 10%         S - Sale      898.00  -
345,601
1250          Chief People Officer         S - Sale      381.73      -
251
1718                           CEO     P - Purchase       87.79
+571
661   Chief Administrative Officer         S - Sale      246.60    -
1,544
...                            ...              ...         ...
...
723                            Dir         S - Sale       50.44    -
2,250
1464            VP, CFO, Treasurer         S - Sale       85.89    -
1,592
1015                      EVP,CHRO         S - Sale       59.85      -
250
1259                           10%         S - Sale      125.00  -
524,691
334                      Pres, CEO         S - Sale      223.64    -
1,461

      shares_held Owned          Value  stock_value  30_days_later
1336       41,190  -10%      -$478,724   104.199997      76.070000
622   168,193,251    0%  -$310,350,358   293.836670     235.910004
1250        2,593   -9%       -$95,814   378.329987     337.290009
1718    2,355,858    0%       +$50,131    89.190002      76.400002
661       111,403   -1%      -$380,750   245.710007     196.419998
...           ...   ...            ...          ...            ...
723       349,006   -1%      -$113,479    50.810001      33.470001
1464       17,575   -8%      -$136,741    86.860001      86.059998
1015       20,811   -1%       -$14,963    60.099998      54.220001
1259    4,415,535  -11%   -$65,586,375   129.210007     133.630005
334       282,650   -1%      -$326,738   219.791565     212.529999

[1649 rows x 14 columns]
```

```python
def check_null_values(df):
    # Get the names of columns that have null values
    null_cols = df.columns[df.isnull().any()]
    # If any columns have null values, print their names
    if len(null_cols) > 0:
        print("The following columns contain null values:")
        for col in null_cols:
            print(col)
    # If no columns have null values, print a message indicating this
```

```python
    else:
        print("No columns contain null values.")


def check_empty_values(df):
    # Get the names of columns that have empty values
    empty_cols = [col for col in df.columns if
df[col].astype(str).str.strip().empty]
    # If any columns have empty values, print their names
    if len(empty_cols) > 0:
        print("The following columns contain empty values:")
        for col in empty_cols:
            print(col)
    # If no columns have empty values, print a message indicating this
    else:
        print("No columns contain empty values.")


def check_nan_values(df):
    # Check if each column is numerical
    num_cols = [col for col in df.columns if
pd.api.types.is_numeric_dtype(df[col])]
    # Get the names of columns that have NaN values
    nan_cols = [col for col in num_cols if pd.to_numeric(df[col],
errors='coerce').isnull().any()]
    # If any columns have NaN values, print their names
    if len(nan_cols) > 0:
        print("The following numerical columns contain NaN values:")
        for col in nan_cols:
            print(col)
    # If no columns have NaN values, print a message indicating this
    else:
        print("No numerical columns contain NaN values.")

def replace_missing_values(df):
    """
    Replace missing (NaN) values in a DataFrame with appropriate
values based on data type of the column.

    Parameters:
        - df (pd.DataFrame): Input DataFrame

    Returns:
        - pd.DataFrame: DataFrame with missing values replaced
    """
    null_columns = df.columns[df.isnull().sum() > 0]
    for column in null_columns:
        if df[column].dtype == 'float64' or df[column].dtype ==
'int64':
            df[column].fillna(df[column].mean(), inplace=True)
```

```python
        else:
            df[column].fillna(df[column].mode().iloc[0], inplace=True)
    return df


def encode_values(column_dict,column):
    unique_values = column.unique()  # Get unique values in the column
    num_variants = len(unique_values)  # Get the number of unique
values
    unique_values = list(enumerate(unique_values))
    for number,value in unique_values:
        column_dict[value]=number
    return column_dict




def replace_items(column, dictionary):
    return column.replace(dictionary)

encoded_values_ticker= encode_values(dict(),df['ticker'])
encoded_values_owner_name = encode_values(dict(),df['owner_name'])

check_null_values(train_data)
check_empty_values(train_data)
check_nan_values(train_data)

No columns contain null values.
No columns contain empty values.
No numerical columns contain NaN values.

# Function to replace 'P' with 1 and 'S' with 0 in a string column
def replace_p_s_with_1_0(value):
    if 'P' in value:
        return 1
    elif 'S' in value:
        return 0
# Define a function for hashing the company names
def hash_trick_binary(s, num_bits=16):
    """
    Hashing trick function to encode company names to binary
representation
    Args:
        s (str): Company name
        num_bits (int): Number of bits for the binary representation
(default: 16)
    Returns:
        str: Binary representation of the hashed company name
    """
    hashed_value = hash(s)  # Use the built-in hash function to hash
the company name
    binary_value = format(hashed_value, '0{}b'.format(num_bits))  #
```

```
Convert to binary representation
    return binary_value

def one_hot_encode_column(df, col_name):
    """
    This function takes a pandas dataframe and a column name, one hot
encodes the column, and returns the resulting dataframe.

    Arguments:
    df -- pandas dataframe
    col_name -- string, the name of the column to be one hot encoded

    Returns:
    pandas dataframe -- the original dataframe with the one hot
encoded column added and the original column removed
    """

    # Select the column to be one hot encoded
    col = df[col_name]

    # Apply one hot encoding to the column
    one_hot_encoded_col = pd.get_dummies(col, prefix=col_name)

    # Concatenate the original dataframe with the one hot encoded
column
    df = pd.concat([df, one_hot_encoded_col], axis=1)

    # Remove the original column
    df.drop(col_name, axis=1, inplace=True)

    return df

df['Title']
```

```
0          VP, Chief Accounting Officer
1                                   CIO
2                                   10%
3        SVP Chief Supply Chain Officer
4                                   10%
                     ...
2057                          CEO, Pres
2058           Co-CEO, Co-Founder, 10%
2059                                CEO
2060           Co-CEO, Co-Founder, 10%
2061                                Dir
Name: Title, Length: 2062, dtype: object
```

```
def clean_array(arr):
    return [word.strip().replace('co-', '') for word in arr]
```

```python
def find_initials(s):
    return ''.join([x[0] for x in s.split(' ')])

#It's for a series object NOT for array
def replace_with_initials(s,in_string):
    new_s = s.copy()
    for i, string in s.items():
            if in_string in string:
                new_s[i] = find_initials(string)
    return new_s

def replace_to_cob(s):
    new_s = s.copy()
    for i, string in s.items():
    # Check if string contains "chair, exec cob" (case insensitive)
       if 'chair' in string or 'cob' in string:
              new_s[i] = 'cob'
    return new_s

# Split the strings on commas and create a list of values for each
cell
train_data['Title'] = train_data['Title'].str.lower()
train_data['Title'] = train_data['Title'].str.split(',')
#Clean_array will remove the co- start from each title
train_data['Title'] = train_data['Title'].apply(clean_array)
unique_values = train_data['Title'].explode()
print(len(unique_values.value_counts()))
unique_values = replace_with_initials(unique_values,'chief')
unique_values = replace_to_cob(unique_values)
unique_values = unique_values.value_counts()
print(unique_values[:50])
```

```
299
dir                                449
cob                                216
ceo                                202
10%                                184
evp                                162
pres                               130
cfo                                122
svp                                 94
gc                                  86
cao                                 75
coo                                 65
vp                                  38
founder                             36
cto                                 28
cro                                 22
cco                                 22
secretary                           21
```

```
see remarks                       21
cmo                               21
cpo                               20
clo                               19
treasurer                         16
chro                              16
cso                               15
cio                               15
cl                                14
controller                        11
d                                  8
hr                                 7
cbo                                7
principal accounting officer       6
cdo                                6
sales                              6
gm                                 5
marketing                          5
exec officer                       5
csco                               5
r                                  4
md                                 4
gen. counsel                       4
core technologies                  4
cea                                3
tax                                3
coo t                              3
systems                            3
cr                                 3
control                            3
operations                         3
fin plan                           3
group pres                         3
Name: Title, dtype: int64
```

```python
def replace_to_initials_for_array(string, df):
    # Loop through the columns of the DataFrame
    for i, value in df.items():
        new_array = []
        # Loop through the values in the column
        for v in value:
            if string in v:
                # Replace string with initials using the
find_initials() function
                new_array.append(find_initials(v))
            else:
                new_array.append(v)
        # Update the column in the DataFrame with the modified values
        df[i] = new_array
```

```
def replace_to_string_for_array(string, df, optional=None,
not_optional=None):
    if optional is None and not_optional is None:
        # If neither optional nor not_optional are provided, replace
string with string
        # in all values of the DataFrame
        for i, value in df.items():
            df = df.apply(lambda v: string if string in v else v)
    elif not_optional is None:
        # If not_optional is not provided, replace string with string
in values that
        # contain either string or optional
        for i, value in df.items():
            new_array = []
            # Loop through the values in the column
            for v in value:
                if string in v or optional in v:
                    new_array.append(string)
                else:
                    new_array.append(v)
            # Update the column in the DataFrame with the modified
values
            df[i] = new_array
    elif optional is None:
        # If optional is not provided, replace string with string in
values that
        # contain string but not not_optional
        for i, value in df.items():
            new_array = []
            # Loop through the values in the column
            for v in value:
                if string in v and not_optional != v:
                    new_array.append(string)
                else:
                    new_array.append(v)
            # Update the column in the DataFrame with the modified
values
            df[i] = new_array

replace_to_string_for_array('cob',df=train_data['Title'],optional='cha
ir')
replace_to_string_for_array('pres',df=train_data['Title'])
replace_to_string_for_array('vp',df=train_data['Title'],not_optional='
evp')
replace_to_initials_for_array('chief',train_data['Title'])
```

```
<ipython-input-57-756befde8387>:33: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation:
```

```
https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#
returning-a-view-versus-a-copy
  df[i] = new_array
<ipython-input-57-756befde8387>:46: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation:
https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#
returning-a-view-versus-a-copy
  df[i] = new_array
<ipython-input-57-756befde8387>:13: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation:
https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#
returning-a-view-versus-a-copy
  df[i] = new_array
```

```
ranks = {
    'founder': 1,
    'cob': 2,
    'ceo': 2,
    'president':3,
    'pres': 3,
    'evp': 3,
    'coo': 4,
    'cfo': 4,
    'cto': 4,
    'cio': 4,
    'chro': 4,
    'gc': 4,
    'vp': 5,
    'controller': 5,
    'cmo': 5,
    'cao': 5,
    'treasurer': 5,
    'secretary': 5,
    '10%': 5,
    'dir':5
    }


# Function to replace titles in an array with their corresponding
ranks from the dictionary,
# and return the minimum rank among them. If title not found in
dictionary, default rank is 5.
def replace_title_with_rank(title_array):
   return min([ranks.get(title, 5) if title in ranks else 5 for title
in title_array]) # Use 5 as default value if title not found in
dictionary
```

```
train_data['Title'] =
train_data['Title'].apply(replace_title_with_rank)

train_data['transaction_type'] =
train_data['transaction_type'].apply(replace_p_s_with_1_0)
train_data['ticker'] =
replace_items(train_data['ticker'],encoded_values_ticker)
train_data['owner_name'] =
replace_items(train_data['owner_name'],encoded_values_owner_name)

columns_to_drop = ['transaction_date', 'trade_date', 'company_name']
train_data=train_data.drop(columns_to_drop, axis=1)

train_data['Qty']= train_data['Qty'].str.replace(",",
"").astype(float)
train_data['shares_held']= train_data['shares_held'].str.replace(",",
"").astype(int)
train_data["Owned"] = train_data["Owned"].str.replace("%",
"").replace("New",0)
train_data['Owned'] =
train_data['Owned'].str.replace('>',"").astype(float)
# Divide by 100
train_data["Owned"] = train_data["Owned"]/100
train_data['Value'] = train_data['Value'].str.replace("$", "")
train_data['Value'] = train_data['Value'].str.replace(",",
"").astype(int)
```

```
<ipython-input-64-72f3c9a12d17>:7: FutureWarning: The default value of
regex will change from True to False in a future version. In addition,
single character regular expressions will *not* be treated as literal
strings when regex=True.
  train_data['Value'] = train_data['Value'].str.replace("$", "")
```

```
train_data
```

```
      ticker  owner_name  Title  transaction_type  last_price
Qty  \
1336     173         918      2                 0      103.04   -
4646.0
622       11         461      2                 0      898.00 -
345601.0
1250     492         859      5                 0      381.73    -
251.0
1718     151        1063      2                 1       87.79
571.0
661      295         486      5                 0      246.60   -
1544.0
...      ...         ...    ...               ...         ...        ..
.
723      115         355      5                 0       50.44   -
2250.0
```

