Web Scraping and Model Development for the Stockholm housing market dataset

Business Problem

To analyze how reduction in interest rates influences property prices and migration patterns in Stockholm's housing market

Objective

To build a Polynomial Regression model to predict prices and investigate the relationship between
property types, interest rates and housing transitions.

Data Collection

1. **Web Scraping the Housing Market Website: www.Booli.se**
2. **Downloading Monetary Policy report : https://www.riksbank.se/**

Data Set Description

```
Sold Price    : Final price at which the house was sold in Swedish
krona(SEK)(kr)
```

```
Street Address: Specific location of the sold house
Sold_date      : Date at which the property sale is legally finalized
Area Name      : Descriptive location area name
Object Type    : Categorical variable which represents the different type
of houses
                 (e.g., Apartment, Rowhouse, Villa etc)
Date           : Interest Rate published date by the Riskbank
Interest Rate : Rate of interest on the specified date
```

1. Web Scraping

In [1]:
```python
#Importing the necessary modules
import requests
import json
import pandas as pd
from bs4 import BeautifulSoup
import time
from datetime import datetime
```

Scraping rowhouse, semi-detached house URLs has been done seperately to avoid overwhelming the server
and time-out error

In [2]:
```python
# Defining base URLs for each object type
base_urls = {
    'Lägenhet': 'https://www.booli.se/sok/slutpriser?areaIds=1&objectType=Lägenhet&
    'Villa': 'https://www.booli.se/sok/slutpriser?areaIds=1&objectType=Villa&sort=s
    }
```

In [3]:
```python
# Initialize a dictionary to store lists for each property type
results = {
    'Lägenhet': [],
    'Villa': []
    }

# Set maximum pages to scrape
max_pages = 300

# Loop through each property type
for object_type, base_url in [('Lägenhet', base_urls['Lägenhet']),
                              ('Villa', base_urls['Villa'])]:


    print(f"Scraping {object_type}")

    # Pagination for scraping multiple desired pages
    for page_number in range(1, max_pages + 1):
        url = base_url.format(page_number)
        response = requests.get(url)

        if response.status_code == 200:
            print(f"Scraping page {page_number} for {object_type}")
```

```
            #Parsing the HTML content using BeautifulSoup
            soup = BeautifulSoup(response.content, 'html.parser')

            #Inspect the scriptid from HTML structure to retrieve data as there is
            script_tag = soup.find('script', id='__NEXT_DATA__')
            json_data = json.loads(script_tag.string)
            apollo_state = json_data['props']['pageProps']['__APOLLO_STATE__']

            # Check for sold properties
            data_found = False
            for key in apollo_state.keys():
                if key.startswith('SoldProperty:'):
                    data_found = True
                    property_data = apollo_state[key]

                    # Only collect data if the object type matches
                    if property_data.get('objectType') == object_type:

                        sold_price = property_data.get('soldPrice', {}).get('format

                        street_address = property_data.get('streetAddress', 'N/A')

                        # Handle living_area extraction safely based on faced chall
                        living_area_data = property_data.get('livingArea', None)

                        if living_area_data is not None:
                            living_area = living_area_data.get('formatted', 'N/A')
                        else:
                            living_area = 'N/A'

                        object_type = property_data.get('objectType', 'N/A')

                        area_name = property_data.get('descriptiveAreaName', 'N/A')

                        sold_date = property_data.get('soldDate', 'N/A')



                        # Append data to the appropriate list
                        results[object_type].append({
                            'Sold Price': sold_price,
                            'Street Address': street_address,
                            'Living Area': living_area,
                            'Object Type': object_type,
                            'Area Name': area_name,
                            'Sold Date': sold_date,
                        })

            # In case, if no data was found on the page, break the loop
            if not data_found:
                print(f"No more data found for {object_type} on page {page_number}.
                break
        else:
            print(f"Failed to retrieve data from page {page_number} for {object_typ
            break
```

```
        # Delay to avoid rate limiting or overwhelming the server (included based o
        time.sleep(2)

# Convert results to DataFrames and save as CSV for data consistency
for object_type, data in results.items():
    df = pd.DataFrame(data)
    df.to_csv(f'{object_type.lower()}.csv', index=False)
```

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In [4]:

```
# Read the individual CSV files
df_rowhouse = pd.read_csv('kedjehus_parhus_radhus.csv')
df_apartment = pd.read_csv('lägenhet.csv')
df_villa = pd.read_csv('villa.csv')
```

2. Monetary Policy rapport data

In [5]:

```
interest_rate_df = pd.read_excel('styrrantan-effektiv.xlsx')
```

In [6]:

```
interest_rate_df
```

Out[6]:

	Date	Interest Rate	Year	Month
0	2006-01-26	1.75	2006	1
1	2006-03-02	2.00	2006	3
2	2006-05-03	2.00	2006	5
3	2006-06-22	2.25	2006	6
4	2006-09-07	2.50	2006	9
...	...	...	...	...
110	2024-04-03	4.00	2024	4
111	2024-05-15	3.75	2024	5
112	2024-07-03	3.75	2024	7
113	2024-08-21	3.50	2024	8
114	2024-10-02	3.25	2024	10

115 rows × 4 columns

Data Cleaning and Data Preprocessing

In [7]:
```
print(df_rowhouse.head())
print(df_apartment.head())
print(df_villa.head())
```

```
      Sold Price      Street Address Living Area Object Type  \
0  4 420 000 kr   Gräsmarksgränd 33       92 m²      Radhus
1  3 799 000 kr   Kattfotsbacken 30      104 m²      Radhus
2  1 350 000 kr     Imatragatan 324      39½ m²      Radhus
3  4 800 000 kr  Torplyckegränd 206      113 m²      Parhus
4  9 450 000 kr        Letstigen 12      102 m²      Radhus

                  Area Name   Sold Date
0                    Farsta  2024-10-24
1  Hässelby Norra Villastad  2024-10-23
2      Akalla Trädgårdsstad  2024-10-22
3                    Vinsta  2024-10-21
4                Bagarmossen  2024-10-21
       Sold Price       Street Address Living Area Object Type  \
0   6 400 000 kr     Vinodlargatan 11      84½ m²    Lägenhet
1   3 300 000 kr      Dalbobranten 31       73 m²    Lägenhet
2   8 100 000 kr  Ludvigsbergsgatan 5       81 m²    Lägenhet
3   3 750 000 kr  Tellusborgsvägen 66       45 m²    Lägenhet
4  13 350 000 kr       Bondegatan 74A       97 m²    Lägenhet

            Area Name   Sold Date
0      Liljeholmskajen  2024-11-11
1              Sköndal  2024-11-11
2  Stockholm Södermalm  2024-11-11
3     Midsommarkransen  2024-11-11
4            Södermalm  2024-11-11
       Sold Price      Street Address Living Area Object Type      Area Name  \
0   6 950 000 kr         Vagnvägen 1       68 m²       Villa         Älvsjö
1   9 400 000 kr   Korpmossevägen 59       69 m²       Villa    Telefonplan
2  10 550 000 kr  Långskeppsgatan 45       95 m²       Villa    Norra Ängby
3   7 850 000 kr      Dalängsvägen 11      131 m²       Villa  Spånga Sundby
4   5 350 000 kr      Eksätravägen 22      145 m²       Villa        Bredäng

    Sold Date
0  2024-11-08
1  2024-11-08
2  2024-11-07
3  2024-11-07
4  2024-11-07
```

In [8]:
```
df_rowhouse.isnull().any()
```

Out[8]:
```
Sold Price        False
Street Address    False
Living Area        True
Object Type       False
Area Name         False
Sold Date         False
dtype: bool
```

In [9]:
```
df_apartment.isnull().any()
```

Out[9]:
```
Sold Price        False
Street Address    False
Living Area        True
Object Type       False
Area Name         False
Sold Date         False
dtype: bool
```

In [10]:
```
df_villa.isnull().any()
```

Out[10]:
```
Sold Price        False
Street Address    False
Living Area        True
Object Type       False
Area Name         False
Sold Date         False
dtype: bool
```

In [11]:
```
#Merging it into a single dataframe
df_merged = pd.concat([df_rowhouse, df_apartment,df_villa],ignore_index = True)
```

In [12]:
```
# Converting sold_date into datetime
df_merged['Sold Date'] = pd.to_datetime(df_merged['Sold Date'])

# Initializing start_date and end_date
start_date = pd.to_datetime('2010-01-01')
end_date = pd.to_datetime('2024-10-25')
```

In [13]:
```
# Extracting 'year' and 'month' as a seperate column from the merged dataset
df_merged['Year'] = pd.DatetimeIndex(df_merged['Sold Date']).year
df_merged['Month'] = pd.DatetimeIndex(df_merged['Sold Date']).month
```

In [14]:
```
# Filtering the dataset based on specific dates
real_estate_df = df_merged[(df_merged['Sold Date'] >= start_date) &
                           (df_merged['Sold Date'] <= end_date)]
```

In [15]:
```
real_estate_df.head()
```

Out[15]:

	Sold Price	Street Address	Living Area	Object Type	Area Name	Sold Date	Year	Month
0	4 420 000 kr	Gräsmarksgränd 33	92 m²	Radhus	Farsta	2024-10-24	2024	10
1	3 799 000 kr	Kattfotsbacken 30	104 m²	Radhus	Hässelby Norra Villastad	2024-10-23	2024	10
2	1 350 000 kr	Imatragatan 324	39½ m²	Radhus	Akalla Trädgårdsstad	2024-10-22	2024	10
3	4 800 000 kr	Torplyckegränd 206	113 m²	Parhus	Vinsta	2024-10-21	2024	10
4	9 450 000 kr	Letstigen 12	102 m²	Radhus	Bagarmossen	2024-10-21	2024	10

In [16]:
```
# Merging interest rate column from the df to the existing df based on year and mon
real_estate_df = real_estate_df.merge(interest_rate_df[['Year','Month','Interest Ra
```

In [17]:
```
real_estate_df.columns
```

Out[17]:
```
Index(['Sold Price', 'Street Address', 'Living Area', 'Object Type',
       'Area Name', 'Sold Date', 'Year', 'Month', 'Interest Rate'],
      dtype='object')
```

In [18]:
```
real_estate_df.shape
```

Out[18]:
```
(30524, 9)
```

In [19]:
```
real_estate_df['Interest Rate'].isnull().sum()
```

Out[19]:
```
15057
```

In [20]:
```
real_estate_df.head()
```

Out[20]:

	Sold Price	Street Address	Living Area	Object Type	Area Name	Sold Date	Year	Month	Interest Rate
0	4 420 000 kr	Gräsmarksgränd 33	92 m²	Radhus	Farsta	2024-10-24	2024	10	3.25
1	3 799 000 kr	Kattfotsbacken 30	104 m²	Radhus	Hässelby Norra Villastad	2024-10-23	2024	10	3.25
2	1 350 000 kr	Imatragatan 324	39½ m²	Radhus	Akalla Trädgårdsstad	2024-10-22	2024	10	3.25
3	4 800 000 kr	Torplyckegränd 206	113 m²	Parhus	Vinsta	2024-10-21	2024	10	3.25
4	9 450 000 kr	Letstigen 12	102 m²	Radhus	Bagarmossen	2024-10-21	2024	10	3.25

In [21]:
```
real_estate_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 30524 entries, 0 to 30523
Data columns (total 9 columns):
 #   Column          Non-Null Count  Dtype
---  ------          --------------  -----
 0   Sold Price      30524 non-null  object
 1   Street Address  30524 non-null  object
 2   Living Area     30439 non-null  object
 3   Object Type     30524 non-null  object
 4   Area Name       30524 non-null  object
 5   Sold Date       30524 non-null  datetime64[ns]
 6   Year            30524 non-null  int64
 7   Month           30524 non-null  int64
 8   Interest Rate   15467 non-null  float64
dtypes: datetime64[ns](1), float64(1), int64(2), object(5)
memory usage: 2.3+ MB
```

In [22]:
```
real_estate_df.describe()
```

Out[22]:

	Year	Month	Interest Rate
count	30524.000000	30524.000000	15467.000000
mean	2020.728509	6.959802	1.631412
std	3.327671	2.951251	1.851864
min	2013.000000	1.000000	-0.500000
25%	2018.000000	5.000000	-0.250000
50%	2021.000000	7.000000	1.000000
75%	2024.000000	9.000000	3.500000
max	2024.000000	12.000000	4.000000

In [23]:
```
real_estate_df['Object Type'].value_counts()
```

Out[23]:
```
Villa       10810
Lägenhet     9582
Radhus       7735
Kedjehus     1637
Parhus        759
Gård            1
Name: Object Type, dtype: int64
```

Handling missing values

In [24]:
```
real_estate_df['Interest Rate'] = real_estate_df['Interest Rate'].fillna(method = '
```

In [25]:
```
real_estate_df['Interest Rate'].isnull().any()
```

Out[25]:
```
False
```

In [26]:
```
# Remove non-numeric characters like comma,sq.m from the column 'Living Area'
real_estate_df['Living Area'] = real_estate_df['Living Area'].str.replace(r'[^\d]',
```

In [27]:
```
# convert it into numeric therby handling NaN values
real_estate_df['Living Area'] = pd.to_numeric(real_estate_df['Living Area'], errors
```

In [28]:
```
# grouping based on object type before filling missing values for the column living
real_estate_df['Living Area'] = real_estate_df.groupby('Object Type')['Living Area'
```

Removing Outlier

In [29]:
```
real_estate_df = real_estate_df[real_estate_df['Object Type'] != 'Gård']
```

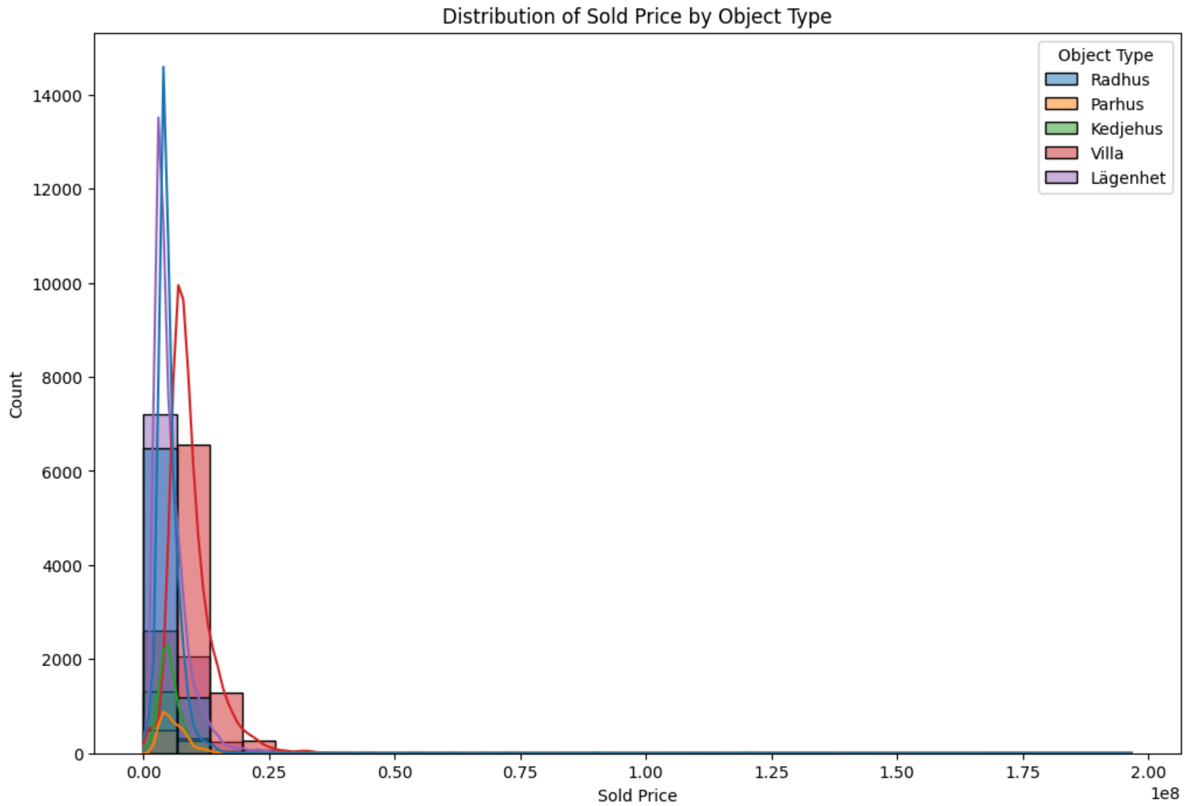
Removing inconsistent dataformat

In [30]:
```
# Remove non-numeric characters like comma, kr from 'Sold Price' and convert it to
real_estate_df['Sold Price'] = real_estate_df['Sold Price'].str.replace(r'[^\d]',''
# Verify the result
print(real_estate_df['Sold Price'].head())
```

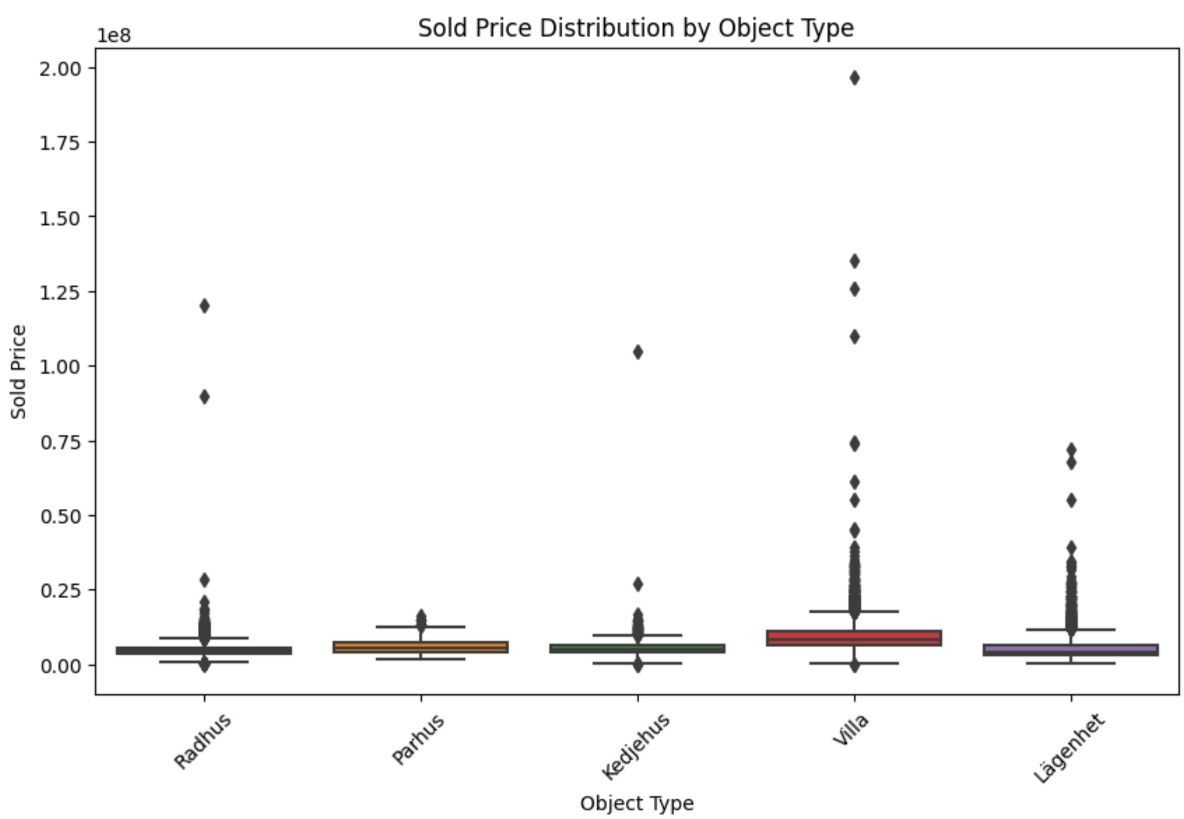
```
0    4420000
1    3799000
2    1350000
3    4800000
4    9450000
Name: Sold Price, dtype: int32
```

Exploratory Data Analysis

In [31]:
```
#Distribution of Sold Price by Object Type
import seaborn as sns
import matplotlib.pyplot as plt

plt.figure(figsize=(12,8))
sns.histplot(data=real_estate_df, x='Sold Price', hue='Object Type', bins=30, kde=T
plt.title('Distribution of Sold Price by Object Type')
plt.show()
```

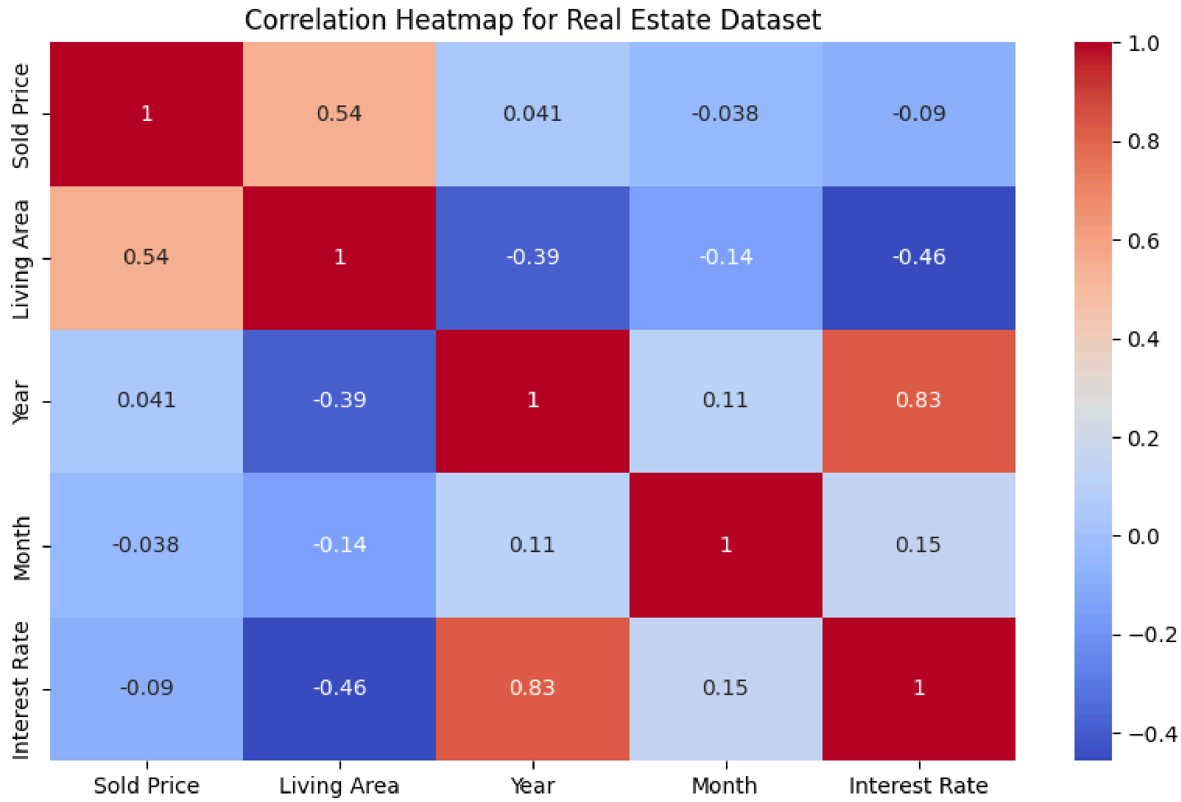


In [32]:
```
# to understand IQR, min and max value of sold price for each object type
plt.figure(figsize=(10,6))
sns.boxplot(data=real_estate_df, x='Object Type', y='Sold Price')
plt.title('Sold Price Distribution by Object Type')
plt.xticks(rotation=45)
plt.show()
```

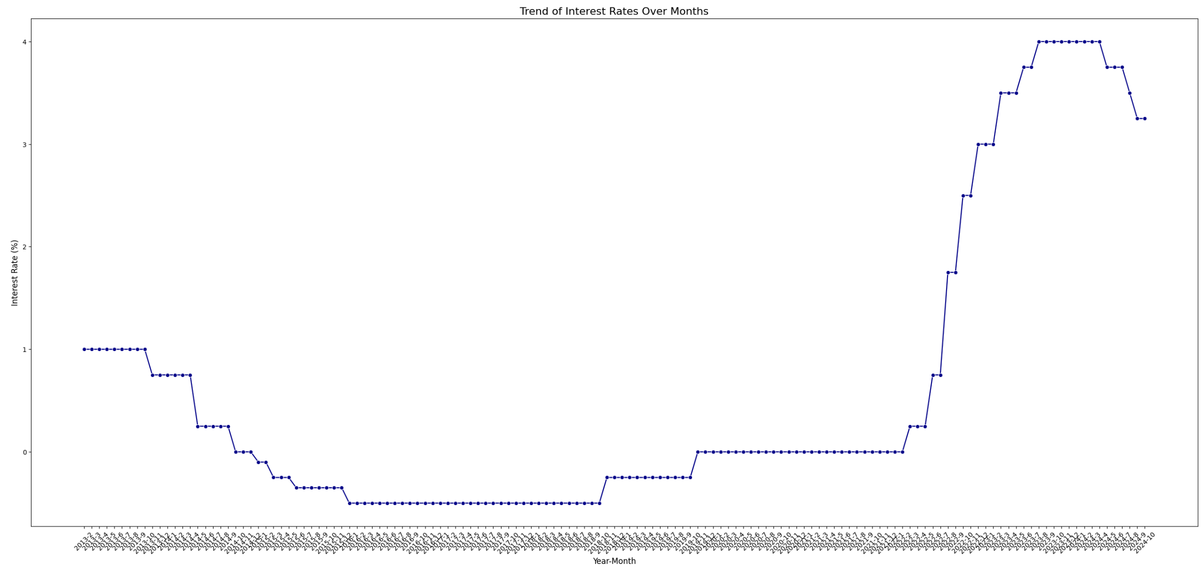


In [33]:
```
# to understand the relationship between numerical variables
plt.figure(figsize = (10,6))
sns.heatmap(real_estate_df.corr(), annot = True, cmap = 'coolwarm')
plt.title('Correlation Heatmap for Real Estate Dataset')
plt.show()
```

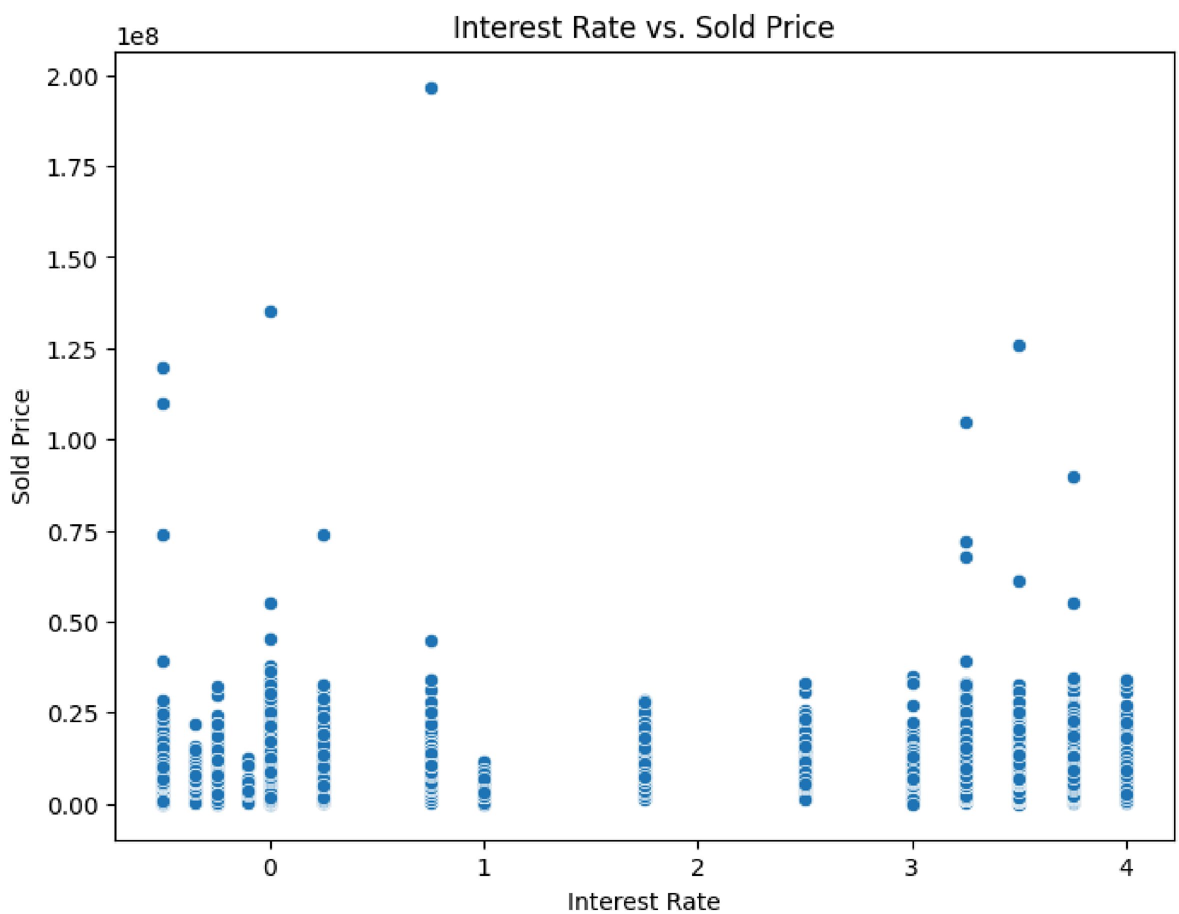
```
C:\Users\nklmy\AppData\Local\Temp\ipykernel_18036\1080443470.py:3: FutureWarning:
The default value of numeric_only in DataFrame.corr is deprecated. In a future ver
sion, it will default to False. Select only valid columns or specify the value of
numeric_only to silence this warning.
  sns.heatmap(real_estate_df.corr(), annot = True, cmap = 'coolwarm')
```



