In [64]:
```
# Import necessary libraries
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from sklearn.linear_model import LinearRegression
from sklearn.tree import DecisionTreeRegressor
from sklearn.ensemble import RandomForestRegressor, GradientBoostingRegressor
from sklearn.svm import SVR
from sklearn.metrics import mean_squared_error, mean_absolute_error, r2_score
from sklearn.model_selection import GridSearchCV
```

In [66]:
```
# Load dataset
url = "CarPrice_Assignment.csv"
df = pd.read_csv(url)
```

In [68]:
```
# 1. Preprocessing
# Check for missing values
print(df.isnull().sum())
```

```
car_ID              0
symboling           0
CarName             0
fueltype            0
aspiration          0
doornumber          0
carbody             0
drivewheel          0
enginelocation      0
wheelbase           0
carlength           0
carwidth            0
carheight           0
curbweight          0
enginetype          0
cylindernumber      0
enginesize          0
fuelsystem          0
boreratio           0
stroke              0
compressionratio    0
horsepower          0
peakrpm             0
citympg             0
highwaympg          0
price               0
dtype: int64
```

In [70]:
```
# Handle missing data
# Filling missing numerical values with the mean
df.fillna(df.mean(), inplace=True)
```

```
---------------------------------------------------------------------------
TypeError                                 Traceback (most recent call last)
Cell In[70], line 3
      1 # Handle missing data
      2 # Filling missing numerical values with the mean
----> 3 df.fillna(df.mean(), inplace=True)

File ~\anaconda3\Lib\site-packages\pandas\core\frame.py:11693, in DataFrame.mean
(self, axis, skipna, numeric_only, **kwargs)
  11685 @doc(make_doc("mean", ndim=2))
  11686 def mean(
  11687     self,
   (...)
  11691     **kwargs,
  11692 ):
> 11693     result = super().mean(axis, skipna, numeric_only, **kwargs)
  11694     if isinstance(result, Series):
  11695         result = result.__finalize__(self, method="mean")

File ~\anaconda3\Lib\site-packages\pandas\core\generic.py:12420, in NDFrame.mean
(self, axis, skipna, numeric_only, **kwargs)
  12413 def mean(
  12414     self,
  12415     axis: Axis | None = 0,
   (...)
  12418     **kwargs,
  12419 ) -> Series | float:
> 12420     return self._stat_function(
  12421         "mean", nanops.nanmean, axis, skipna, numeric_only, **kwargs
  12422     )

File ~\anaconda3\Lib\site-packages\pandas\core\generic.py:12377, in NDFrame._stat
_function(self, name, func, axis, skipna, numeric_only, **kwargs)
  12373 nv.validate_func(name, (), kwargs)
  12375 validate_bool_kwarg(skipna, "skipna", none_allowed=False)
> 12377 return self._reduce(
  12378     func, name=name, axis=axis, skipna=skipna, numeric_only=numeric_only
  12379 )

File ~\anaconda3\Lib\site-packages\pandas\core\frame.py:11562, in DataFrame._redu
ce(self, op, name, axis, skipna, numeric_only, filter_type, **kwds)
  11558     df = df.T
  11560 # After possibly _get_data and transposing, we are now in the
  11561 #  simple case where we can use BlockManager.reduce
> 11562 res = df._mgr.reduce(blk_func)
  11563 out = df._constructor_from_mgr(res, axes=res.axes).iloc[0]
  11564 if out_dtype is not None and out.dtype != "boolean":

File ~\anaconda3\Lib\site-packages\pandas\core\internals\managers.py:1500, in Blo
ckManager.reduce(self, func)
   1498 res_blocks: list[Block] = []
   1499 for blk in self.blocks:
-> 1500     nbs = blk.reduce(func)
   1501     res_blocks.extend(nbs)
   1503 index = Index([None])  # placeholder

File ~\anaconda3\Lib\site-packages\pandas\core\internals\blocks.py:404, in Block.
reduce(self, func)
    398 @final
    399 def reduce(self, func) -> list[Block]:
```

```
    400     # We will apply the function and reshape the result into a single-row
    401     #  Block with the same mgr_locs; squeezing will be done at a higher l
evel
    402     assert self.ndim == 2
--> 404     result = func(self.values)
    406     if self.values.ndim == 1:
    407         res_values = result

File ~\anaconda3\Lib\site-packages\pandas\core\frame.py:11481, in DataFrame._redu
ce.<locals>.blk_func(values, axis)
  11479         return np.array([result])
  11480 else:
> 11481     return op(values, axis=axis, skipna=skipna, **kwds)

File ~\anaconda3\Lib\site-packages\pandas\core\nanops.py:147, in bottleneck_switc
h.__call__.<locals>.f(values, axis, skipna, **kwds)
    145         result = alt(values, axis=axis, skipna=skipna, **kwds)
    146 else:
--> 147     result = alt(values, axis=axis, skipna=skipna, **kwds)
    149 return result

File ~\anaconda3\Lib\site-packages\pandas\core\nanops.py:404, in _datetimelike_co
mpat.<locals>.new_func(values, axis, skipna, mask, **kwargs)
    401 if datetimelike and mask is None:
    402     mask = isna(values)
--> 404 result = func(values, axis=axis, skipna=skipna, mask=mask, **kwargs)
    406 if datetimelike:
    407     result = _wrap_results(result, orig_values.dtype, fill_value=iNaT)

File ~\anaconda3\Lib\site-packages\pandas\core\nanops.py:720, in nanmean(values,
axis, skipna, mask)
    718 count = _get_counts(values.shape, mask, axis, dtype=dtype_count)
    719 the_sum = values.sum(axis, dtype=dtype_sum)
--> 720 the_sum = _ensure_numeric(the_sum)
    722 if axis is not None and getattr(the_sum, "ndim", False):
    723     count = cast(np.ndarray, count)

File ~\anaconda3\Lib\site-packages\pandas\core\nanops.py:1686, in _ensure_numeric
(x)
   1683 inferred = lib.infer_dtype(x)
   1684 if inferred in ["string", "mixed"]:
   1685     # GH#44008, GH#36703 avoid casting e.g. strings to numeric
-> 1686     raise TypeError(f"Could not convert {x} to numeric")
   1687 try:
   1688     x = x.astype(np.complex128)

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eric
```