```
1464     542         992      4                 0       85.89   -
1592.0
1015     403         682      3                 0       59.85    -
250.0
1259     202         864      5                 0      125.00 -
524691.0
334       15         272      2                 0      223.64   -
1461.0

      shares_held  Owned      Value  stock_value  30_days_later
1336        41190  -0.10    -478724   104.199997      76.070000
622     168193251   0.00 -310350358   293.836670     235.910004
1250         2593  -0.09     -95814   378.329987     337.290009
1718      2355858   0.00      50131    89.190002      76.400002
661        111403  -0.01    -380750   245.710007     196.419998
...           ...    ...        ...          ...            ...
723        349006  -0.01    -113479    50.810001      33.470001
1464        17575  -0.08    -136741    86.860001      86.059998
1015        20811  -0.01     -14963    60.099998      54.220001
1259      4415535  -0.11  -65586375   129.210007     133.630005
334        282650  -0.01    -326738   219.791565     212.529999

[1649 rows x 11 columns]
```

```
check_null_values(train_data)
check_empty_values(train_data)
check_nan_values(train_data)
```

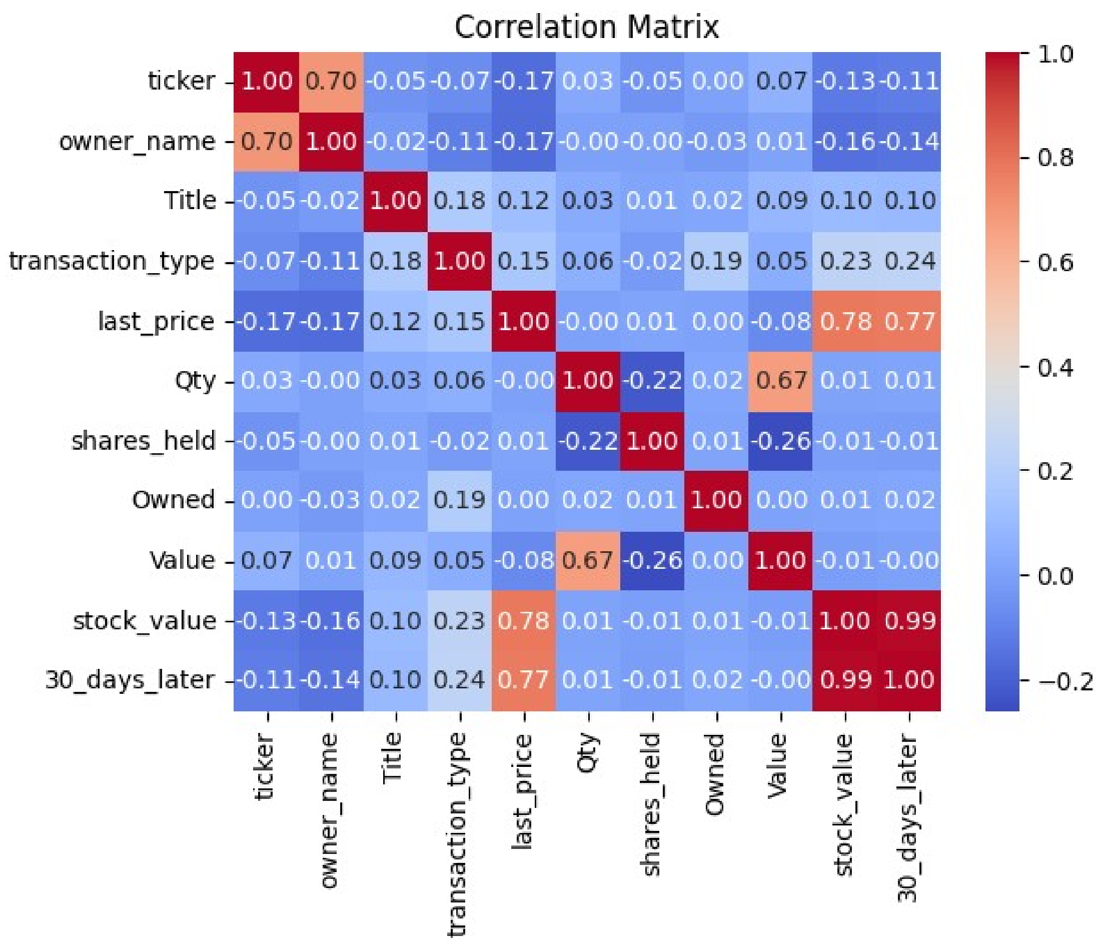
```
The following columns contain null values:
Owned
No columns contain empty values.
The following numerical columns contain NaN values:
Owned
```

```
train_data = replace_missing_values(train_data)
train_data
```

```
      ticker  owner_name  Title  transaction_type  last_price
Qty  \
1336     173         918      2                 0      103.04   -
4646.0
622       11         461      2                 0      898.00 -
345601.0
1250     492         859      5                 0      381.73    -
251.0
1718     151        1063      2                 1       87.79
571.0
661      295         486      5                 0      246.60   -
1544.0
...      ...         ...    ...               ...         ...        ..
.
```

```
723      115        355     5                  0       50.44   -
2250.0
1464     542        992     4                  0       85.89   -
1592.0
1015     403        682     3                  0       59.85    -
250.0
1259     202        864     5                  0      125.00 -
524691.0
334       15        272     2                  0      223.64   -
1461.0

      shares_held  Owned      Value  stock_value  30_days_later
1336        41190  -0.10    -478724   104.199997      76.070000
622     168193251   0.00 -310350358   293.836670     235.910004
1250         2593  -0.09     -95814   378.329987     337.290009
1718      2355858   0.00      50131    89.190002      76.400002
661        111403  -0.01    -380750   245.710007     196.419998
...           ...    ...        ...          ...            ...
723        349006  -0.01    -113479    50.810001      33.470001
1464        17575  -0.08    -136741    86.860001      86.059998
1015        20811  -0.01     -14963    60.099998      54.220001
1259      4415535  -0.11  -65586375   129.210007     133.630005
334        282650  -0.01    -326738   219.791565     212.529999

[1649 rows x 11 columns]
```

```python
# Compute the correlation matrix
corr_matrix = train_data.corr()

# Create a heatmap of the correlation matrix
sns.heatmap(corr_matrix, cmap='coolwarm', annot=True, fmt=".2f")
plt.title('Correlation Matrix')
plt.show()
```




```
train_data

      ticker  owner_name  Title  transaction_type  last_price   
Qty  \
1336     173         918      2                 0      103.04   -
4646.0
622       11         461      2                 0      898.00 -
345601.0
1250     492         859      5                 0      381.73    -
251.0
1718     151        1063      2                 1       87.79     
571.0
661      295         486      5                 0      246.60   -
1544.0
...      ...         ...    ...               ...         ...       ..
.
723      115         355      5                 0       50.44   -
2250.0
1464     542         992      4                 0       85.89   -
1592.0
1015     403         682      3                 0       59.85    -
250.0
```

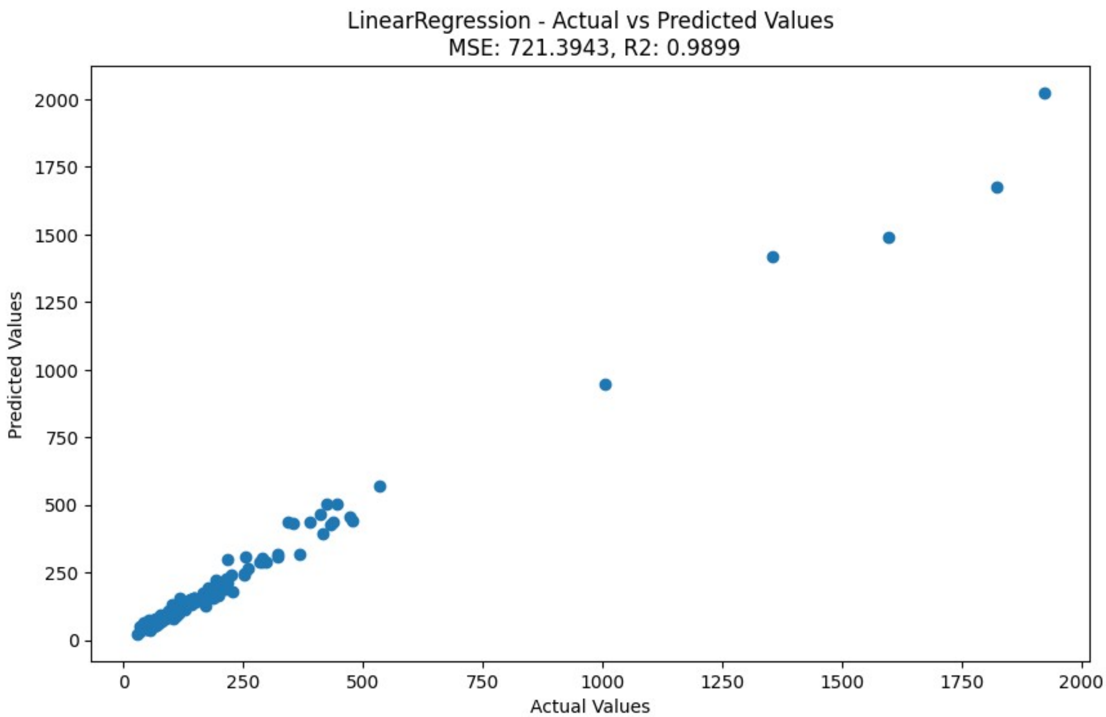
```
1259     202         864      5                 0      125.00 -
524691.0
334       15         272      2                 0      223.64   -
1461.0

      shares_held  Owned      Value  stock_value  30_days_later
1336        41190  -0.10    -478724   104.199997      76.070000
622     168193251   0.00 -310350358   293.836670     235.910004
1250         2593  -0.09     -95814   378.329987     337.290009
1718      2355858   0.00      50131    89.190002      76.400002
661        111403  -0.01    -380750   245.710007     196.419998
...           ...    ...        ...          ...            ...
723        349006  -0.01    -113479    50.810001      33.470001
1464        17575  -0.08    -136741    86.860001      86.059998
1015        20811  -0.01     -14963    60.099998      54.220001
1259      4415535  -0.11  -65586375   129.210007     133.630005
334        282650  -0.01    -326738   219.791565     212.529999

[1649 rows x 11 columns]
```

```
# Define the parameter grid for grid search for Ridge and Lasso
regression
param_grid_ridge = {'alpha': np.logspace(-3, 3, 7)} # alpha values
ranging from 0.001 to 1000
param_grid_lasso = {'alpha': np.logspace(-3, 3, 7)} # alpha values
ranging from 0.001 to 1000

X = train_data.drop('30_days_later', axis=1)  # Replace 'target' with
the column name of your target variable
y = train_data['30_days_later']  # Replace 'target' with the column
name of your target variable

# Create an array of regression models
models = [LinearRegression(), Ridge(),
Lasso(),DecisionTreeRegressor()]

# Define different test sizes
test_sizes = [0.10, 0.15, 0.2, 0.25]

# Create a dictionary to store model information
model_info = {}

# Loop through each test size
for test_size in test_sizes:
    X_train, X_test, y_train, y_test = train_test_split(X, y,
test_size=test_size, random_state=42)
    print('Test size:', test_size)

    # Loop through each model
    for model in models:
```

```
        model_name = model.__class__.__name__

        # Perform grid search with cross-validation
        if model_name == 'LinearRegression':
            param_grid = {}
        elif model_name == 'Ridge':
            param_grid = param_grid_ridge
        elif model_name == 'Lasso':
            param_grid = param_grid_lasso
        elif model_name == 'DecisionTreeRegressor':
          param_grid = {}

        grid_search = GridSearchCV(model, param_grid, cv=5)
        grid_search.fit(X_train, y_train)

        # Get the best hyperparameters
        best_params = grid_search.best_params_
        best_alpha = best_params['alpha'] if 'alpha' in best_params
else None

        # Train the model with the best hyperparameters
        model_best = model.__class__(**best_params) if best_alpha else
model.__class__()
        trained_model=model_best.fit(X_train, y_train)

        # Make predictions on the test set
        y_pred = model_best.predict(X_test)

        # Calculate metrics
        mse = mean_squared_error(y_test, y_pred)
        r2 = r2_score(y_test, y_pred)

        # Store model information in the dictionary
        model_info[model_name] = {
            'best_params': best_params,
            'best_alpha': best_alpha,
            'trained_model':trained_model,
            'model': model_best,
            'X_train': X_train,
            'y_train': y_train,
            'X_test': X_test,
            'y_test': y_test,
            'y_pred': y_pred,
            'mse': mse,
            'r2': r2
        }

        # Plot the results
        plt.figure(figsize=(10, 6))
        plt.scatter(y_test, y_pred)
```

```
        plt.xlabel('Actual Values')
        plt.ylabel('Predicted Values')
        plt.title('{} - Actual vs Predicted Values\n MSE: {:.4f}, R2: 
{:.4f}'.format(model_name, mse, r2))
        plt.show()

# Access model information from the dictionary
# Example usage:
# best_params_ridge = model_info['Ridge']['best_params']
```

```
Test size: 0.1
```

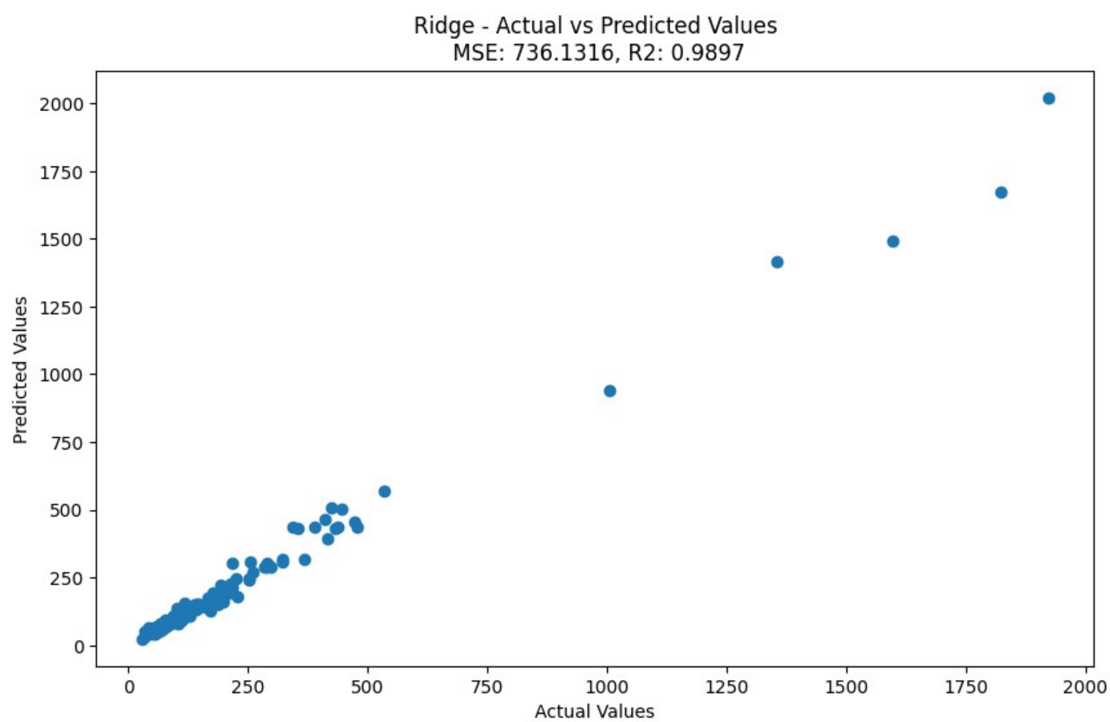


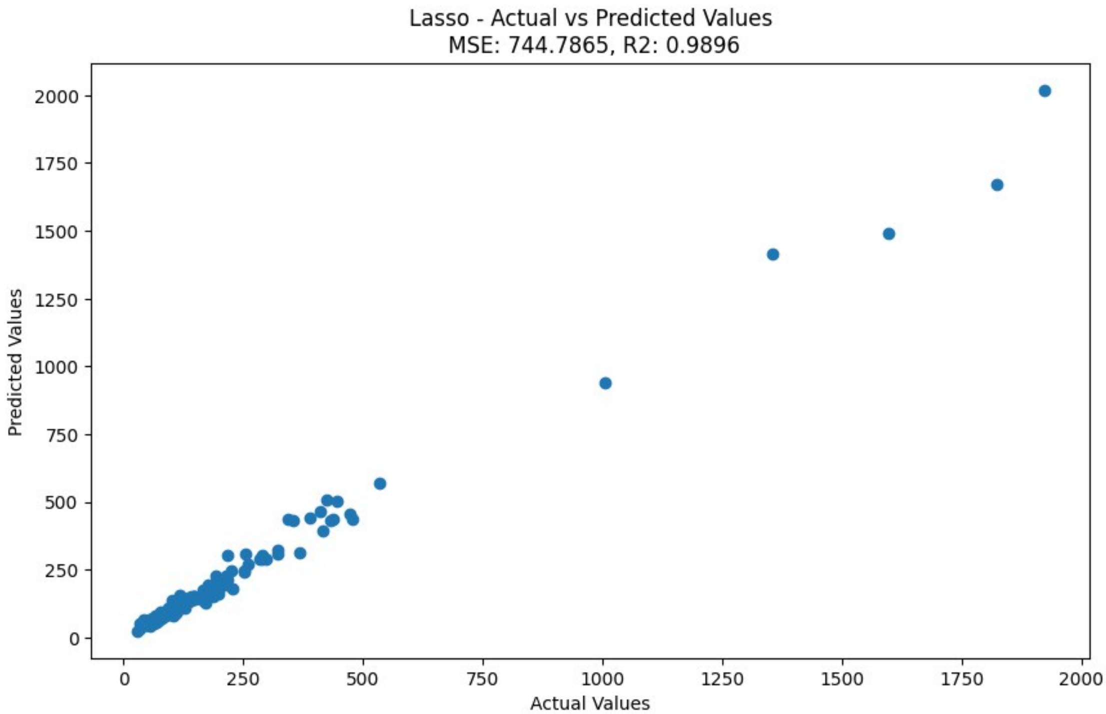

```
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/
_ridge.py:216: LinAlgWarning: Ill-conditioned matrix (rcond=9.1921e-
18): result may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=7.52635e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=1.58972e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=7.25785e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
```

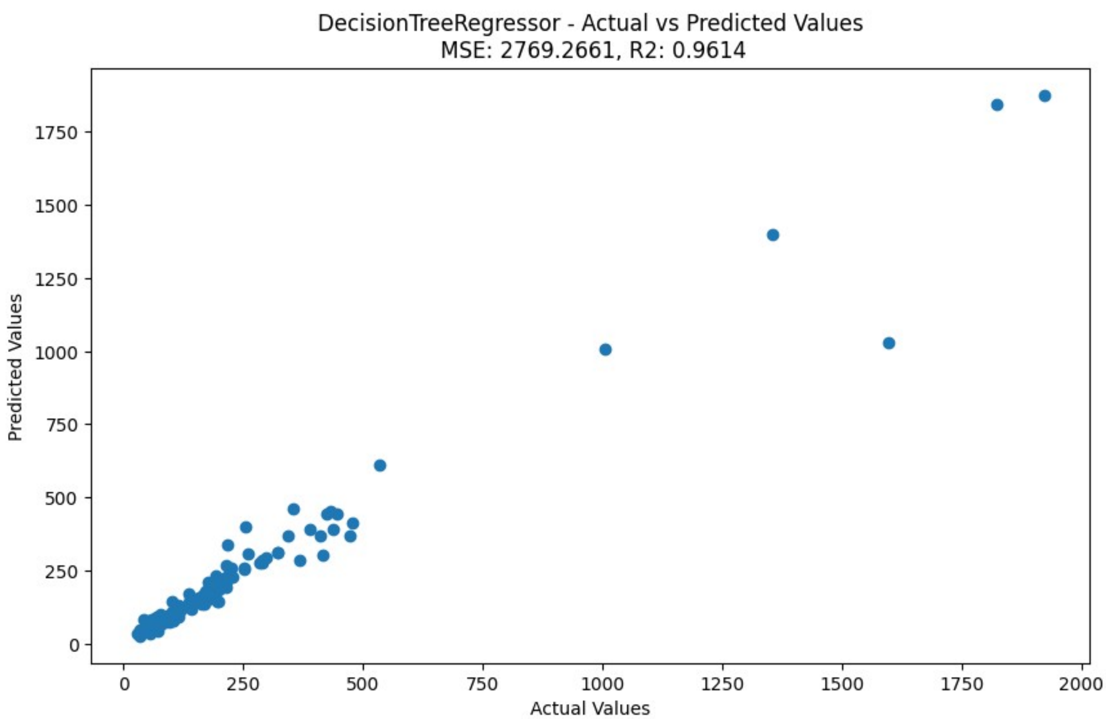
```
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=7.32093e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=9.1928e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=7.52686e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=1.58984e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=7.25835e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=7.32142e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=9.19982e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=7.532e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=1.59102e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=7.26337e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=7.32631e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=9.26998e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=7.58336e-18): result
```

```
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=1.6028e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=7.31357e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=7.37521e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=9.97222e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=8.09785e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=1.72075e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=7.81642e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=7.86512e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=1.70451e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=1.33114e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=2.90592e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=1.29083e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
```

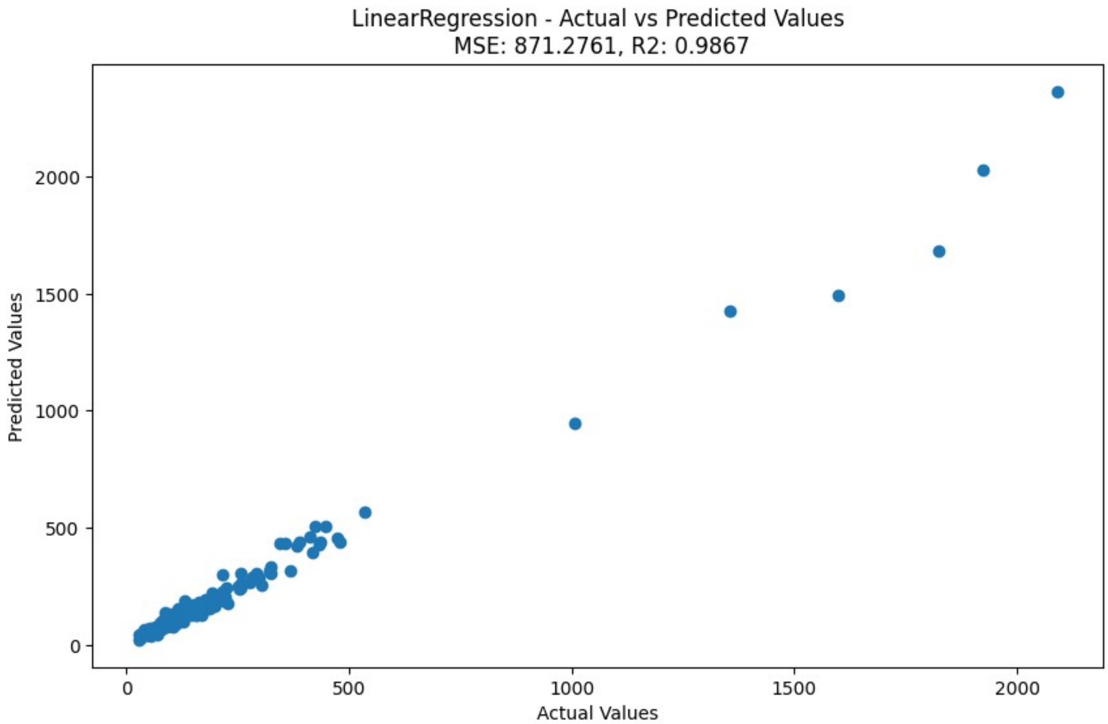
```
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=1.28292e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=9.34976e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=6.75499e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=6.56962e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=6.45294e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=6.46587e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=6.46587e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
```








```
Test size: 0.15
```

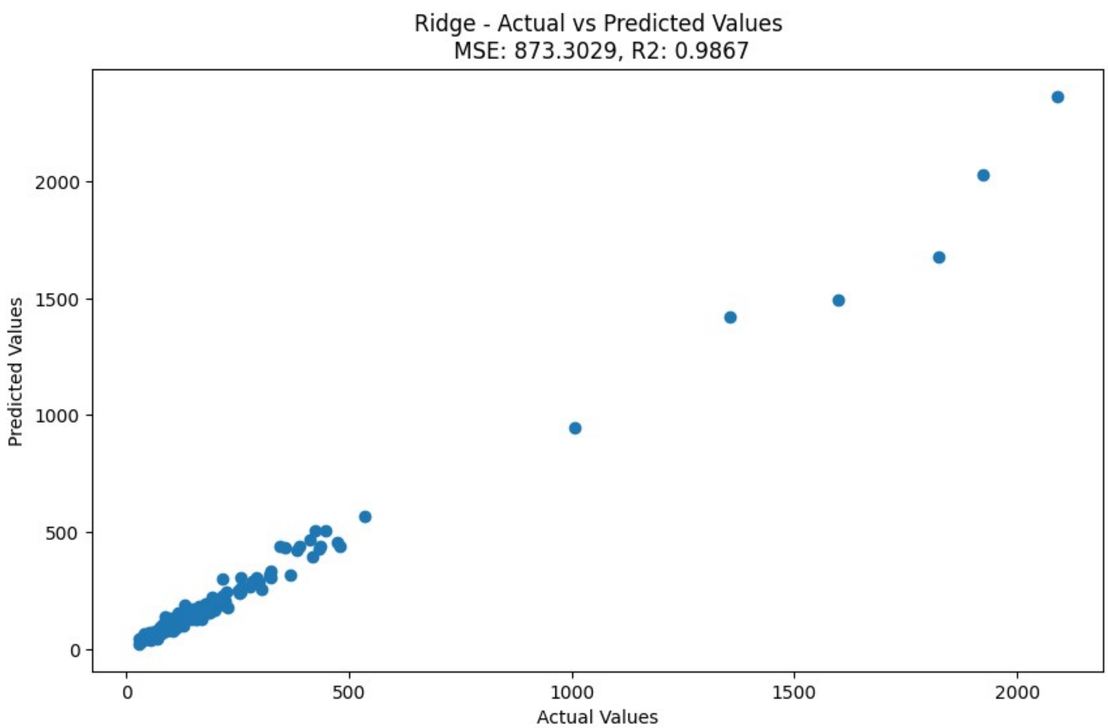


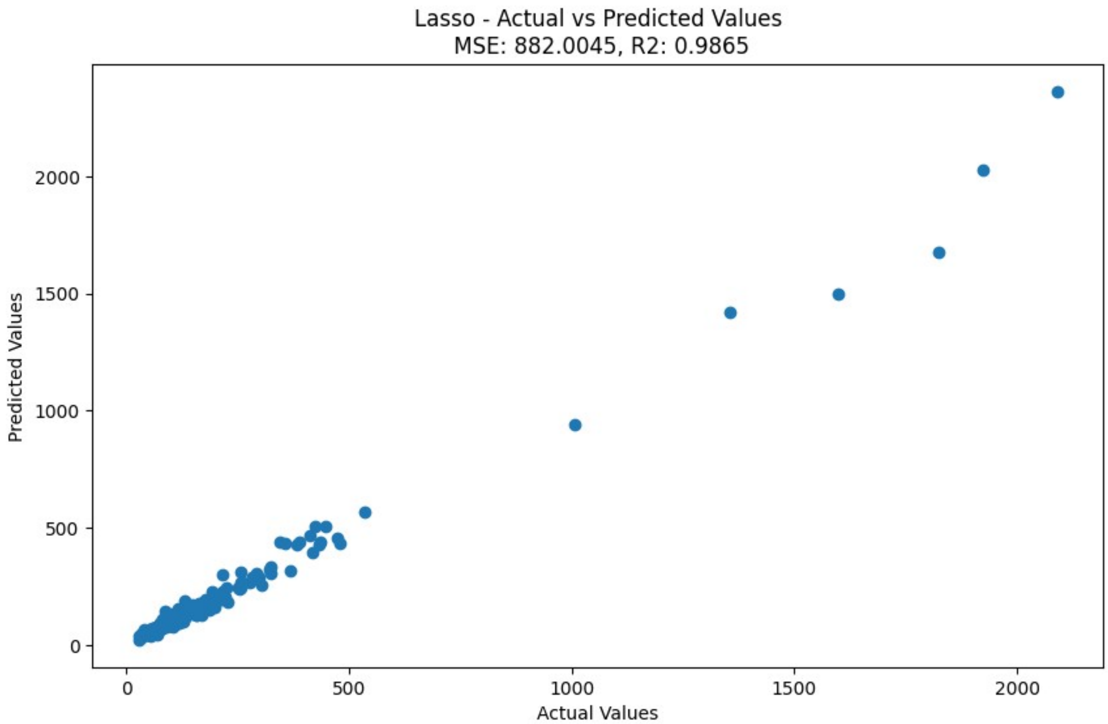

```
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/
_ridge.py:216: LinAlgWarning: Ill-conditioned matrix (rcond=8.79884e-
18): result may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=1.0156e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=8.82335e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=6.91709e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=6.88759e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=8.79956e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=1.01568e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
```

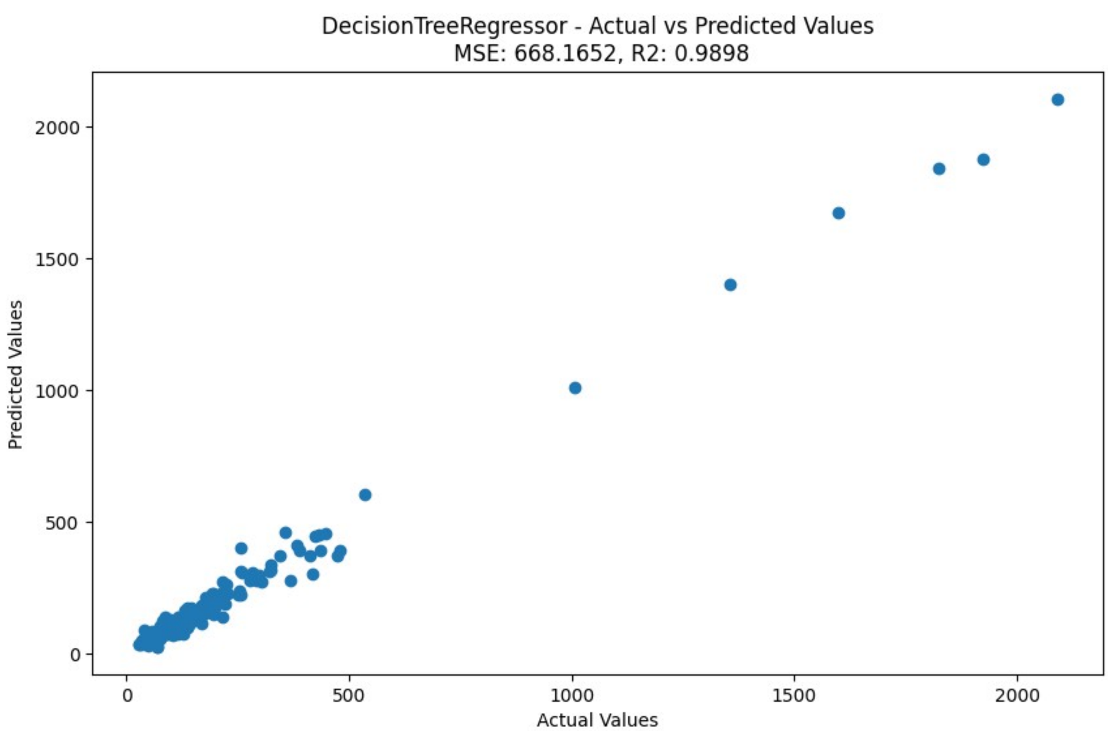
```
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=8.82399e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=6.91759e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=6.88807e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=8.80671e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=1.01647e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=8.83042e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=6.9226e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=6.89295e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=8.87829e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=1.02432e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=8.89476e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=6.97266e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=6.94176e-18): result
```

```
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=9.59506e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=1.10296e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=9.53928e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=7.47416e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=7.43076e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=1.68316e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=1.89574e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=1.60769e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=1.25576e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=1.23905e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=9.10377e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=1.05174e-16): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
```

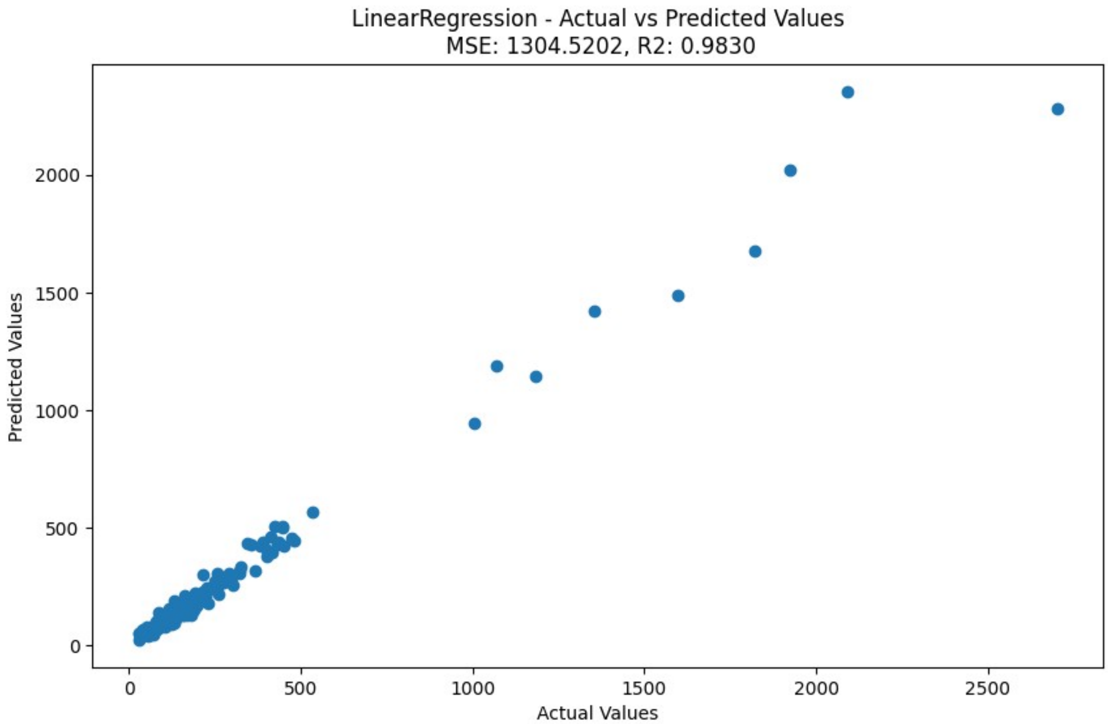
```
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=8.42578e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=6.5422e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=6.42e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=1.35632e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=1.35632e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
```




Lasso - Actual vs Predicted Values
MSE: 882.0045, R2: 0.9865
Predicted Values
Actual Values
0
500
1000
1500
2000


DecisionTreeRegressor - Actual vs Predicted Values
MSE: 668.1652, R2: 0.9898
Predicted Values
Actual Values
0
500
1000
1500
2000

```
Test size: 0.2
```

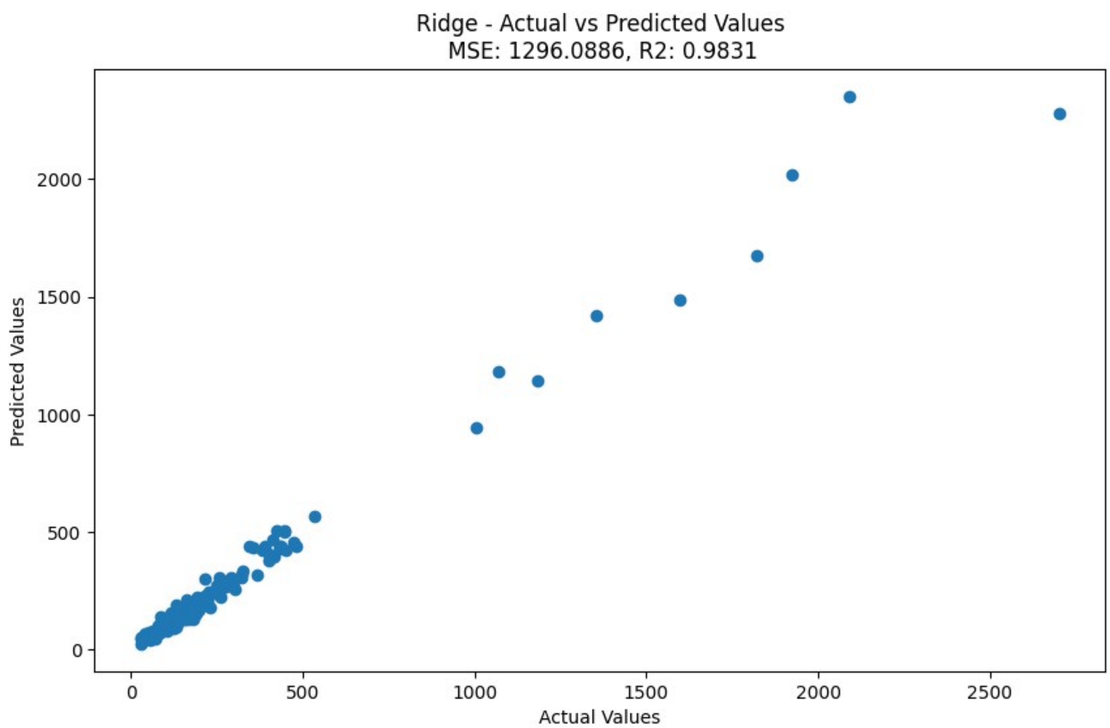


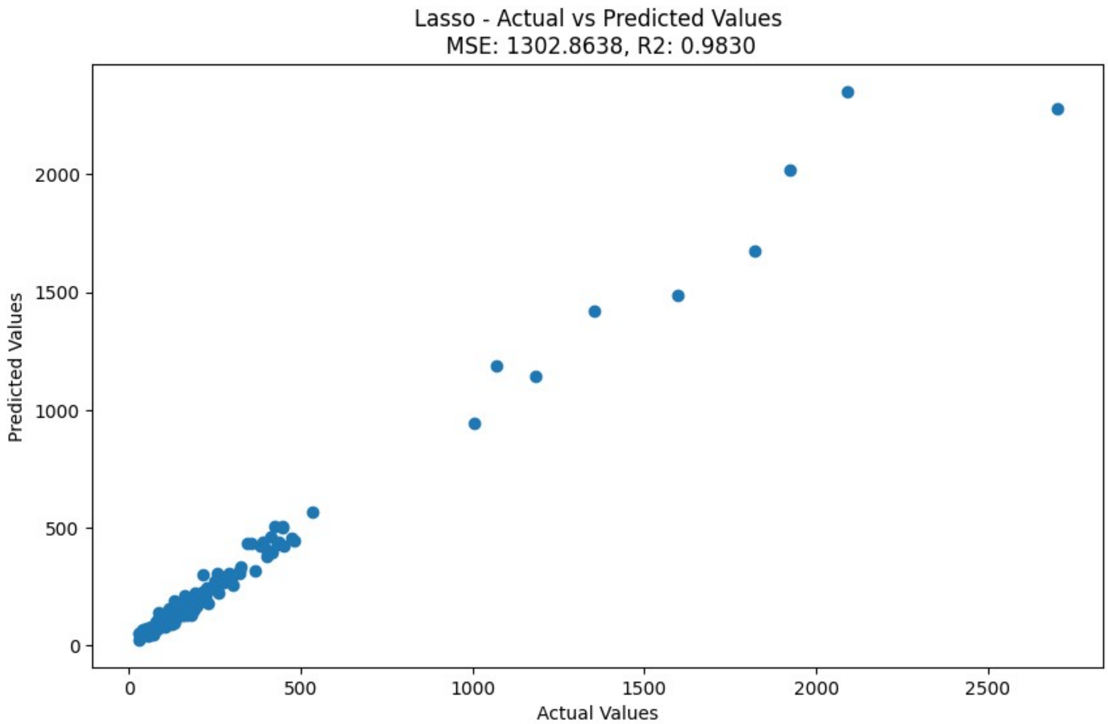

```
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/
_ridge.py:216: LinAlgWarning: Ill-conditioned matrix (rcond=8.33997e-
18): result may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=9.55553e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=8.2572e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=6.56183e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=6.45069e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=8.34068e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=9.55631e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
```

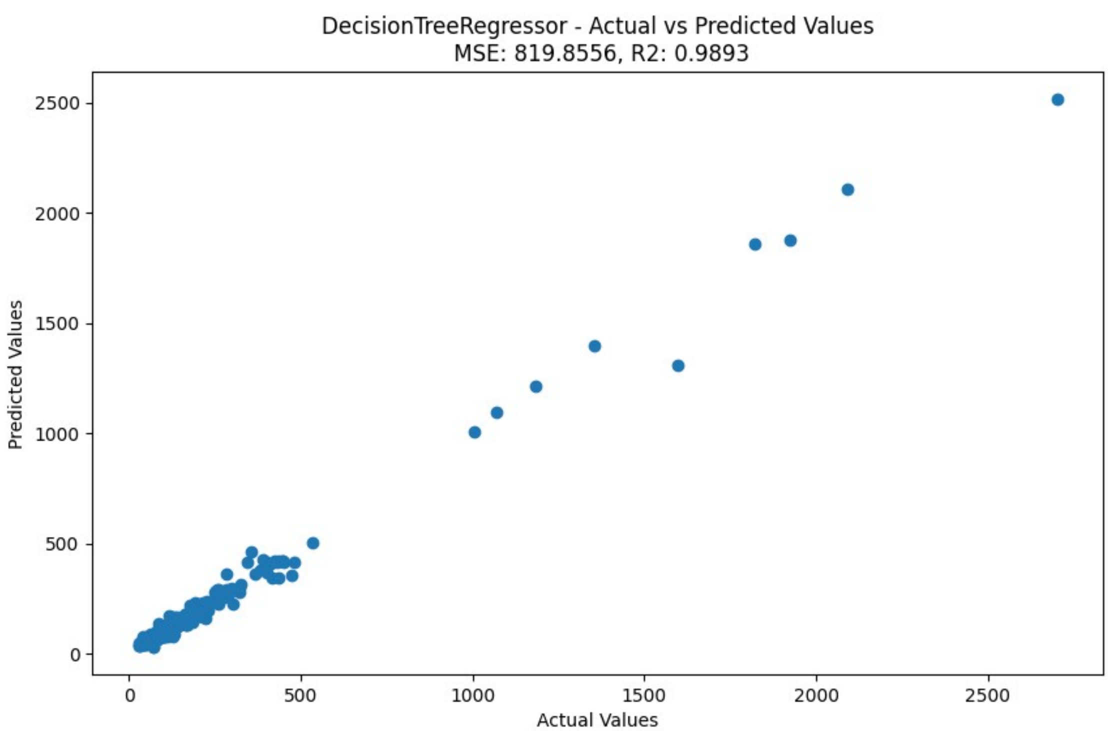
```
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=8.25784e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=6.56233e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=6.45118e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=8.34781e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=9.56417e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=8.26427e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=6.56734e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=6.45606e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=8.41915e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=9.64272e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=8.32857e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=6.61736e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=6.5049e-18): result
```

```
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=9.13367e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=1.04294e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=8.97285e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=7.11855e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=6.99427e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=1.63601e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=1.83747e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=1.55131e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=1.22038e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=1.19617e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=9.06579e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=1.00106e-16): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
```

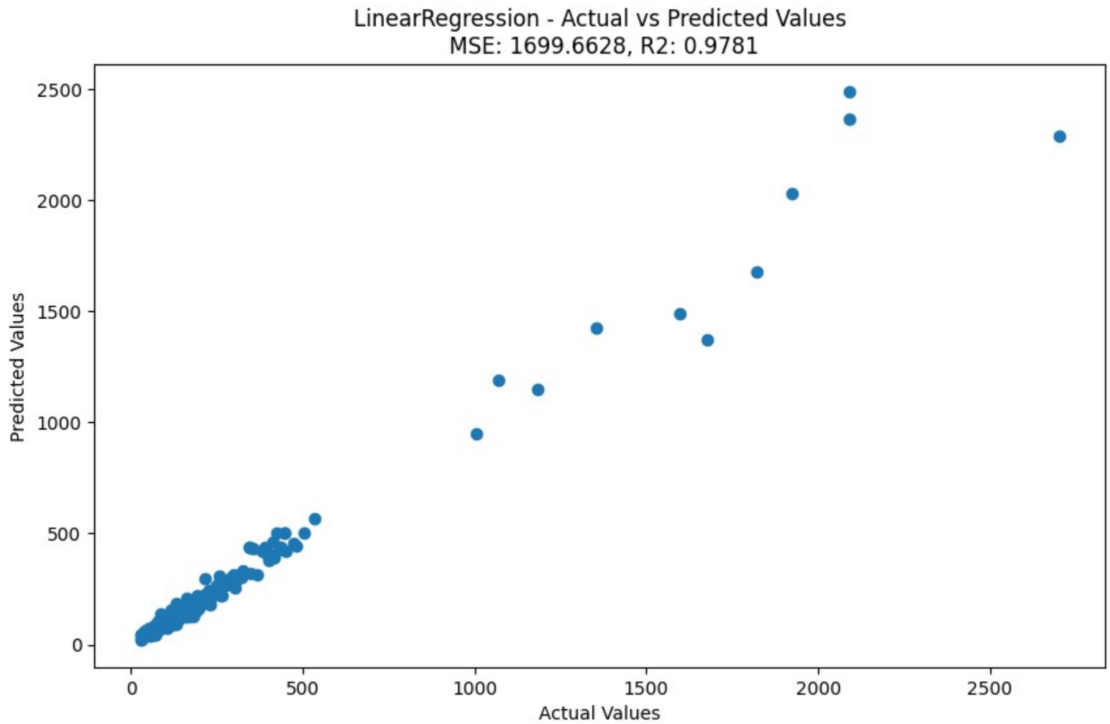
```
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=8.38873e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=6.52187e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=6.39472e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=1.30975e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=1.30975e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
```








```
Test size: 0.25
```

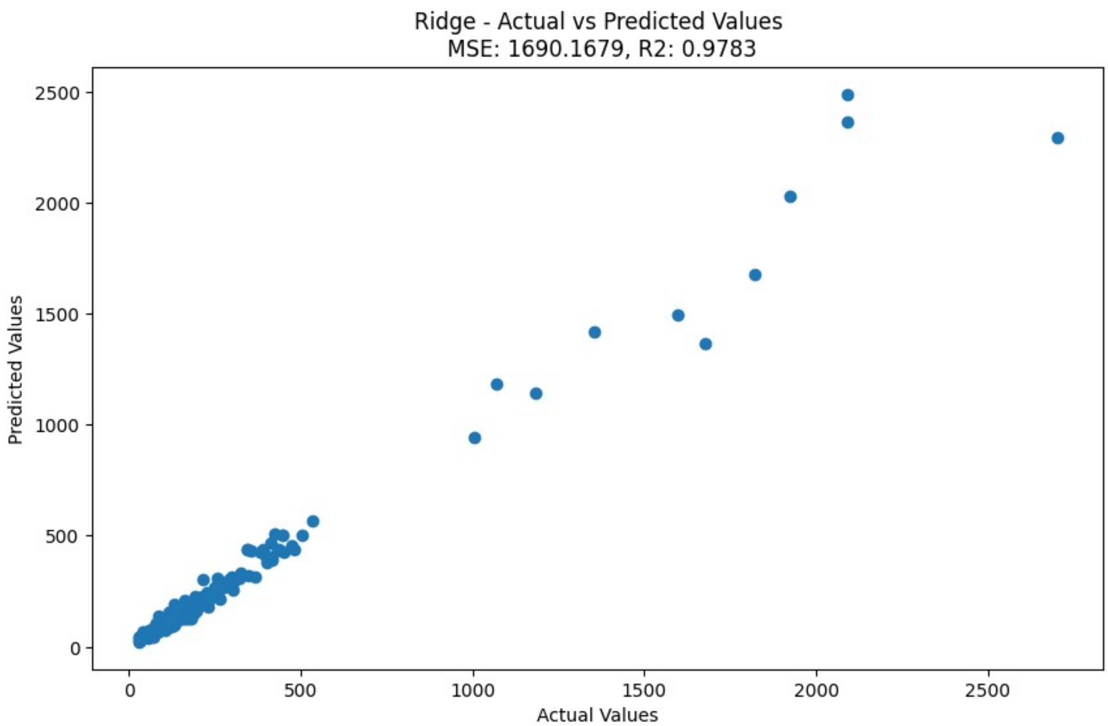


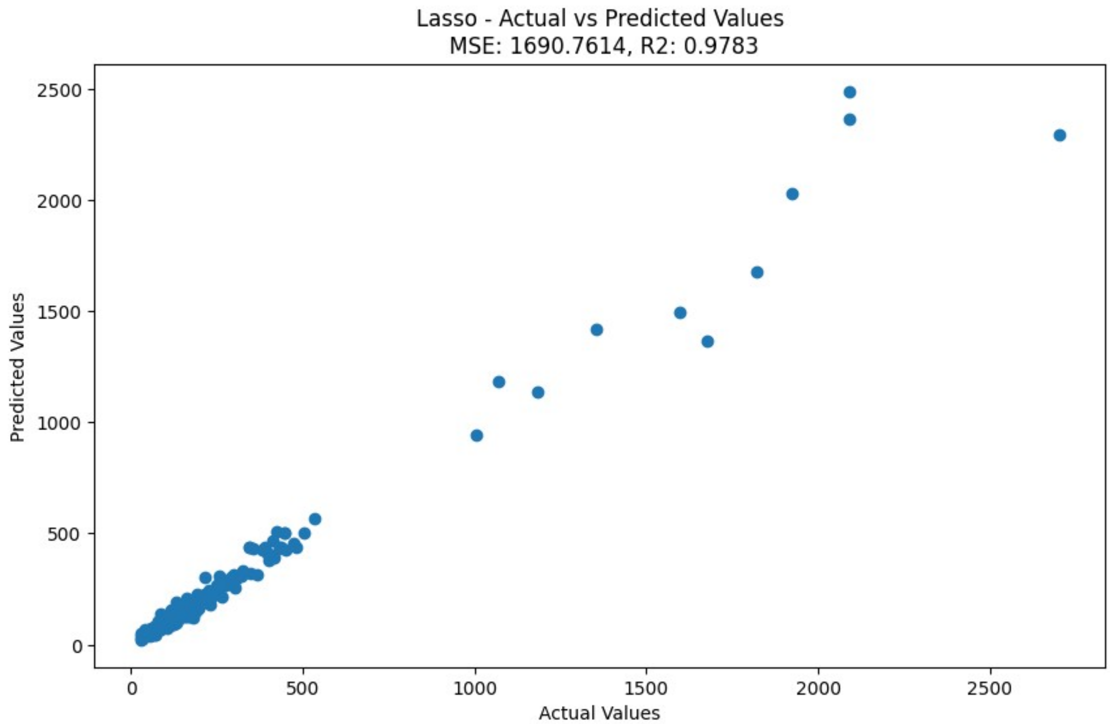

```
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/
_ridge.py:216: LinAlgWarning: Ill-conditioned matrix (rcond=7.97284e-
18): result may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=7.22669e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=5.55779e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=5.74054e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=5.83503e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=7.97355e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=7.22801e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
```

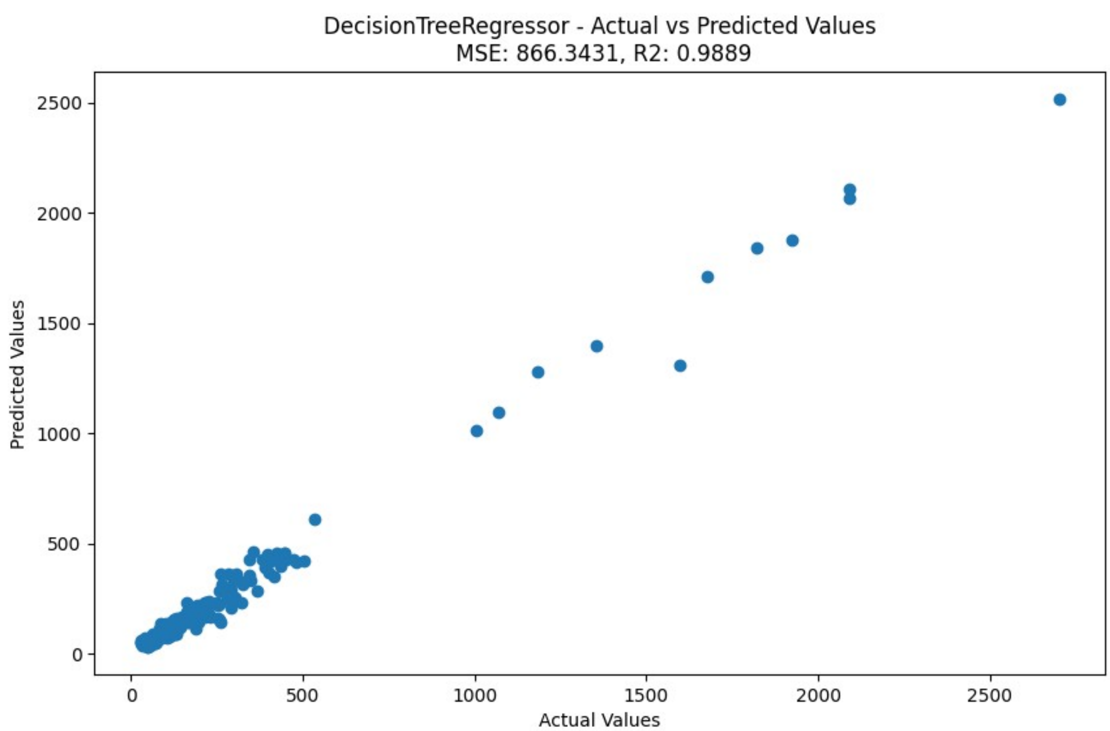
```
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=5.55828e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=5.74106e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=5.83553e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=7.98069e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=7.24116e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=5.56319e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=5.74625e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=5.84056e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=8.05207e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=7.37277e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=5.6123e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=5.79822e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=5.89085e-18): result
```

```
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=8.76718e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=8.69518e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=6.10424e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=6.31831e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=6.39451e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=1.60085e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=2.22898e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=1.10824e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=1.15477e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=1.1488e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=9.06236e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=6.24462e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
```

```
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=6.74473e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=6.78903e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=6.65023e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=6.65023e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
```

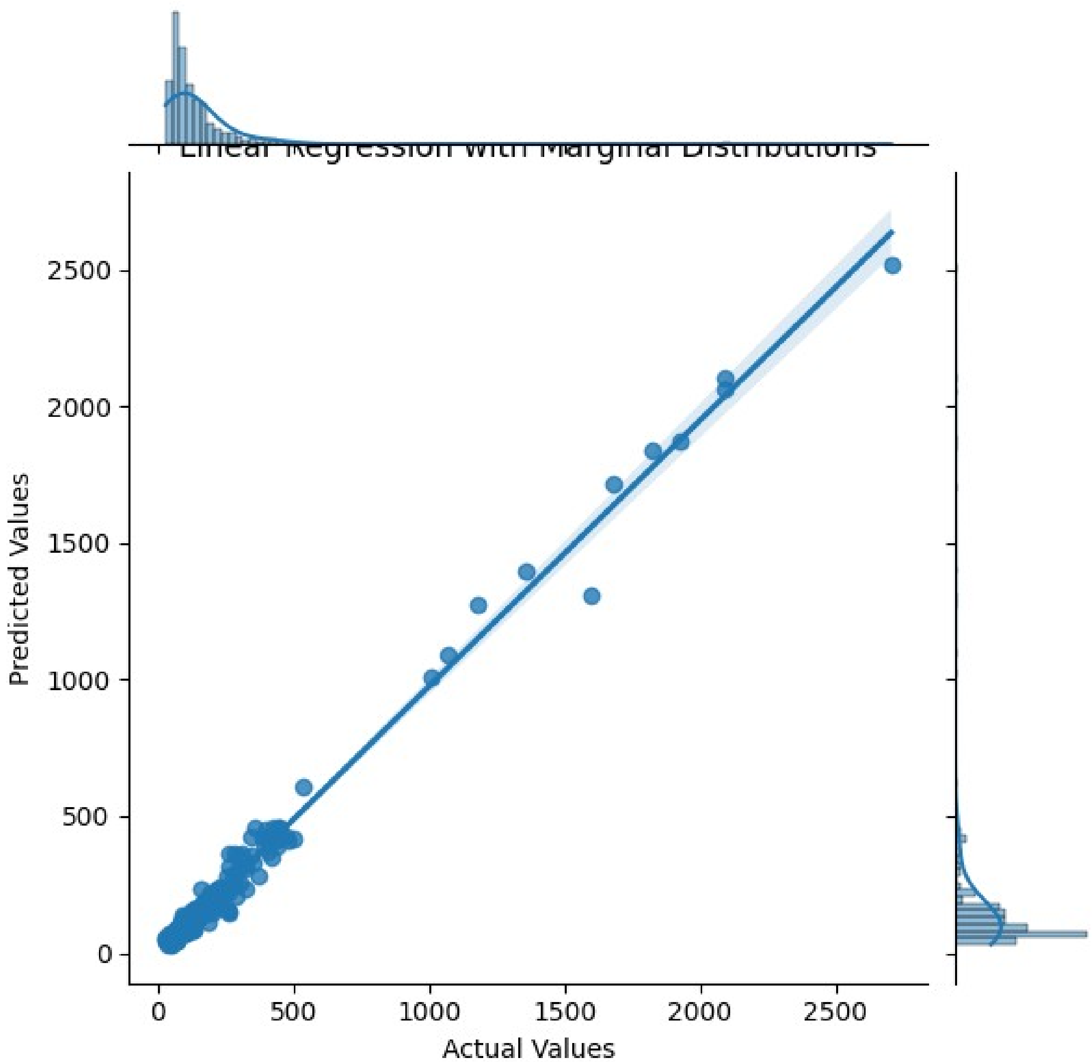







```
data = {'Actual': y_test, 'Predicted': y_pred}
prediction = pd.DataFrame(data)

sns.jointplot(x='Actual', y='Predicted', data=prediction, kind='reg')
```

```python
# Set labels and title
plt.xlabel('Actual Values')
plt.ylabel('Predicted Values')
plt.title('Linear Regression with Marginal Distributions')

# Show the plot
plt.show()
```

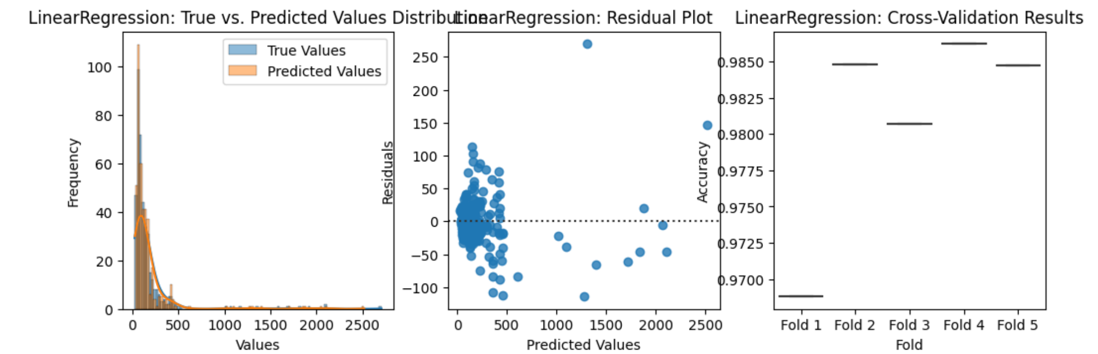


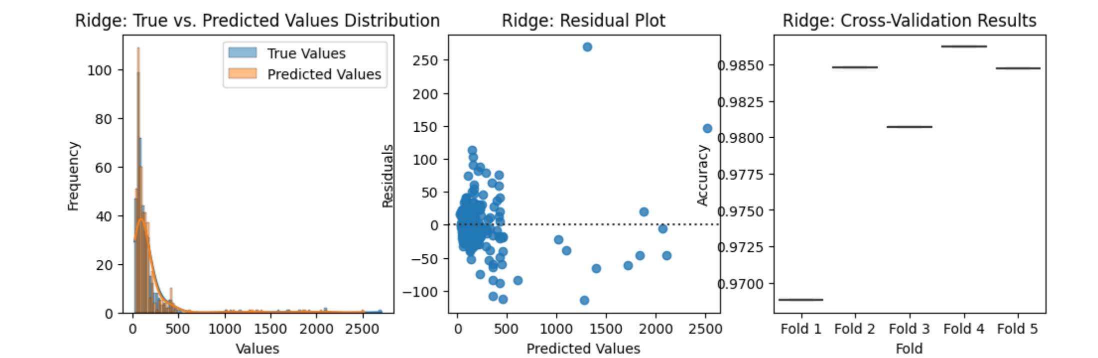

```python
# Set up the subplots
n_models = len(models)  # Replace 'models' with your array of models
fig, axes = plt.subplots(n_models, 3, figsize=(12, n_models*5))  # 3
columns for histograms, residual plots, and boxplots
fig.subplots_adjust(hspace=0.5)  # Add vertical space between subplots

# Loop over the models and create plots
for i, model in enumerate(models):  # Replace 'models' with your array
of models
```

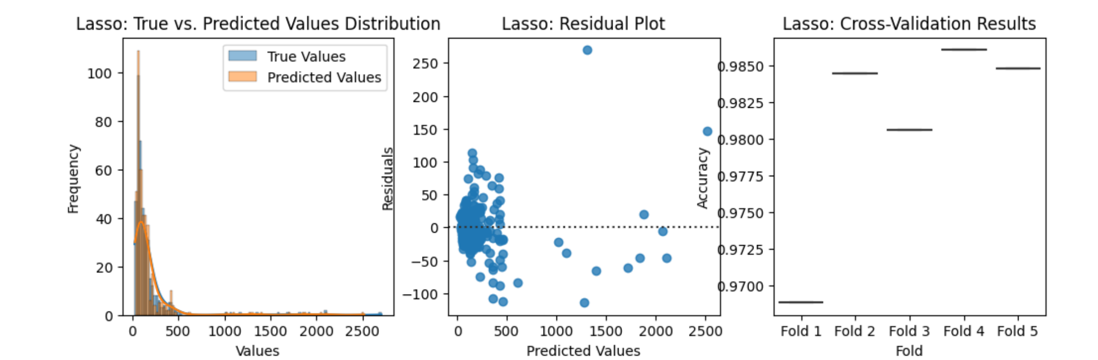
```
    model_name = type(model).__name__

    # Create histogram of true and predicted values
    sns.histplot(y_test, kde=True, label='True Values', ax=axes[i, 0])
    sns.histplot(y_pred, kde=True, label='Predicted Values',
ax=axes[i, 0])
    axes[i, 0].set_xlabel('Values')
    axes[i, 0].set_ylabel('Frequency')
    axes[i, 0].set_title(f'{model_name}: True vs. Predicted Values
Distribution')
    axes[i, 0].legend()

    # Create residual plot
    sns.residplot(x=y_pred, y=y_test, ax=axes[i, 1])
    axes[i, 1].set_xlabel('Predicted Values')
    axes[i, 1].set_ylabel('Residuals')
    axes[i, 1].set_title(f'{model_name}: Residual Plot')

    # Perform cross-validation and get results
    scores = cross_val_score(model, X, y, cv=5)  # Replace 'model',
'X', and 'y' with your specific model, features, and target variable
    fold_labels = [f"Fold {i+1}" for i in range(len(scores))]

    # Create boxplot to visualize cross-validation results
    sns.boxplot(x=fold_labels, y=scores, ax=axes[i, 2])
    axes[i, 2].set_xlabel("Fold")
    axes[i, 2].set_ylabel("Accuracy")  # Replace with appropriate
evaluation metric
    axes[i, 2].set_title(f'{model_name}: Cross-Validation Results')

# Show the plots
plt.show()
```

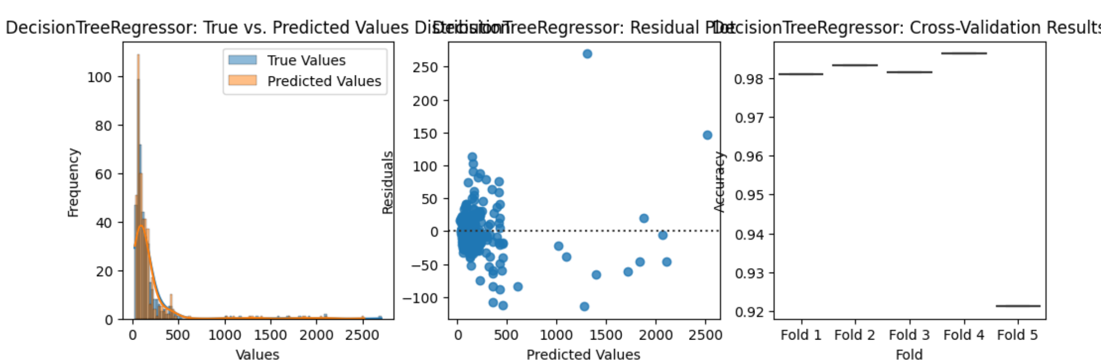
```
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/
_ridge.py:216: LinAlgWarning: Ill-conditioned matrix (rcond=3.62174e-
18): result may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=6.92413e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=9.20821e-18): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
216: LinAlgWarning: Ill-conditioned matrix (rcond=1.08241e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
/usr/local/lib/python3.9/dist-packages/sklearn/linear_model/_ridge.py:
```

```
216: LinAlgWarning: Ill-conditioned matrix (rcond=1.09699e-17): result
may not be accurate.
  return linalg.solve(A, Xy, assume_a="pos", overwrite_a=True).T
```





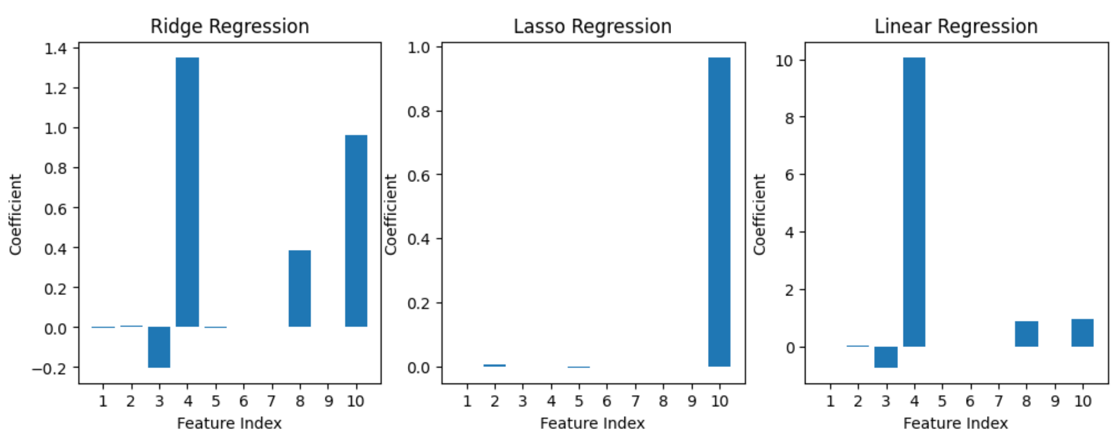




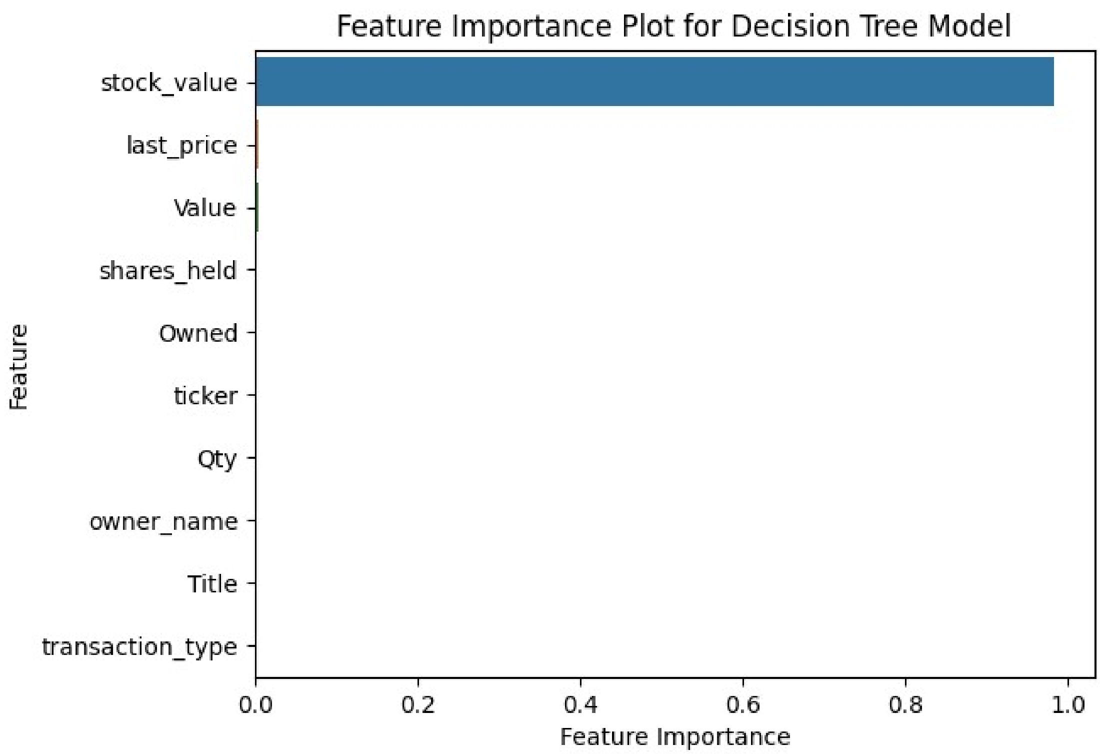

```
# Create a figure with subplots for each model
fig, axes = plt.subplots(1, 3, figsize=(12, 4))
```

```
model_info['Ridge']['coefficients'] = model_info['Ridge']
['model'].coef_
model_info['Lasso']['coefficients'] = model_info['Lasso']
['model'].coef_
model_info['LinearRegression']['coefficients'] =
model_info['LinearRegression']['model'].coef_

# Plot coefficients for Ridge model
ridge_coefs = model_info['Ridge']['coefficients']
axes[0].bar(range(len(ridge_coefs)), ridge_coefs)
axes[0].set_xticks(range(len(ridge_coefs)))
axes[0].set_xticklabels(range(1, len(ridge_coefs)+1))
axes[0].set_xlabel('Feature Index')
axes[0].set_ylabel('Coefficient')
axes[0].set_title('Ridge Regression')

# Plot coefficients for Lasso model
lasso_coefs = model_info['Lasso']['coefficients']
axes[1].bar(range(len(lasso_coefs)), lasso_coefs)
axes[1].set_xticks(range(len(lasso_coefs)))
axes[1].set_xticklabels(range(1, len(lasso_coefs)+1))
axes[1].set_xlabel('Feature Index')
axes[1].set_ylabel('Coefficient')
axes[1].set_title('Lasso Regression')

# Plot coefficients for Linear model
linear_coefs = model_info['LinearRegression']['coefficients']
axes[2].bar(range(len(linear_coefs)), linear_coefs)
axes[2].set_xticks(range(len(linear_coefs)))
axes[2].set_xticklabels(range(1, len(linear_coefs)+1))
axes[2].set_xlabel('Feature Index')
axes[2].set_ylabel('Coefficient')
axes[2].set_title('Linear Regression')
```