In [34]:
```
# Create a 'Year-Month' column to represent it in the plot
real_estate_df['Year-Month'] = real_estate_df['Year'].astype(str) + '-' + real_esta

# Sort by 'Year-Month' to ensure proper order
real_estate_df = real_estate_df.sort_values(by=['Year', 'Month'])

# Plotting the interest rate trend over months
plt.figure(figsize=(32,14))
sns.lineplot(data=real_estate_df, x='Year-Month', y='Interest Rate', color = 'darkb

# Customize the plot
plt.title('Trend of Interest Rates Over Months', fontsize=16)
plt.xlabel('Year-Month', fontsize=12)
plt.ylabel('Interest Rate (%)', fontsize=12)
plt.xticks(rotation=45)
plt.show()
```

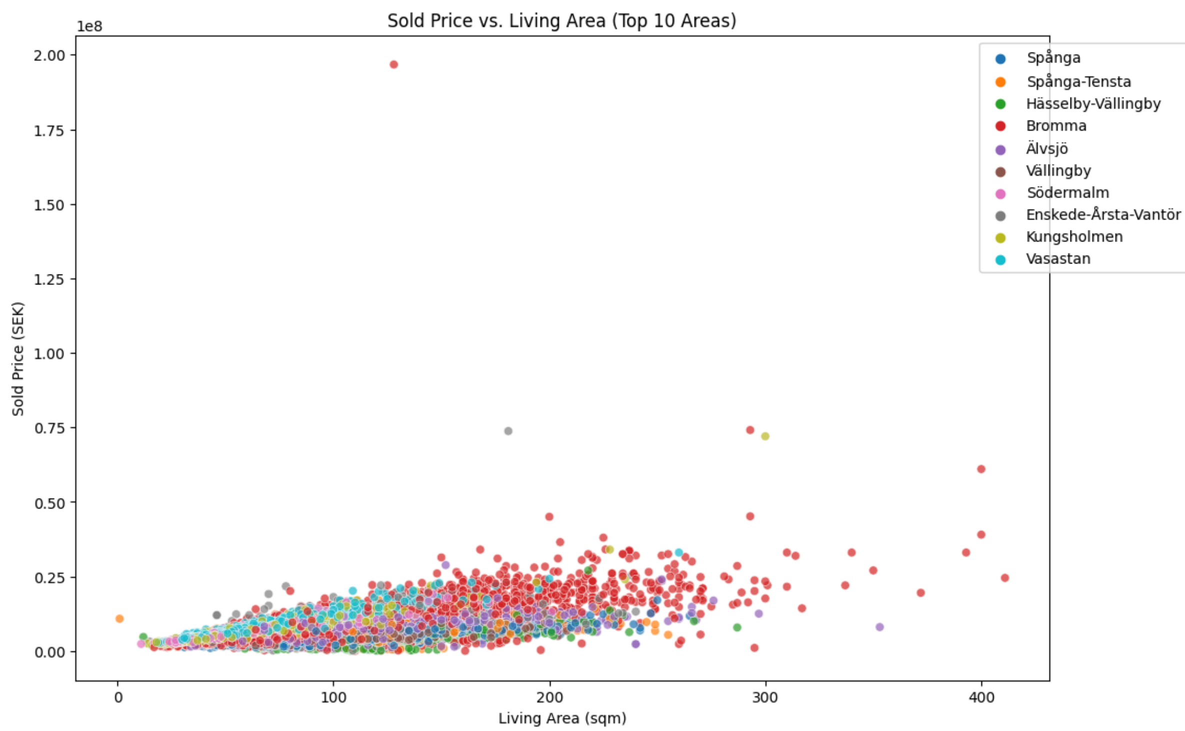


In [35]:
```
# Scatter plot: Interest Rate vs. Sold Price
plt.figure(figsize=(8,6))
sns.scatterplot(x=real_estate_df['Interest Rate'], y=real_estate_df['Sold Price'])
plt.title('Interest Rate vs. Sold Price')
plt.show()
```



In [36]:
```
# Extracting top 10 areas by count (regardless of the property type,total count mat
top_areas = real_estate_df['Area Name'].value_counts().nlargest(10).index
filtered_df = real_estate_df[real_estate_df['Area Name'].isin(top_areas)]
```

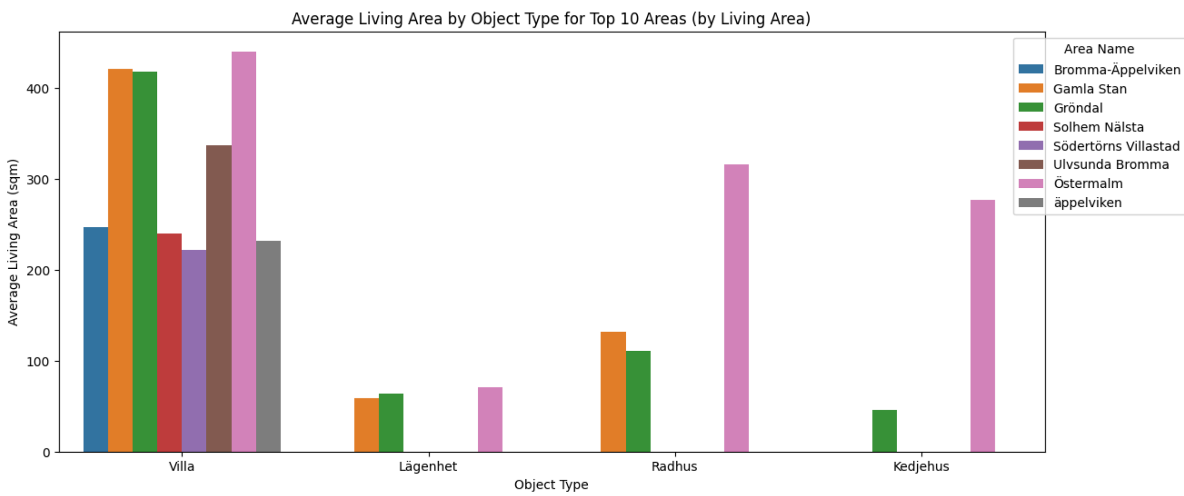
```
# Plot
plt.figure(figsize=(12,8))
sns.scatterplot(data=filtered_df, x='Living Area', y='Sold Price', hue='Area Name',
plt.title('Sold Price vs. Living Area (Top 10 Areas)')
plt.ylabel('Sold Price (SEK)')
plt.xlabel('Living Area (sqm)')
plt.legend(loc='upper right', bbox_to_anchor=(1.15, 1))
plt.show()
```

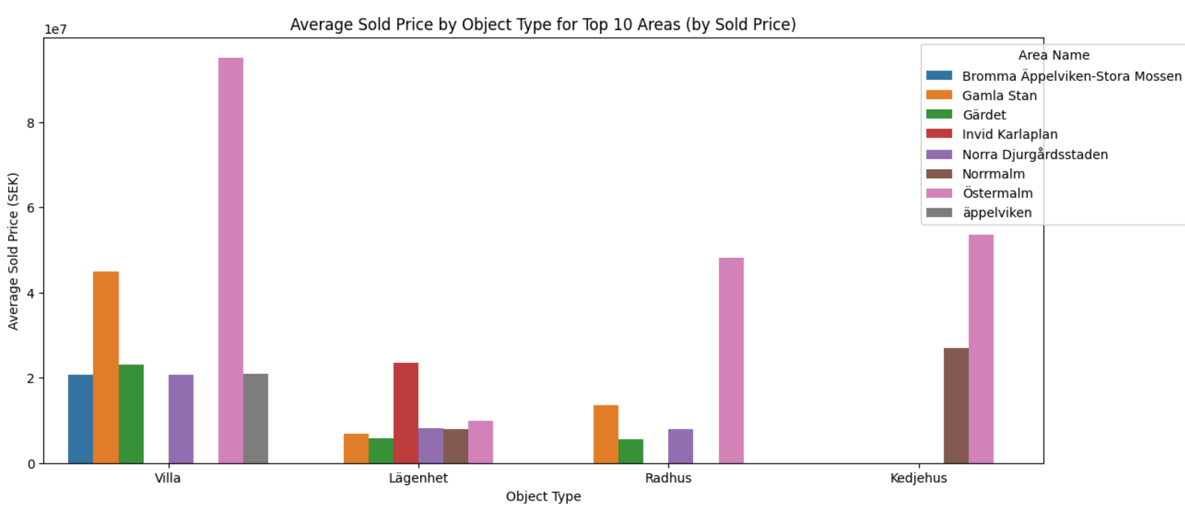


In [37]:
```
# Calculate average Living Area and Sold Price by Area and Object Type
area_stats = real_estate_df.groupby(['Area Name', 'Object Type']).agg(
    avg_living_area=('Living Area', 'mean'),
    avg_sold_price=('Sold Price', 'mean')
).reset_index()

# Get top 10 areas by average Living Area
top_areas_living_area = area_stats.nlargest(10, 'avg_living_area')['Area Name']
# Get top 10 areas by average Sold Price
top_areas_sold_price = area_stats.nlargest(10, 'avg_sold_price')['Area Name']
```

In [38]:
```
# Plot Average Living Area and Sold Price Across Object Types for Top 10 Areas
import seaborn as sns
import matplotlib.pyplot as plt

# Filter data for top 10 areas by Living Area and Sold Price
filtered_living_area = area_stats[area_stats['Area Name'].isin(top_areas_living_are
filtered_sold_price = area_stats[area_stats['Area Name'].isin(top_areas_sold_price)

# Plot for Average Living Area
plt.figure(figsize=(14, 6))
sns.barplot(
    data=filtered_living_area,
    x='Object Type',
```

```
    y='avg_living_area',
    hue='Area Name',
    palette='tab10'
)
plt.title('Average Living Area by Object Type for Top 10 Areas (by Living Area)')
plt.ylabel('Average Living Area (sqm)')
plt.xlabel('Object Type')
plt.legend(title='Area Name', loc='upper right', bbox_to_anchor=(1.15, 1))
plt.show()

# Plot for Average Sold Price
plt.figure(figsize=(14, 6))
sns.barplot(
    data=filtered_sold_price,
    x='Object Type',
    y='avg_sold_price',
    hue='Area Name',
    palette='tab10'
)
plt.title('Average Sold Price by Object Type for Top 10 Areas (by Sold Price)')
plt.ylabel('Average Sold Price (SEK)')
plt.xlabel('Object Type')
plt.legend(title='Area Name', loc='upper right', bbox_to_anchor=(1.15, 1))
plt.show()
```





Encoding Categorical Variable

In [39]:
```
real_estate_df = pd.get_dummies(real_estate_df, columns = ['Object Type'], drop_fir
```

In [40]:
```
real_estate_df
```

Out[40]:

	Sold Price	Street Address	Living Area	Area Name	Sold Date	Year	Month	Interest Rate	Year-Month
10447	2000000	Torpstugegränd 32	90.0	Spånga	2013-02-28	2013	2	1.00	2013-2
10448	4100000	Lisebergsvägen 109A	136.0	Älvsjö Liseberg	2013-02-28	2013	2	1.00	2013-2
10449	3250000	Ekshäradsgatan 228	87.0	Farsta	2013-02-28	2013	2	1.00	2013-2
10450	2800000	Gillsätragränd 88	126.0	Sätra	2013-02-28	2013	2	1.00	2013-2
10451	4460000	Älvkvarnsvägen 76	150.0	Spånga-Tensta	2013-02-28	2013	2	1.00	2013-2
...	...	...	...	...	...	...	...	...	...
20211	8000000	Doktor Abrahams väg 46	85.0	Bromma Kyrka	2024-10-01	2024	10	3.25	2024-10
20212	9200000	Bollstavägen 2	101.0	Stureby	2024-10-01	2024	10	3.25	2024-10
20213	7700000	Granskogsvägen 31	184.0	Hässelby Norra Villastad	2024-10-01	2024	10	3.25	2024-10
20214	9925000	Mälarhöjdsvägen 69	95.0	Hägersten-Liljeholmen	2024-10-01	2024	10	3.25	2024-10
20215	15250000	Tussmötevägen 223	140.0	Enskede-Årsta-Vantör	2024-10-01	2024	10	3.25	2024-10

30523 rows × 13 columns

Feature Scaling

In [41]:
```
import numpy as np
```

In [42]:
```
real_estate_df['Sold Price Log'] = np.log(real_estate_df['Sold Price'])
```

Model Development

1. Train-Test data split

In [43]:
```
# importing the necessary library
from sklearn.model_selection import train_test_split

X = real_estate_df.drop(columns = ['Sold Price','Street Address','Area Name','Sold
y = real_estate_df['Sold Price']

# spliting the dataset into training and test data
X_train, X_test, y_train, y_test = train_test_split(X,y, test_size = 0.2, random_st
```

2. Training the Model

In [45]:
```
# training the multiple linear regression model on the training data set'
from sklearn.preprocessing import PolynomialFeatures
from sklearn.linear_model import LinearRegression
pol_reg = PolynomialFeatures(degree=3)

# Transforming the features
X_pol = pol_reg.fit_transform(X_train)

# Fitting the Linear Regression model
lin_reg_of_poly = LinearRegression()
lin_reg_of_poly.fit(X_pol, y_train)

# Transforming the test data
X_test_pol = pol_reg.transform(X_test)
```

3. Model Prediction

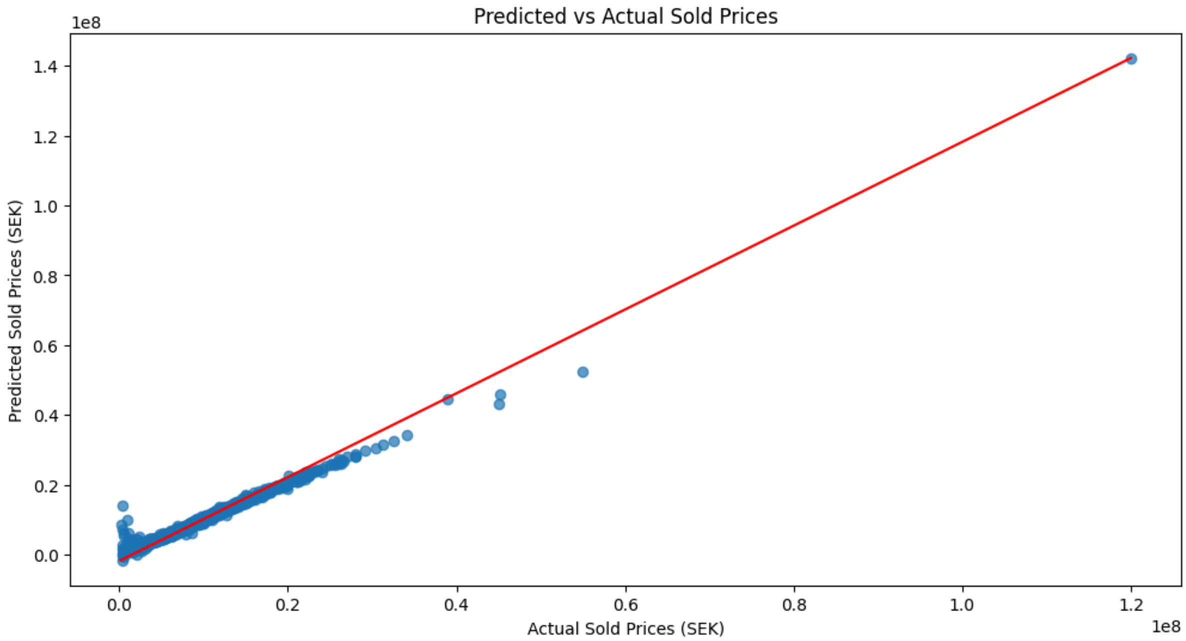
In [46]:
```
# Making predictions on the transformed test data
y_pred = lin_reg_of_poly.predict(X_test_pol)
```

4. Model Evaluation

In [47]:
```
# Mean Squared Error and R-squared for model evaluation
from sklearn.metrics import mean_squared_error, r2_score

mse = mean_squared_error(y_test, y_pred)
r2 = r2_score(y_test, y_pred)

# Calculate Root Mean Squared Error (RMSE)
rmse = np.sqrt(mse)

print(f'Root Mean Squared Error: {rmse:.2f} SEK')

print(f'R-squared: {r2}')
```

```
Root Mean Squared Error: 501764.27 SEK
R-squared: 0.9861467444091133
```

In [48]:
```
# Plotting predicted vs actual values
plt.figure(figsize=(12, 6))
plt.scatter(y_test, y_pred, alpha=0.7)
plt.plot([y_test.min(), y_test.max()], [y_pred.min(), y_pred.max()], color='red')
plt.title('Predicted vs Actual Sold Prices')
plt.xlabel('Actual Sold Prices (SEK)')
plt.ylabel('Predicted Sold Prices (SEK)')
plt.show()
```



5. Saving the model

In [49]:
```
# Save the model to a file
import joblib
joblib.dump(lin_reg_of_poly, 'stockholm_property_price_model.pkl')
```

Out[49]: ['stockholm_property_price_model.pkl']