In [72]:
```
# Convert categorical columns (if any) to numerical using one-hot encoding or la
df = pd.get_dummies(df, drop_first=True)
```

In [74]:
```
# Feature and Target separation
X = df.drop('price', axis=1)  # assuming 'price' is the target variable
y = df['price']
```

In [76]:
```
# Split the data into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_
```

In [78]:
```
# Feature scaling (Standardization)
scaler = StandardScaler()
X_train = scaler.fit_transform(X_train)
X_test = scaler.transform(X_test)
```

In [80]:
```
# 2. Model Implementation

# Linear Regression
lr = LinearRegression()
lr.fit(X_train, y_train)
y_pred_lr = lr.predict(X_test)
```

In [82]:
```
# Decision Tree Regressor
dt = DecisionTreeRegressor(random_state=42)
dt.fit(X_train, y_train)
y_pred_dt = dt.predict(X_test)
```

In [84]:
```
# Random Forest Regressor
rf = RandomForestRegressor(random_state=42)
rf.fit(X_train, y_train)
y_pred_rf = rf.predict(X_test)
```

In [86]:
```
# Gradient Boosting Regressor
gb = GradientBoostingRegressor(random_state=42)
gb.fit(X_train, y_train)
y_pred_gb = gb.predict(X_test)
```

In [88]:
```
# Support Vector Regressor (SVR)
svr = SVR()
svr.fit(X_train, y_train)
y_pred_svr = svr.predict(X_test)
```

