In [1]:

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
%matplotlib inline
import seaborn as sns
sns.set()

import warnings
warnings.filterwarnings("ignore")

from sklearn.linear_model import LinearRegression
```

In [2]:

```
raw_data = pd.read_csv("USA_Housing.csv")
raw_data.head()
```

Out[2]:

	Avg. Area Income	Avg. Area House Age	Avg. Area Number of Rooms	Avg. Area Number of Bedrooms	Area Population	Price	Address
0	79545.458574	5.682861	7.009188	4.09	23086.800503	1.059034e+06	208 Michael Ferry Apt. 674\nLaurabury, NE 3701...
1	79248.642455	6.002900	6.730821	3.09	40173.072174	1.505891e+06	188 Johnson Views Suite 079\nLake Kathleen, CA...
2	61287.067179	5.865890	8.512727	5.13	36882.159400	1.058988e+06	9127 Elizabeth Stravenue\nDanieltown, WI 06482...
3	63345.240046	7.188236	5.586729	3.26	34310.242831	1.260617e+06	USS Barnett\nFPO AP 44820
4	59982.197226	5.040555	7.839388	4.23	26354.109472	6.309435e+05	USNS Raymond\nFPO AE 09386

In [3]:

```
raw_data.describe()
```

Out[3]:

	Avg. Area Income	Avg. Area House Age	Avg. Area Number of Rooms	Avg. Area Number of Bedrooms	Area Population	Price
count	5000.000000	5000.000000	5000.000000	5000.000000	5000.000000	5.000000e+03
mean	68583.108984	5.977222	6.987792	3.981330	36163.516039	1.232073e+06
std	10657.991214	0.991456	1.005833	1.234137	9925.650114	3.531176e+05
min	17796.631190	2.644304	3.236194	2.000000	172.610686	1.593866e+04
25%	61480.562388	5.322283	6.299250	3.140000	29403.928702	9.975771e+05
50%	68804.286404	5.970429	7.002902	4.050000	36199.406689	1.232669e+06

	Avg. Area Income	Avg. Area House Age	Avg. Area Number of Rooms	Avg. Area Number of Bedrooms	Area Population	Price
75%	75783.338666	6.650808	7.665871	4.490000	42861.290769	1.471210e+06
max	107701.748378	9.519088	10.759588	6.500000	69621.713378	2.469066e+06

In [4]:

```
raw_data.isnull().sum()
```

Out[4]:

```
Avg. Area Income                0
Avg. Area House Age             0
Avg. Area Number of Rooms       0
Avg. Area Number of Bedrooms    0
Area Population                 0
Price                           0
Address                         0
dtype: int64
```

In [5]:

```
data = raw_data.drop("Address", axis=1)
data.describe()
```

Out[5]:

	Avg. Area Income	Avg. Area House Age	Avg. Area Number of Rooms	Avg. Area Number of Bedrooms	Area Population	Price
count	5000.000000	5000.000000	5000.000000	5000.000000	5000.000000	5.000000e+03
mean	68583.108984	5.977222	6.987792	3.981330	36163.516039	1.232073e+06
std	10657.991214	0.991456	1.005833	1.234137	9925.650114	3.531176e+05
min	17796.631190	2.644304	3.236194	2.000000	172.610686	1.593866e+04
25%	61480.562388	5.322283	6.299250	3.140000	29403.928702	9.975771e+05
50%	68804.286404	5.970429	7.002902	4.050000	36199.406689	1.232669e+06
75%	75783.338666	6.650808	7.665871	4.490000	42861.290769	1.471210e+06
max	107701.748378	9.519088	10.759588	6.500000	69621.713378	2.469066e+06

In [6]:

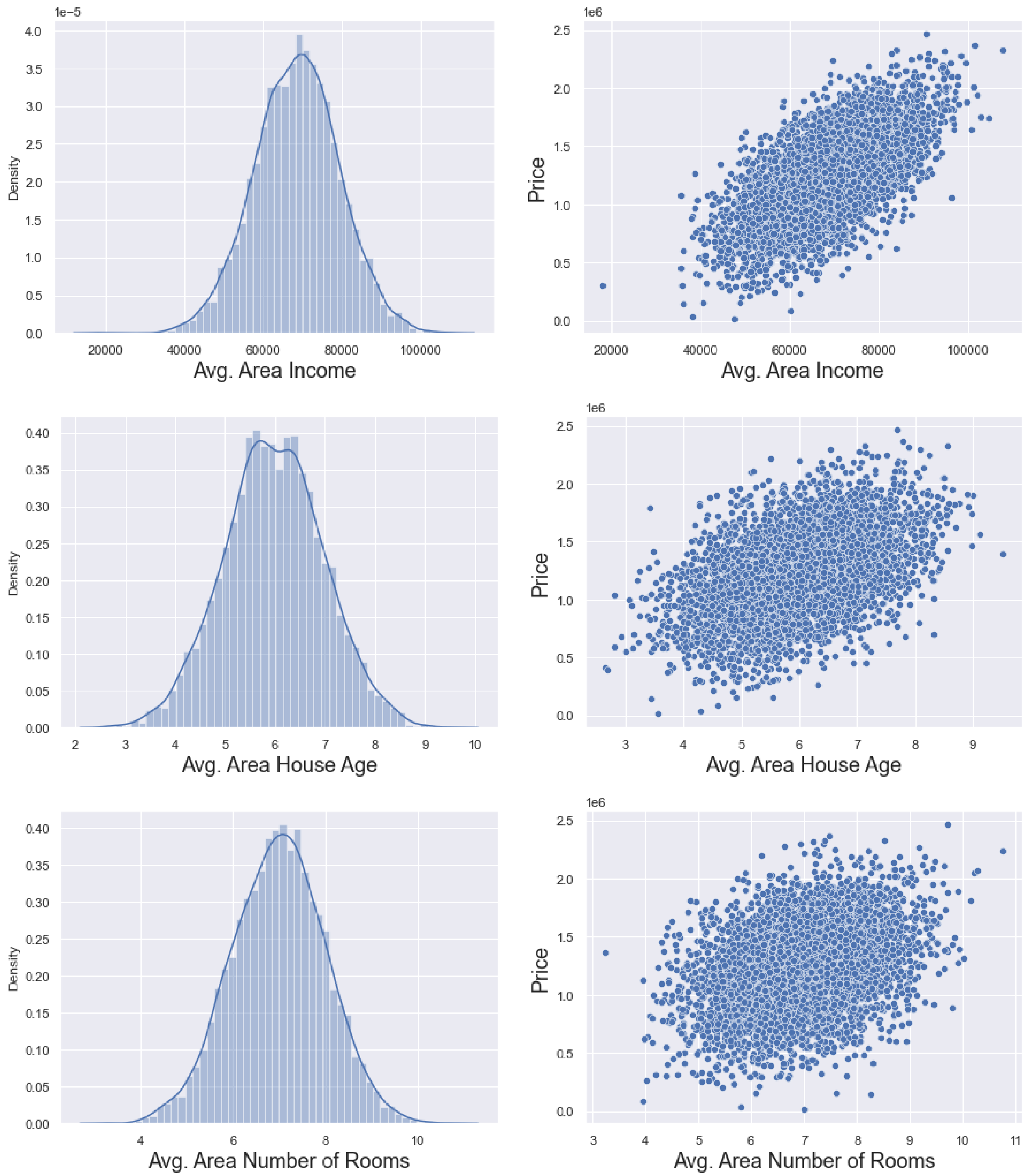
```
target = data.Price
inputs = data.drop("Price",axis=1)
```

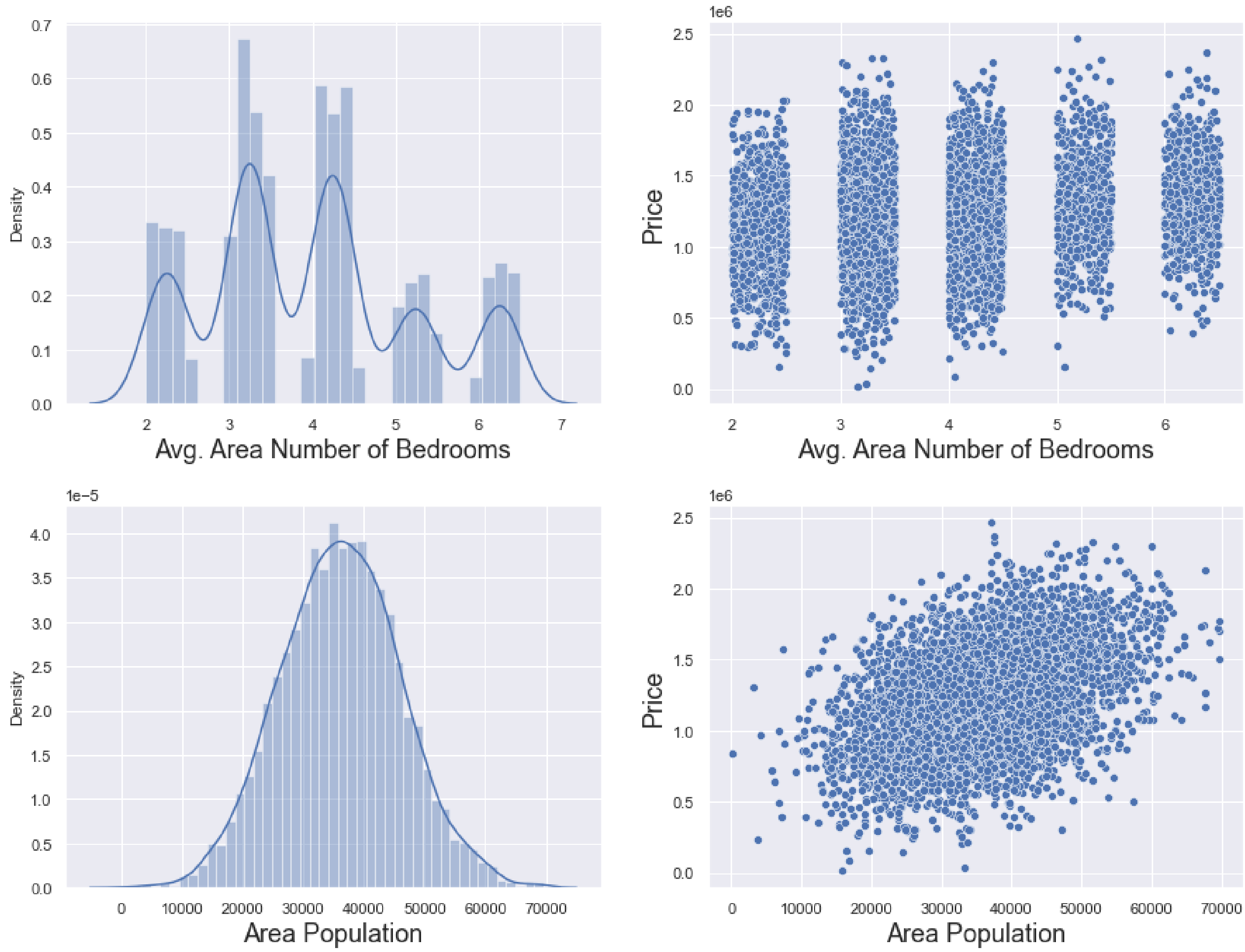
In [7]:

```
def scatter_distplot(df, col):
    fig, axes = plt.subplots(1,2,figsize=(15,5))

    dist_plot = sns.distplot(df[col], ax=axes[0])
    dist_plot.set_xlabel(col, fontsize=18)

    scatter_plot = sns.scatterplot(x=df[col], y=target, ax=axes[1])
    scatter_plot.set_xlabel(col, fontsize=18)
    scatter_plot.set_ylabel("Price", fontsize=18)
```

In [8]:

```
for col in inputs.columns:
    scatter_distplot(inputs, col)
```





In [9]:
```
sns.heatmap(data.corr(), annot=True)
```

Out[9]:
```
<AxesSubplot:>
```

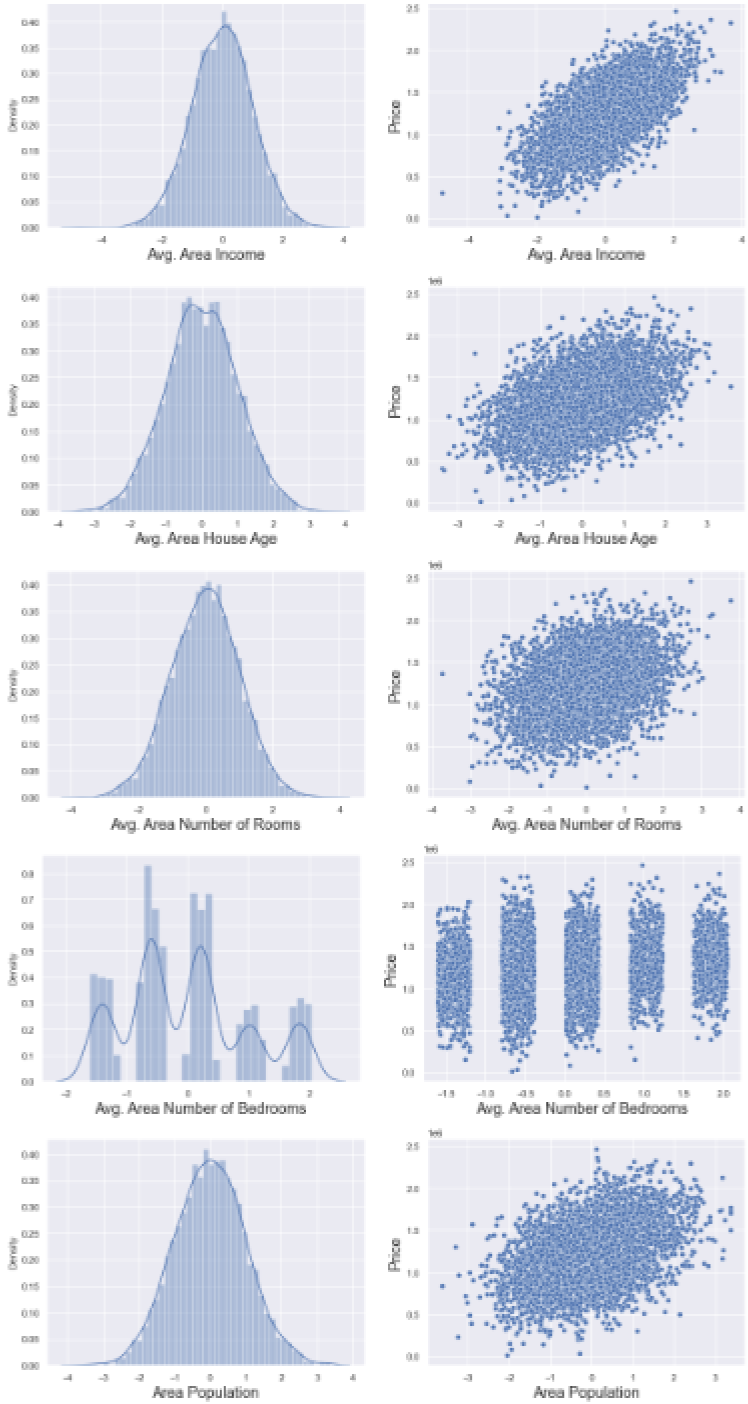
In [10]:

```
from statsmodels.stats.outliers_influence import variance_inflation_factor

vif = pd.DataFrame()
vif["features"] = inputs.columns
vif["VIF"] = [variance_inflation_factor(inputs.values, i) for i in range(inputs.shape[1
vif
```

Out[10]:

	features	VIF
0	Avg. Area Income	29.650899
1	Avg. Area House Age	27.447775
2	Avg. Area Number of Rooms	45.257291
3	Avg. Area Number of Bedrooms	14.537873
4	Area Population	12.825450

Data that has been standardized



Split Unscaled Data

In [11]:
```
from sklearn.model_selection import train_test_split

x_train_no_std, x_test_no_std, y_train_no_std, y_test_no_std = train_test_split(inputs,
```

Build Model for Unscaled Data

In [12]:
```
reg_no_std = LinearRegression()
reg_no_std.fit(x_train_no_std, y_train_no_std)
```

Out[12]:
```
LinearRegression()
```

In [13]:

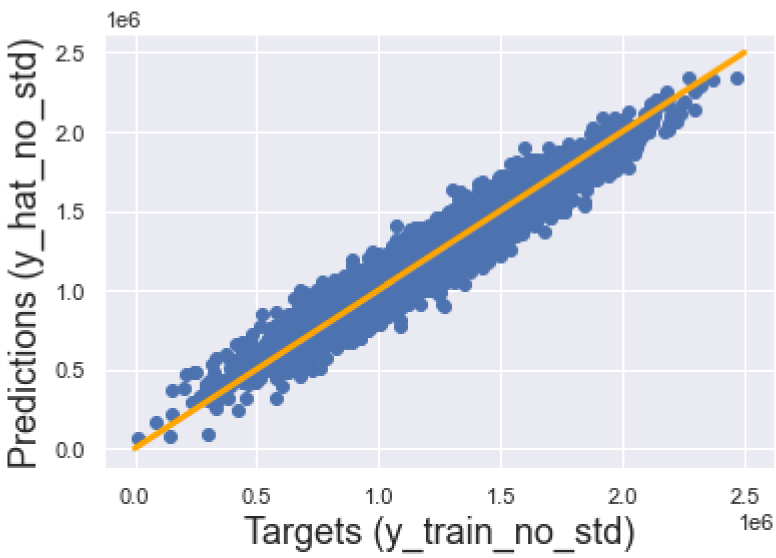
```
y_hat_no_std = reg_no_std.predict(x_train_no_std)
```

In [14]:

```
plt.scatter(y_train_no_std, y_hat_no_std)
plt.xlabel("Targets (y_train_no_std)", fontsize=18)
plt.ylabel("Predictions (y_hat_no_std)", fontsize=18)

x = np.linspace(0,2.5e6)
y = x
plt.plot(x,y,c="orange",lw=3)
```

Out[14]:

```
[<matplotlib.lines.Line2D at 0x136980b6220>]
```



In [15]:

```
r_score_train_no_std = reg_no_std.score(x_train_no_std, y_train_no_std)
r_score_train_no_std
```

Out[15]:

```
0.9181859079129733
```

In [16]:

```
y_hat_test_no_std = reg_no_std.predict(x_test_no_std)
```

In [17]:

```
summary_table_no_std = pd.DataFrame(columns=["coefficient"], data=reg_no_std.coef_)
summary_table_no_std["features"] = inputs.columns
summary_table_no_std
```

Out[17]:

	coefficient	features
0	21.614312	Avg. Area Income
1	166242.121249	Avg. Area House Age
2	119446.083411	Avg. Area Number of Rooms
3	2206.646418	Avg. Area Number of Bedrooms
4	15.270291	Area Population

Performance of Unscaled Data Testing

In [18]:

```
plt.scatter(x=y_test_no_std, y=y_hat_test_no_std)
plt.xlabel("Targets (y_test_no_std)", fontsize=18)
plt.ylabel("Predictions (y_hat_test_no_std)", fontsize=18)
```

Out[18]:

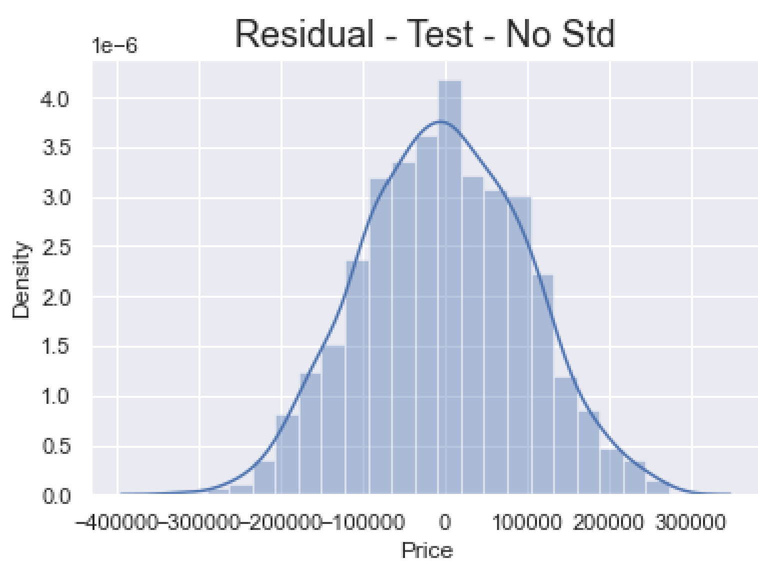
```
Text(0, 0.5, 'Predictions (y_hat_test_no_std)')
```

In [19]:

```
sns.distplot(y_test_no_std - y_hat_test_no_std)
plt.title("Residual - Test - No Std", fontsize=18)
```

Out[19]:

```
Text(0.5, 1.0, 'Residual - Test - No Std')
```



In [20]:

```
print(f"Overall:\n{(y_test_no_std - y_hat_test_no_std).describe()}\n")
print(f"Skewness: {round((y_test_no_std - y_hat_test_no_std).skew(),2)}")
print(f"Mean: {round((y_test_no_std - y_hat_test_no_std).mean(),2)}")
print(f"Median: {round((y_test_no_std - y_hat_test_no_std).median(),2)}")
```

```
Overall:
count      1000.000000
```

```
mean      -1509.359987
std       99279.941321
min     -318855.632591
25%      -73293.466123
50%         -64.842674
75%       69749.509331
max      273870.406074
Name: Price, dtype: float64

Skewness: 0.01
Mean: -1509.36
Median: -64.84
```

In [21]:

```
r_score_test_no_std = reg_no_std.score(x_test_no_std, y_test_no_std)
r_score_test_no_std
```

Out[21]:

```
0.9172058023346339
```

In [22]:

```
r_square_no_std_summary = pd.Series(data=round(r_score_train_no_std,5), index=["r_score
r_square_no_std_summary["r_score_test_no_std"] = round(r_score_test_no_std,5)
r_square_no_std_summary.to_frame()
```

Out[22]:

	0
r_score_train_no_std	0.91819
r_score_test_no_std	0.91721

Split Scaled Data

In [23]:

```
from sklearn.preprocessing import StandardScaler
scaler = StandardScaler()
scaler.fit(inputs)
```

Out[23]:

```
StandardScaler()
```

In [24]:

```
inputs_scaled = scaler.transform(inputs)
```

In [25]:

```
x_train, x_test, y_train, y_test = train_test_split(inputs_scaled, target, test_size=0.
```

In [26]:

```
inputs_df = pd.DataFrame(data=inputs_scaled, columns=inputs.columns)
inputs_df["Price"] = target.values
inputs_df
```

Out[26]:

	Avg. Area Income	Avg. Area House Age	Avg. Area Number of Rooms	Avg. Area Number of Bedrooms	Area Population	Price
0	1.028660	-0.296927	0.021274	0.088062	-1.317599	1.059034e+06
1	1.000808	0.025902	-0.255506	-0.722301	0.403999	1.505891e+06
2	-0.684629	-0.112303	1.516243	0.930840	0.072410	1.058988e+06

	Avg. Area Income	Avg. Area House Age	Avg. Area Number of Rooms	Avg. Area Number of Bedrooms	Area Population	Price
3	-0.491499	1.221572	-1.393077	-0.584540	-0.186734	1.260617e+06
4	-0.807073	-0.944834	0.846742	0.201513	-0.988387	6.309435e+05
...	...	...	...	...	...	...
4995	-0.752109	1.869297	-0.845588	-0.422467	-1.342732	1.060194e+06
4996	0.929740	1.030822	-0.408686	0.031337	-1.062747	1.482618e+06
4997	-0.487235	1.284470	-2.170269	-1.500251	-0.291937	1.030730e+06
4998	-0.054592	-0.446694	0.141541	1.182053	0.651116	1.198657e+06
4999	-0.288313	0.015215	-0.194342	0.071855	1.041625	1.298950e+06

5000 rows × 6 columns

In [27]:
```
sns.heatmap(inputs_df.corr(), annot=True)
```

Out[27]:
```
<AxesSubplot:>
```

Build Model for Scaled Data

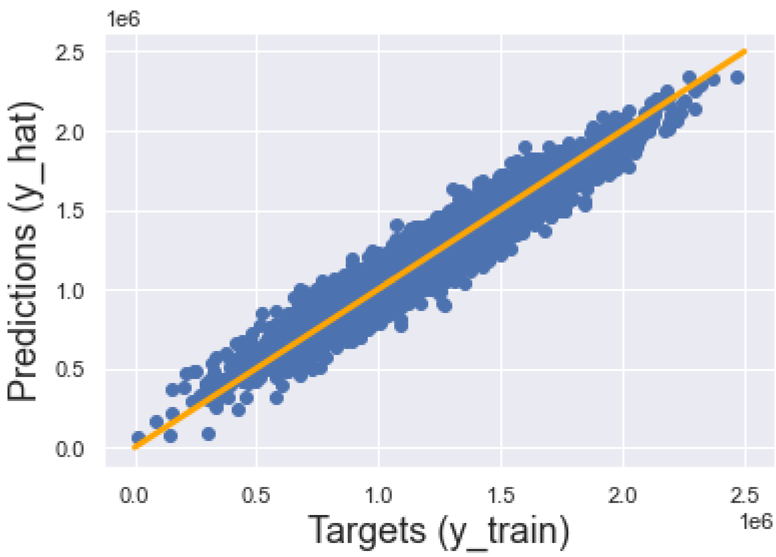
In [28]:
```
reg = LinearRegression()
reg.fit(x_train, y_train)
```

Out[28]:
```
LinearRegression()
```

In [29]:
```
y_hat = reg.predict(x_train)
```

In [30]:
```
plt.scatter(y_train, y_hat)
plt.xlabel("Targets (y_train)", fontsize=18)
plt.ylabel("Predictions (y_hat)", fontsize=18)

x = np.linspace(0,2.5e6)
y = x
plt.plot(x,y,c="orange",lw=3)
```

Out[30]:
```
[<matplotlib.lines.Line2D at 0x1369858be50>]
```



In [31]:
```
reg.intercept_
```

Out[31]:
```
1232374.526139742
```

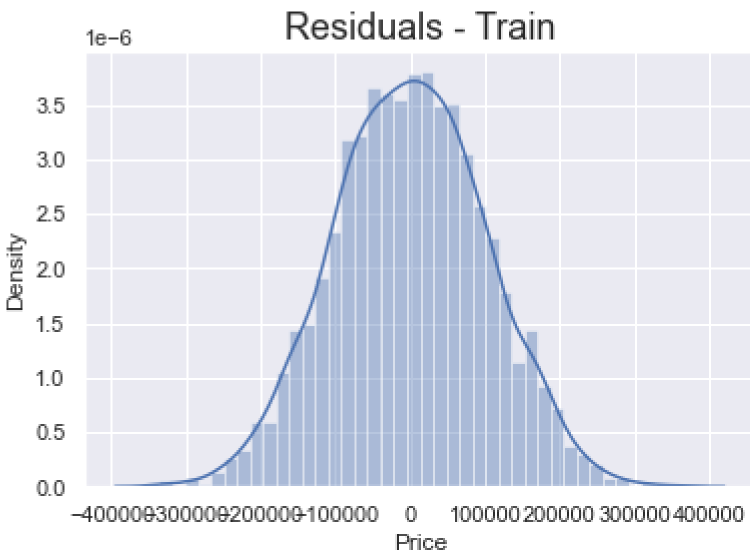
In [32]:
```
reg_summary = pd.DataFrame(columns=["weights"], data=reg.coef_)
reg_summary["features"] = inputs.columns
reg_summary
```

Out[32]:

	weights	features
0	230342.105520	Avg. Area Income
1	164805.295458	Avg. Area House Age
2	120130.825156	Avg. Area Number of Rooms
3	2723.032232	Avg. Area Number of Bedrooms
4	151552.410072	Area Population

In [33]:
```
residuals_train = y_train - y_hat
sns.distplot(residuals_train)
plt.title("Residuals - Train", fontsize=18)
residuals_train.describe()
```

Out[33]:
```
count    4.000000e+03
mean    -5.312904e-11
std      1.015767e+05
min     -3.370071e+05
25%     -6.991187e+04
50%     -1.058613e+02
75%      6.895613e+04
max      3.624884e+05
Name: Price, dtype: float64
```



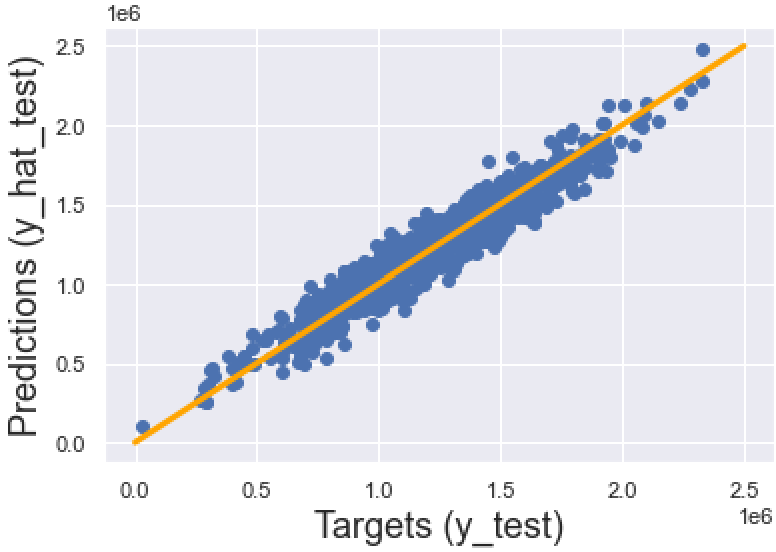
In [34]:
```
r_score_train = reg.score(x_train, y_train)
```

Performance of Scaled Data - Testing

In [35]:
```
y_hat_test = reg.predict(x_test)
```

In [36]:
```
plt.scatter(y_test, y_hat_test)
plt.xlabel("Targets (y_test)", fontsize=18)
plt.ylabel("Predictions (y_hat_test)", fontsize=18)

x = np.linspace(0,2.5e6)
y = x
plt.plot(x,y,c="orange",lw=3)
```

Out[36]:
```
[<matplotlib.lines.Line2D at 0x13698035670>]
```

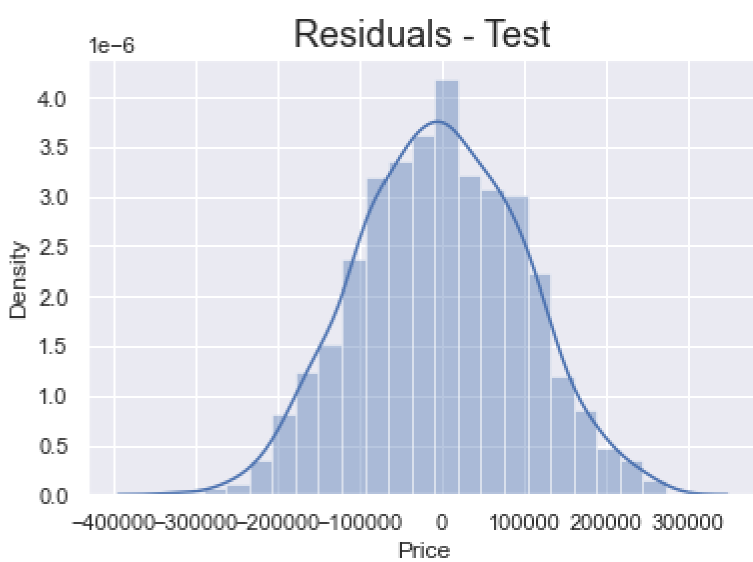


In [37]:

```
sns.distplot(y_test - y_hat_test)
plt.title("Residuals - Test", fontsize=18)
```

Out[37]:

```
Text(0.5, 1.0, 'Residuals - Test')
```



In [38]:

```
print(f"Overall:\n{(y_test - y_hat_test).describe()}\n")
print(f"Skewness: {round((y_test - y_hat_test).skew(),2)}")
print(f"Mean: {round((y_test - y_hat_test).mean(),2)}")
print(f"Median: {round((y_test - y_hat_test).median(),2)}")
```

```
Overall:
count      1000.000000
mean      -1509.359987
std       99279.941322
min     -318855.632592
25%      -73293.466123
50%         -64.842674
75%       69749.509331
max      273870.406074
Name: Price, dtype: float64
```

```
Skewness: 0.01
Mean: -1509.36
Median: -64.84
```

In [39]:

```
r_score_test = reg.score(x_test, y_test)
```

Unscaled vs Scaled (R_Squared)

In [40]:

```
r_score_summary = pd.DataFrame(columns = ["train", "test"], index=["std", "no_std"], da
r_score_summary
```

Out[40]:

	train	test
std	0.918186	0.917206
no_std	0.918186	0.917206

Unscaled vs Scaled (Coefficient)

In [41]:

```
pd.concat([summary_table_no_std, reg_summary], axis=1)
```

Out[41]:

	coefficient	features	weights	features
0	21.614312	Avg. Area Income	230342.105520	Avg. Area Income
1	166242.121249	Avg. Area House Age	164805.295458	Avg. Area House Age
2	119446.083411	Avg. Area Number of Rooms	120130.825156	Avg. Area Number of Rooms
3	2206.646418	Avg. Area Number of Bedrooms	2723.032232	Avg. Area Number of Bedrooms
4	15.270291	Area Population	151552.410072	Area Population

Conclusion

- Two similar model test performance indicates that standardization have ***nothing to do with improving our model prediction ability***.
- From the distribution of each of the standardized predictors, we can see the ***standardized normal distribution (mean = 0, stdev = 1) of each feature***.
- ***No effect*** on the shape of relationship scatter plots ***between predictors and the target***
- The only ***difference*** here is the ***coefficient*** between scaled and unscaled data. When we scaled it, the `coefficient` becomes `weight` and it shows how significantly each predictors affect the target.
- ***Ranking*** from the first to the bottom of ***level of effect power***: `Avg. Area Incomee`, `Avg. Area House Age`, `Area Population`, `Avg. Area Number of Roooms`, `Avg. Area Number of Bedrooms`. We can also see the ***same pattern on the heatmap of correlation between variables***
- However the coefficient helps us understand that ***how many units of price change if we increase/decrease 1 unit of a feature***.