```
Text(0.5, 1.0, 'Linear Regression')
```

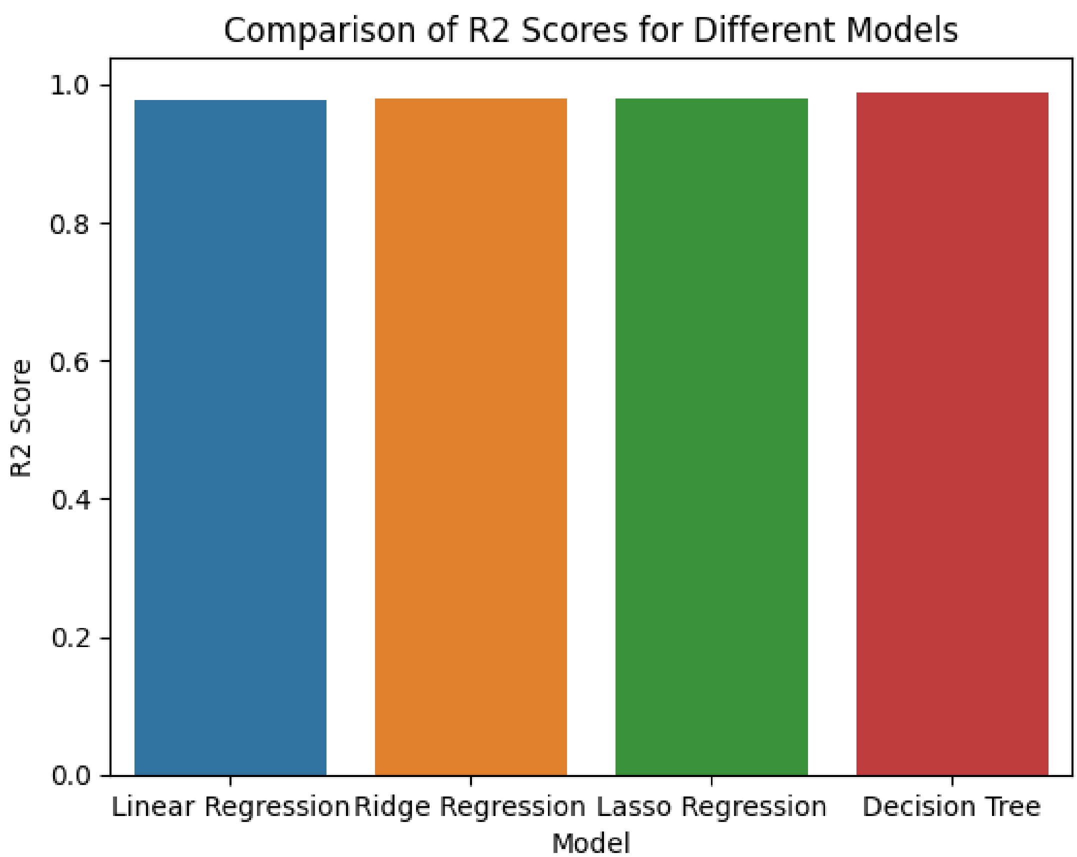


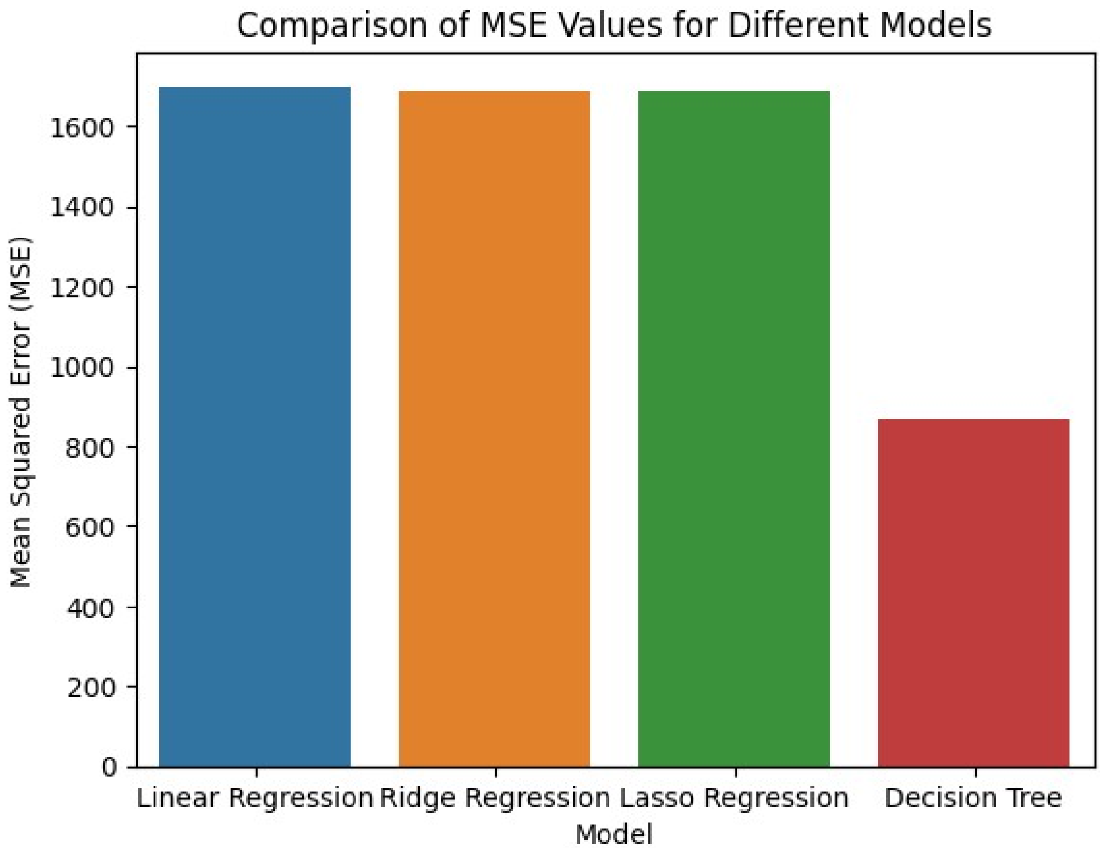
```
# Get feature importances from the model
feature_importances = model_info['DecisionTreeRegressor']
['model'].feature_importances_

# Create a DataFrame to store feature importances
feature_df = pd.DataFrame({'Feature': X_train.columns, 'Importance':
feature_importances})

# Sort the DataFrame by feature importances
feature_df = feature_df.sort_values('Importance', ascending=False)

# Create a bar plot to visualize feature importances
sns.barplot(x='Importance', y='Feature', data=feature_df)
plt.xlabel('Feature Importance')
plt.ylabel('Feature')
plt.title('Feature Importance Plot for Decision Tree Model')
plt.show()
```




```
# Create a dictionary to store the performance metrics of each model
model_performance = {
    'Linear Regression': {'R2': model_info['LinearRegression']['r2'],
'MSE': model_info['LinearRegression']['mse']},
    'Ridge Regression': {'R2':  model_info['Ridge']['r2'], 'MSE':
model_info['Ridge']['mse']},
    'Lasso Regression': {'R2': model_info['Lasso']['r2'], 'MSE':
model_info['Lasso']['mse']},
    'Decision Tree': {'R2':  model_info['DecisionTreeRegressor']
```

```
['r2'], 'MSE': model_info['DecisionTreeRegressor']['mse']}
}

# Convert the dictionary to a DataFrame
model_df = pd.DataFrame(model_performance).T

# Create a bar plot to compare R2 scores
sns.barplot(x=model_df.index, y=model_df['R2'])
plt.xlabel('Model')
plt.ylabel('R2 Score')
plt.title('Comparison of R2 Scores for Different Models')
plt.show()

# Create a bar plot to compare MSE values
sns.barplot(x=model_df.index, y=model_df['MSE'])
plt.xlabel('Model')
plt.ylabel('Mean Squared Error (MSE)')
plt.title('Comparison of MSE Values for Different Models')
plt.show()
```






```
check_null_values(test_data)
check_empty_values(test_data)
check_nan_values(test_data)
```

```
No columns contain null values.
No columns contain empty values.
No numerical columns contain NaN values.
```

```
# Split the strings on commas and create a list of values for each
cell
test_data['Title'] = test_data['Title'].str.lower()
test_data['Title'] = test_data['Title'].str.split(',')
#Clean_array will remove the co- start from each title
test_data['Title'] = test_data['Title'].apply(clean_array)
replace_to_string_for_array('cob',df=test_data['Title'],optional='chai
r')
replace_to_string_for_array('pres',df=test_data['Title'])
replace_to_string_for_array('vp',df=test_data['Title'],not_optional='e
vp')
replace_to_initials_for_array('chief',test_data['Title'])
test_data['Title'] = test_data['Title'].apply(replace_title_with_rank)
```

```
<ipython-input-57-756befde8387>:33: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame
```

```
See the caveats in the documentation:
https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#
returning-a-view-versus-a-copy
  df[i] = new_array
<ipython-input-57-756befde8387>:46: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation:
https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#
returning-a-view-versus-a-copy
  df[i] = new_array
<ipython-input-57-756befde8387>:13: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation:
https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#
returning-a-view-versus-a-copy
  df[i] = new_array
```

```
test_data['Qty']= test_data['Qty'].str.replace(",", "").astype(float)
test_data['shares_held']= test_data['shares_held'].str.replace(",",
"").astype(int)
test_data["Owned"] = test_data["Owned"].str.replace("%",
"").replace("New",0)
test_data['Owned'] =
test_data['Owned'].str.replace('>',"").astype(float)
# Divide by 100
test_data["Owned"] = test_data["Owned"]/100
test_data['Value'] = test_data['Value'].str.replace("$", "")
test_data['Value'] = test_data['Value'].str.replace(",",
"").astype(int)
```

```
<ipython-input-78-fa3b1365255d>:7: FutureWarning: The default value of
regex will change from True to False in a future version. In addition,
single character regular expressions will *not* be treated as literal
strings when regex=True.
  test_data['Value'] = test_data['Value'].str.replace("$", "")
```

```
test_data['transaction_type'] =
test_data['transaction_type'].apply(replace_p_s_with_1_0)
test_data['ticker'] =
replace_items(test_data['ticker'],encoded_values_ticker)
test_data['owner_name'] =
replace_items(test_data['owner_name'],encoded_values_owner_name)
test_data=test_data.drop(columns_to_drop, axis=1)
```

```
test_data
```

```
      ticker  owner_name  Title  transaction_type  last_price      Qty
\
```

```
1846     579         1184       2                   0       145.94  -6500.0

1435      35          167       5                   0        98.60   -300.0

10        10           10       3                   0       147.72  -1442.0

11        11           11       5                   0      1160.85  -1100.0

264      161          217       2                   0       140.22  -2000.0

...      ...          ...     ...                 ...          ...      ...

1183     468          807       3                   0        80.00  -3164.0

1724     542          992       4                   0       109.38   -846.0

788       31           31       5                   0        50.31 -10200.0

1295     343          889       5                   0        71.53  -5412.0

1269     499          871       4                   0       220.00  -2000.0


      shares_held  Owned    Value  stock_value  30_days_later
1846       143790  -0.04  -948597   146.309998     162.559998
1435        36440  -0.01   -29580    98.809998     104.930000
10          77300  -0.02  -213017   141.789993     118.089996
11          22905  -0.05 -1276940   362.706665     297.046661
264        157617  -0.01  -280440   133.220001     122.980003
...           ...    ...      ...          ...            ...
1183        49303  -0.06  -253120    81.010002      66.709999
1724        12275  -0.06   -92535   109.750000     116.400002
788       2123999   0.00  -513162    49.349998      47.180000
1295        65132  -0.08  -387131    71.680000      61.680000
1269        37187  -0.05  -440000   212.559998     219.710007

[413 rows x 11 columns]
```

```
check_null_values(test_data)
check_empty_values(test_data)
check_nan_values(test_data)
```

```
No columns contain null values.
No columns contain empty values.
No numerical columns contain NaN values.
```

```
test_data = replace_missing_values(test_data)
test_data
```

```
      ticker  owner_name  Title  transaction_type  last_price      Qty  \
1846     579        1184      2                 0      145.94  -6500.0

1435      35         167      5                 0       98.60   -300.0

10        10          10      3                 0      147.72  -1442.0

11        11          11      5                 0     1160.85  -1100.0

264      161         217      2                 0      140.22  -2000.0

...      ...         ...    ...               ...         ...      ...

1183     468         807      3                 0       80.00  -3164.0

1724     542         992      4                 0      109.38   -846.0

788       31          31      5                 0       50.31 -10200.0

1295     343         889      5                 0       71.53  -5412.0

1269     499         871      4                 0      220.00  -2000.0


      shares_held  Owned    Value  stock_value  30_days_later
1846       143790  -0.04  -948597   146.309998     162.559998
1435        36440  -0.01   -29580    98.809998     104.930000
10          77300  -0.02  -213017   141.789993     118.089996
11          22905  -0.05 -1276940   362.706665     297.046661
264        157617  -0.01  -280440   133.220001     122.980003
...           ...    ...      ...          ...            ...
1183        49303  -0.06  -253120    81.010002      66.709999
1724        12275  -0.06   -92535   109.750000     116.400002
788       2123999   0.00  -513162    49.349998      47.180000
1295        65132  -0.08  -387131    71.680000      61.680000
1269        37187  -0.05  -440000   212.559998     219.710007

[413 rows x 11 columns]
```

```python
test_X = test_data.drop('30_days_later', axis=1)
test_y = test_data['30_days_later']

for model_name, model in model_info.items():
    model_obj = model['model']

    y_pred = model_obj.predict(test_X)

    mse = mean_squared_error(test_y, y_pred)
```

```
    rmse = np.sqrt(mse)

    print("Model: {}".format(model_name))
    print("Mean Squared Error (MSE) on Test Data: {:.2f}".format(mse))
    print("Root Mean Squared Error (RMSE) on Test Data:
{:.2f}".format(rmse))
    print("---")
```

```
Model: LinearRegression
Mean Squared Error (MSE) on Test Data: 1335.66
Root Mean Squared Error (RMSE) on Test Data: 36.55
---
Model: Ridge
Mean Squared Error (MSE) on Test Data: 1304.55
Root Mean Squared Error (RMSE) on Test Data: 36.12
---
Model: Lasso
Mean Squared Error (MSE) on Test Data: 1304.20
Root Mean Squared Error (RMSE) on Test Data: 36.11
---
Model: DecisionTreeRegressor
Mean Squared Error (MSE) on Test Data: 1295.98
Root Mean Squared Error (RMSE) on Test Data: 36.00
---
```

```
import joblib
import os



# Loop through the models in 'model_info' dictionary
for model_name, model in model_info.items():
    # Extract the model from the dictionary
    model_obj = model['model']

    # Save the model to a binary file
    file_name = "{}.joblib".format(model_name) # File name for the
model
    file_path = os.path.join(drive_path[:-1], file_name)
    joblib.dump(model_obj, file_name) # Save the model to file
    print("Model '{}' saved as {}".format(model_name, file_name))
```

```
Model 'LinearRegression' saved as LinearRegression.joblib
Model 'Ridge' saved as Ridge.joblib
Model 'Lasso' saved as Lasso.joblib
Model 'DecisionTreeRegressor' saved as DecisionTreeRegressor.joblib
```

```
import pickle

def save_dicts_to_file(dict1, dict2, file_path):
```

```python
    with open(file_path, 'wb') as f:
        pickle.dump([dict1, dict2], f)


save_dicts_to_file(encoded_values_owner_name,encoded_values_ticker,'en
coded_dicts')
```