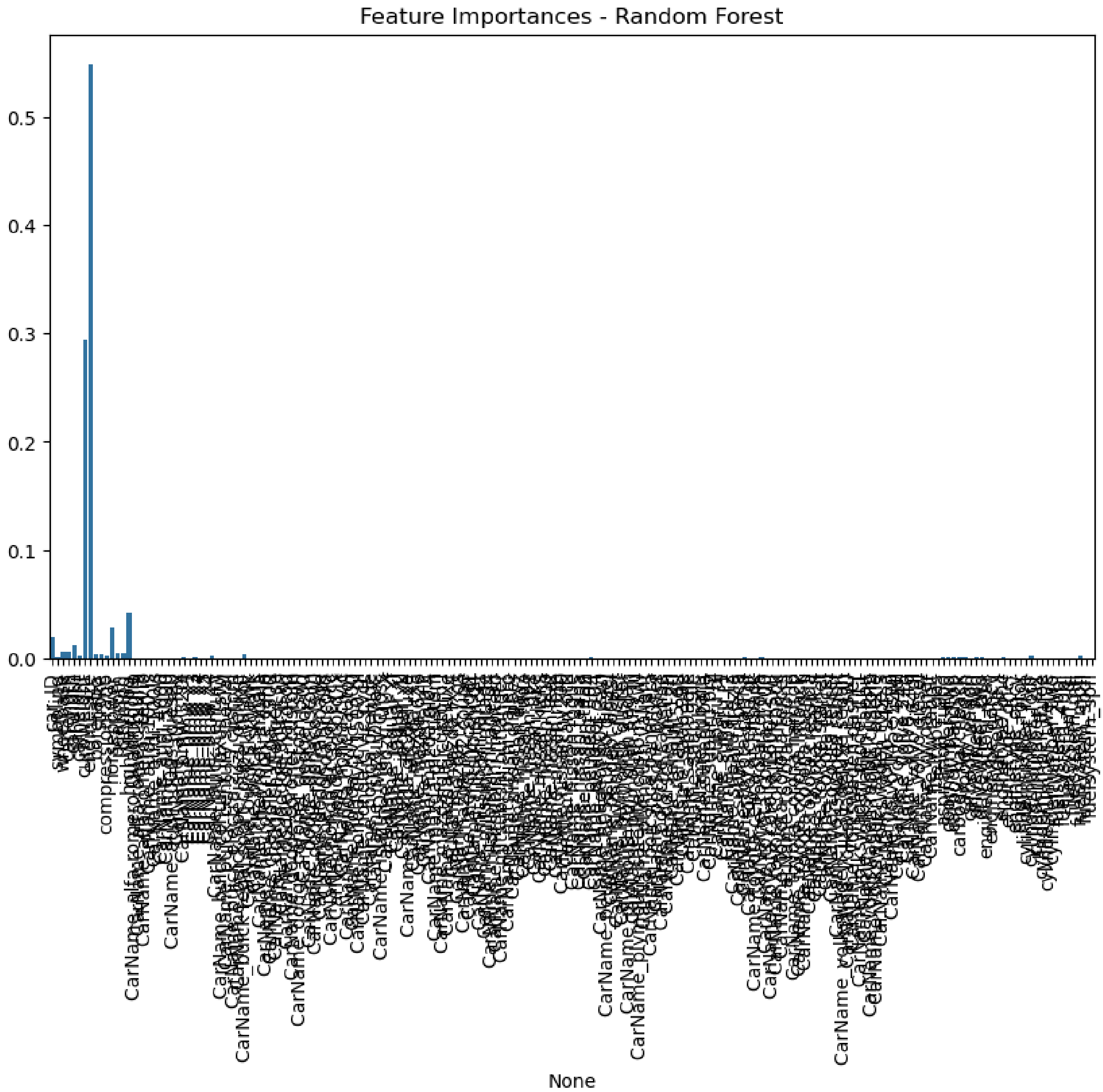
In [90]:
```
# 3. Model Evaluation

# Evaluate each model
def evaluate_model(model_name, y_true, y_pred):
    r2 = r2_score(y_true, y_pred)
    mse = mean_squared_error(y_true, y_pred)
    mae = mean_absolute_error(y_true, y_pred)
    print(f"Model: {model_name}")
    print(f"R-squared: {r2:.4f}")
    print(f"MSE: {mse:.4f}")
    print(f"MAE: {mae:.4f}\n")

evaluate_model('Linear Regression', y_test, y_pred_lr)
evaluate_model('Decision Tree Regressor', y_test, y_pred_dt)
evaluate_model('Random Forest Regressor', y_test, y_pred_rf)
```

```
evaluate_model('Gradient Boosting Regressor', y_test, y_pred_gb)
evaluate_model('Support Vector Regressor', y_test, y_pred_svr)
```

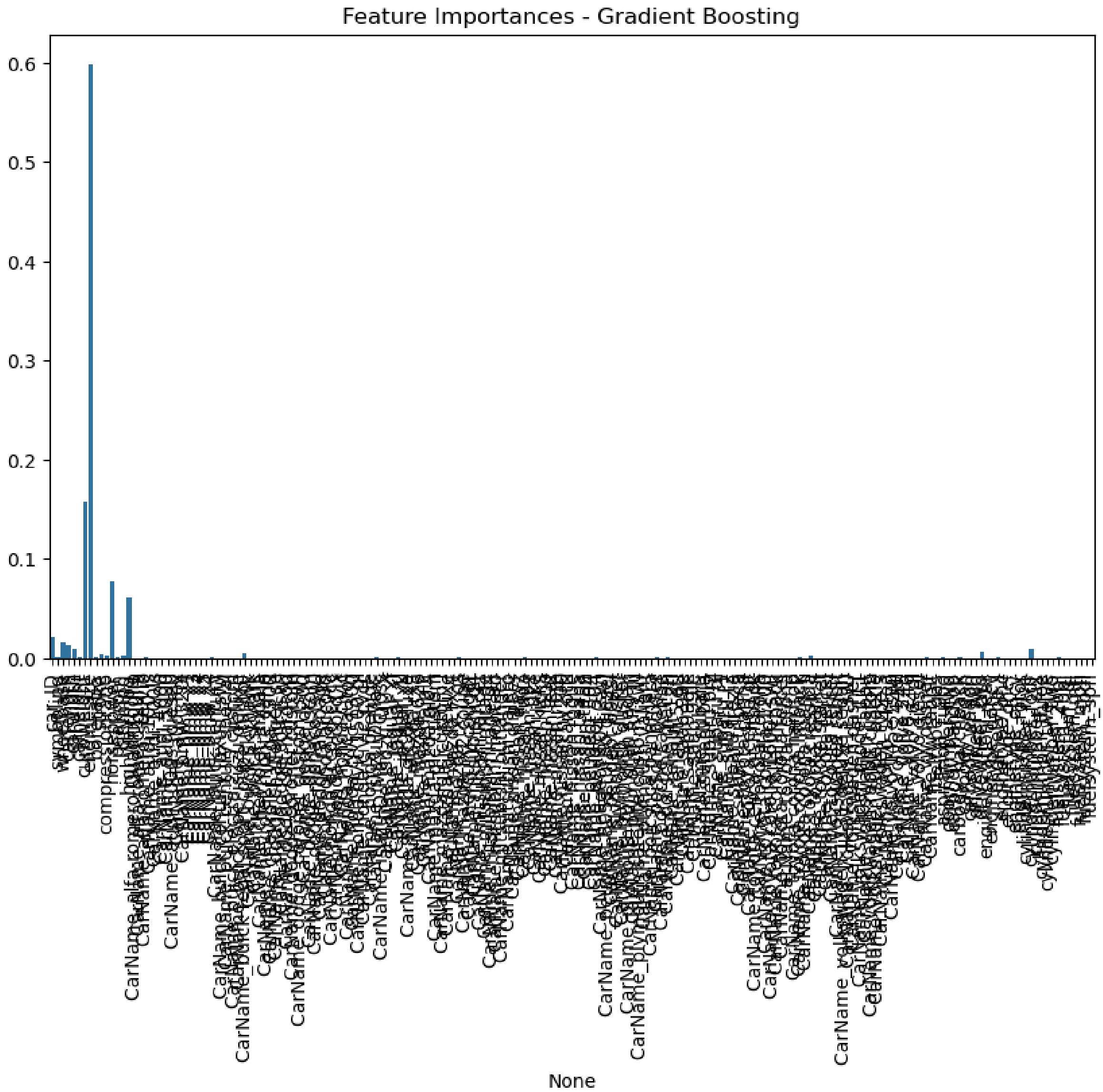
```
Model: Linear Regression
R-squared: -3338166280152721685217280.0000
MSE: 26352826852014566881123868082176.0000
MAE: 2482893968886244.0000

Model: Decision Tree Regressor
R-squared: 0.8666
MSE: 10532678.5297
MAE: 2098.3090

Model: Random Forest Regressor
R-squared: 0.9537
MSE: 3652007.2005
MAE: 1378.8925

Model: Gradient Boosting Regressor
R-squared: 0.9316
MSE: 5402849.3765
MAE: 1685.6164

Model: Support Vector Regressor
R-squared: -0.1017
MSE: 86973995.1459
MAE: 5705.0610
```

In [92]:
```
# 4. Feature Importance Analysis
# Random Forest and Gradient Boosting provide feature importances
feature_importances_rf = rf.feature_importances_
feature_importances_gb = gb.feature_importances_
```

In [56]:
```
# Plot feature importances for Random Forest
plt.figure(figsize=(10, 6))
sns.barplot(x=X.columns, y=feature_importances_rf)
plt.title("Feature Importances - Random Forest")
plt.xticks(rotation=90)
plt.show()
```



In [58]:
```
# Plot feature importances for Gradient Boosting
plt.figure(figsize=(10, 6))
sns.barplot(x=X.columns, y=feature_importances_gb)
plt.title("Feature Importances - Gradient Boosting")
plt.xticks(rotation=90)
plt.show()
```



In [62]:

```python
# 5. Hyperparameter Tuning (Example for Random Forest)
param_grid = {
    'n_estimators': [100, 200, 300],
    'max_depth': [10, 20, 30],
    'min_samples_split': [2, 5, 10]
}
grid_search = GridSearchCV(RandomForestRegressor(random_state=42), param_grid, c
grid_search.fit(X_train, y_train)

# Best parameters
print(f"Best Parameters: {grid_search.best_params_}")

# Evaluate the tuned model
best_rf = grid_search.best_estimator_
y_pred_best_rf = best_rf.predict(X_test)
evaluate_model('Tuned Random Forest', y_test, y_pred_best_rf)
```

```
Best Parameters: {'max_depth': 10, 'min_samples_split': 2, 'n_estimators': 100}
Model: Tuned Random Forest
R-squared: 0.9528
MSE: 3722559.9635
MAE: 1380.4867
```

In [ ]: