In [1]:
```
import os
import numpy as np
import pandas as pd
from matplotlib import pyplot as plt
import seaborn as sns

import warnings
warnings.filterwarnings('ignore')
```

In [2]:
```
data_path = "..\\data\\raw\\smedebtsu.xlsx"
```

In [3]:
```
data = pd.read_excel(data_path)
data
```

Out[3]:

	Date	Day	Month	Year	LenderA	LenderB	LenderC	LenderD	LenderE	LenderF	LenderG	LenderH	LenderI	LenderJ
0	2013-10-13 00:00:00	13	10	2013	74349.0	70109.93	11477.84	4884	0.0	61763.24	0.00	0.00	2442.00	0.0
1	2013-11-13 00:00:00	13	11	2013	73535.0	66083.05	9607.84	5170	0.0	61763.24	2563.00	0.00	2422.09	0.0
2	2013-12-10 00:00:00	10	12	2013	71027.0	93500.00	14300.00	4950	0.0	59400.00	12232.00	0.00	2640.00	0.0
3	2014-01-23 00:00:00	23	1	2014	0.0	15741.00	14300.00	3300	262944.0	0.00	3168.00	0.00	0.00	0.0
4	2014-03-05 00:00:00	5	3	2014	0.0	14850.00	13200.00	3476	254177.0	0.00	4400.00	0.00	0.00	0.0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
109	2022-11-28 00:00:00	28	11	2022	28369.0	115775.00	0.00	0	245740.0	22638.00	62084.00	104335.00	14025.00	19800.0
110	2023-02-05 00:00:00	5	2	2023	26774.0	108064.00	0.00	0	234740.0	15125.00	57772.00	98703.00	8800.00	15400.0
111	2023-03-05 00:00:00	5	3	2023	26202.0	104225.00	0.00	0	231077.0	11352.00	56826.00	95810.00	5500.00	13200.0
112	2023-04-05 00:00:00	5	4	2023	25432.0	100375.00	0.00	0	227403.0	7579.00	54618.08	92689.96	0.00	11000.0
113	2023-05-05 00:00:00	5	5	2023	24893.0	95975.00	0.00	0	223729.0	3773.00	51876.00	89023.00	0.00	8800.0

114 rows × 15 columns

In [4]:
```python
# Descriptive statistics
data.describe()
```

Out[4]:

	Day	Month	Year	LenderA	LenderB	LenderC	LenderD	LenderE	LenderF	
count	114.000000	114.000000	114.000000	114.000000	114.000000	114.000000	114.000000	114.000000	114.000000	
mean	13.614035	7.096491	2017.605263	38755.816579	66840.291930	1406.541053	971.956140	185799.648158	40254.729649	2
std	8.636728	3.672354	3.012124	41698.925450	46056.428855	3637.700561	1896.312866	93078.720974	56996.382488	2
min	1.000000	1.000000	2013.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	
25%	7.250000	4.000000	2015.000000	0.000000	22000.000000	0.000000	0.000000	108655.250000	0.000000	
50%	12.500000	8.000000	2017.000000	31707.500000	76131.000000	0.000000	0.000000	210353.000000	0.000000	1
75%	20.750000	10.000000	2020.000000	60709.000000	106909.000000	0.000000	783.750000	252254.750000	76238.250000	4
max	31.000000	12.000000	2023.000000	138754.000000	146476.000000	14300.000000	7986.000000	352099.000000	176000.000000	7

Exploratory Data Analysis

Overall goal:

- Get an understanding for which variables are important
- Check any duplicates, missing values, or incorrect data

Data Preprocessing

- Check missing values/ duplicates/ outlier points

In [5]:
```python
# the length of data
print(f"The Length of the data: {data.shape}")
```

```
The Length of the data: (114, 15)
```

Check missing values

In [6]:
```
# Missing values
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 114 entries, 0 to 113
Data columns (total 15 columns):
 #   Column   Non-Null Count  Dtype  
---  ------   --------------  -----  
 0   Date     114 non-null    object 
 1   Day      114 non-null    int64  
 2   Month    114 non-null    int64  
 3   Year     114 non-null    int64  
 4   LenderA  114 non-null    float64
 5   LenderB  114 non-null    float64
 6   LenderC  114 non-null    float64
 7   LenderD  114 non-null    int64  
 8   LenderE  114 non-null    float64
 9   LenderF  114 non-null    float64
 10  LenderG  114 non-null    float64
 11  LenderH  114 non-null    float64
 12  LenderI  114 non-null    float64
 13  LenderJ  114 non-null    float64
 14  LenderK  114 non-null    float64
dtypes: float64(10), int64(4), object(1)
memory usage: 13.5+ KB
```

[Comment] We don't see any missing values

Check duplicates

In [7]:
```python
# Convert objects to datetime
# In the Date column, there are the following cases: 04/042022 -- 02/052022 -- 02/052022,
# so I use 3 other columns to create the "Date_time" column
data['Date_time'] = pd.to_datetime(data[['Day', 'Month', 'Year']])
data = data.drop(columns=['Date', 'Day', 'Month', 'Year'])
data.head()
```

Out[7]:

	LenderA	LenderB	LenderC	LenderD	LenderE	LenderF	LenderG	LenderH	LenderI	LenderJ	LenderK	Date_time
0	74349.0	70109.93	11477.84	4884	0.0	61763.24	0.0	0.0	2442.00	0.0	2981.00	2013-10-13
1	73535.0	66083.05	9607.84	5170	0.0	61763.24	2563.0	0.0	2422.09	0.0	6844.09	2013-11-13
2	71027.0	93500.00	14300.00	4950	0.0	59400.00	12232.0	0.0	2640.00	0.0	7150.00	2013-12-10
3	0.0	15741.00	14300.00	3300	262944.0	0.00	3168.0	0.0	0.00	0.0	0.00	2014-01-23
4	0.0	14850.00	13200.00	3476	254177.0	0.00	4400.0	0.0	0.00	0.0	0.00	2014-03-05

In [8]:
```python
# Move the 'Date_time' column from last to first position
cols = ['Date_time'] + [col for col in data.columns if col != 'Date_time']
data = data.reindex(columns=cols)
data.head()
```

Out[8]:

	Date_time	LenderA	LenderB	LenderC	LenderD	LenderE	LenderF	LenderG	LenderH	LenderI	LenderJ	LenderK
0	2013-10-13	74349.0	70109.93	11477.84	4884	0.0	61763.24	0.0	0.0	2442.00	0.0	2981.00
1	2013-11-13	73535.0	66083.05	9607.84	5170	0.0	61763.24	2563.0	0.0	2422.09	0.0	6844.09
2	2013-12-10	71027.0	93500.00	14300.00	4950	0.0	59400.00	12232.0	0.0	2640.00	0.0	7150.00
3	2014-01-23	0.0	15741.00	14300.00	3300	262944.0	0.00	3168.0	0.0	0.00	0.0	0.00
4	2014-03-05	0.0	14850.00	13200.00	3476	254177.0	0.00	4400.0	0.0	0.00	0.0	0.00

In [9]:
```
# Show the number of duplicated observations
print(f"The number of duplicated values in the dataset: {data.duplicated().sum()}")
```

```
The number of duplicated values in the dataset: 30
```

In [10]:
```
# Remove duplicate rows
data = data.drop_duplicates(ignore_index=True)
data
```

Out[10]:

	Date_time	LenderA	LenderB	LenderC	LenderD	LenderE	LenderF	LenderG	LenderH	LenderI	LenderJ	LenderK
0	2013-10-13	74349.0	70109.93	11477.84	4884	0.0	61763.24	0.00	0.00	2442.00	0.0	2981.00
1	2013-11-13	73535.0	66083.05	9607.84	5170	0.0	61763.24	2563.00	0.00	2422.09	0.0	6844.09
2	2013-12-10	71027.0	93500.00	14300.00	4950	0.0	59400.00	12232.00	0.00	2640.00	0.0	7150.00
3	2014-01-23	0.0	15741.00	14300.00	3300	262944.0	0.00	3168.00	0.00	0.00	0.0	0.00
4	2014-03-05	0.0	14850.00	13200.00	3476	254177.0	0.00	4400.00	0.00	0.00	0.0	0.00
...	...	...	...	...	...	...	...	...	...	...	...	...
79	2022-11-28	28369.0	115775.00	0.00	0	245740.0	22638.00	62084.00	104335.00	14025.00	19800.0	0.00
80	2023-02-05	26774.0	108064.00	0.00	0	234740.0	15125.00	57772.00	98703.00	8800.00	15400.0	0.00
81	2023-03-05	26202.0	104225.00	0.00	0	231077.0	11352.00	56826.00	95810.00	5500.00	13200.0	0.00
82	2023-04-05	25432.0	100375.00	0.00	0	227403.0	7579.00	54618.08	92689.96	0.00	11000.0	0.00
83	2023-05-05	24893.0	95975.00	0.00	0	223729.0	3773.00	51876.00	89023.00	0.00	8800.0	0.00

84 rows × 12 columns

In [11]:
```
# Sort Datet time
data = data.sort_values(by='Date_time')
```

Data Visualization

- Figure 1: Show the development of average debts over the years
- Figure 2: Show the actual total debts (from all lenders) on every month of the year over the past 10 years

Visualize the average debts

In [12]:
```
df_average_debts = data.copy()
df_average_debts.head()
```

Out[12]:

	Date_time	LenderA	LenderB	LenderC	LenderD	LenderE	LenderF	LenderG	LenderH	LenderI	LenderJ	LenderK
0	2013-10-13	74349.0	70109.93	11477.84	4884	0.0	61763.24	0.0	0.0	2442.00	0.0	2981.00
1	2013-11-13	73535.0	66083.05	9607.84	5170	0.0	61763.24	2563.0	0.0	2422.09	0.0	6844.09
2	2013-12-10	71027.0	93500.00	14300.00	4950	0.0	59400.00	12232.0	0.0	2640.00	0.0	7150.00
3	2014-01-23	0.0	15741.00	14300.00	3300	262944.0	0.00	3168.0	0.0	0.00	0.0	0.00
4	2014-03-05	0.0	14850.00	13200.00	3476	254177.0	0.00	4400.0	0.0	0.00	0.0	0.00

In [13]:
```
# Calculate the average debts of every month over 10 years
df_average_debts['Total_debts'] = df_average_debts.sum(axis=1)
df_average_debts.head()
```

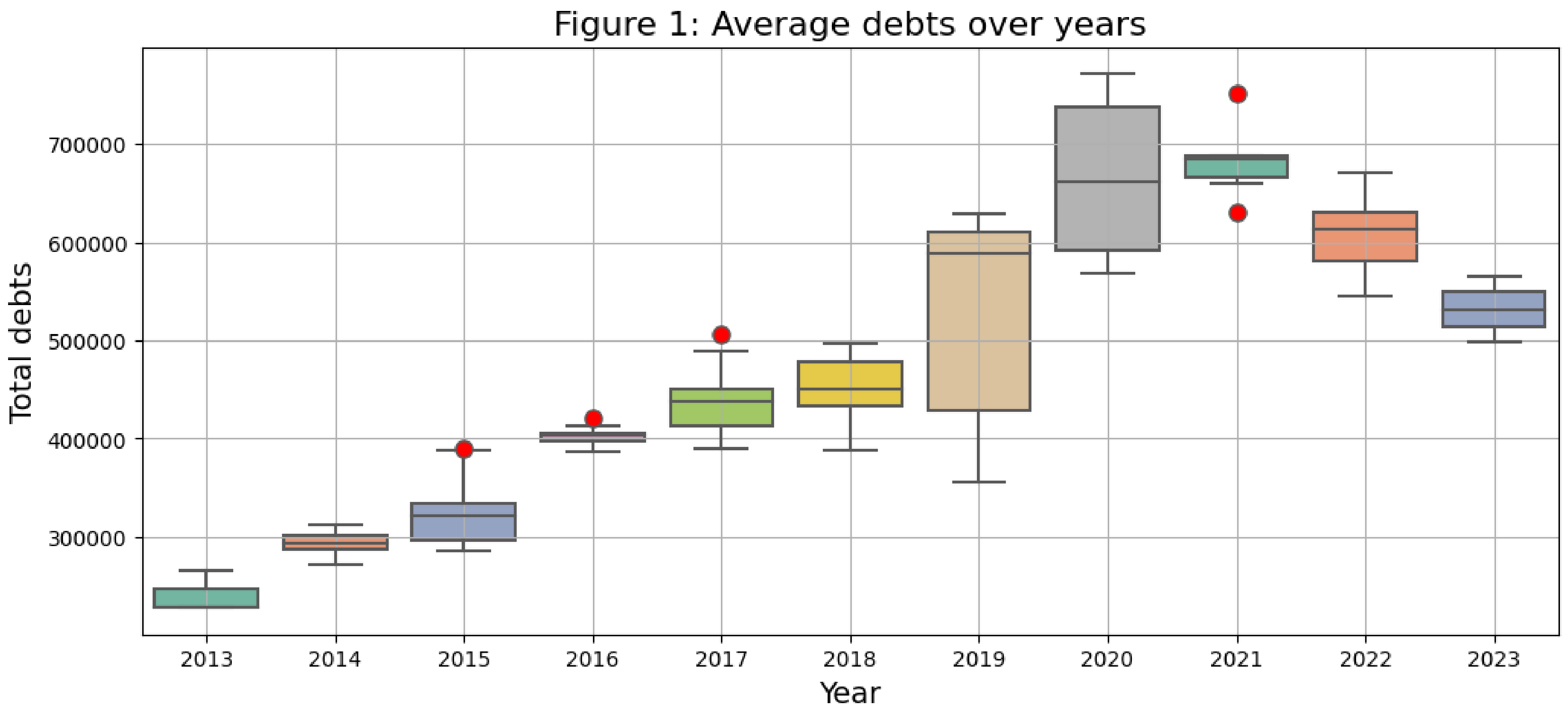
Out[13]:

	Date_time	LenderA	LenderB	LenderC	LenderD	LenderE	LenderF	LenderG	LenderH	LenderI	LenderJ	LenderK	Total_debts
0	2013-10-13	74349.0	70109.93	11477.84	4884	0.0	61763.24	0.0	0.0	2442.00	0.0	2981.00	228007.01
1	2013-11-13	73535.0	66083.05	9607.84	5170	0.0	61763.24	2563.0	0.0	2422.09	0.0	6844.09	227988.31
2	2013-12-10	71027.0	93500.00	14300.00	4950	0.0	59400.00	12232.0	0.0	2640.00	0.0	7150.00	265199.00
3	2014-01-23	0.0	15741.00	14300.00	3300	262944.0	0.00	3168.0	0.0	0.00	0.0	0.00	299453.00
4	2014-03-05	0.0	14850.00	13200.00	3476	254177.0	0.00	4400.0	0.0	0.00	0.0	0.00	290103.00

In [14]:
```python
fig, ax = plt.subplots(figsize=(12, 5))

sns.boxplot(
    x=df_average_debts['Date_time'].dt.year,
    y=df_average_debts['Total_debts'],
    palette='Set2',
    flierprops=dict(marker='o', markerfacecolor='red', markersize=8)
)

plt.title('Figure 1: Average debts over years', fontsize=16)
plt.xlabel('Year', fontsize=14)
plt.ylabel('Total debts', fontsize=14)
plt.grid(True)
plt.show()
```



Visualize the total debts

In [15]:
```
# # Convert an the object/int64 to a datetime timestamp
# df_total_debts['Month_year'] = pd.to_datetime(df_total_debts['Month'] + '-' + df_total_debts['Year'].as
# df_total_debts.head()

# Calculate the average debts of every month over 10 years
df_total_debts = data.copy()
df_total_debts['Total_debts'] = df_total_debts.sum(axis=1)
df_total_debts.head()
```

Out[15]:

	Date_time	LenderA	LenderB	LenderC	LenderD	LenderE	LenderF	LenderG	LenderH	LenderI	LenderJ	LenderK	Total_debts
0	2013-10-13	74349.0	70109.93	11477.84	4884	0.0	61763.24	0.0	0.0	2442.00	0.0	2981.00	228007.01
1	2013-11-13	73535.0	66083.05	9607.84	5170	0.0	61763.24	2563.0	0.0	2422.09	0.0	6844.09	227988.31
2	2013-12-10	71027.0	93500.00	14300.00	4950	0.0	59400.00	12232.0	0.0	2640.00	0.0	7150.00	265199.00
3	2014-01-23	0.0	15741.00	14300.00	3300	262944.0	0.00	3168.0	0.0	0.00	0.0	0.00	299453.00
4	2014-03-05	0.0	14850.00	13200.00	3476	254177.0	0.00	4400.0	0.0	0.00	0.0	0.00	290103.00

In [16]:
```
df1 = df_total_debts[['Date_time', 'Total_debts']]
df1.head()
```

Out[16]:

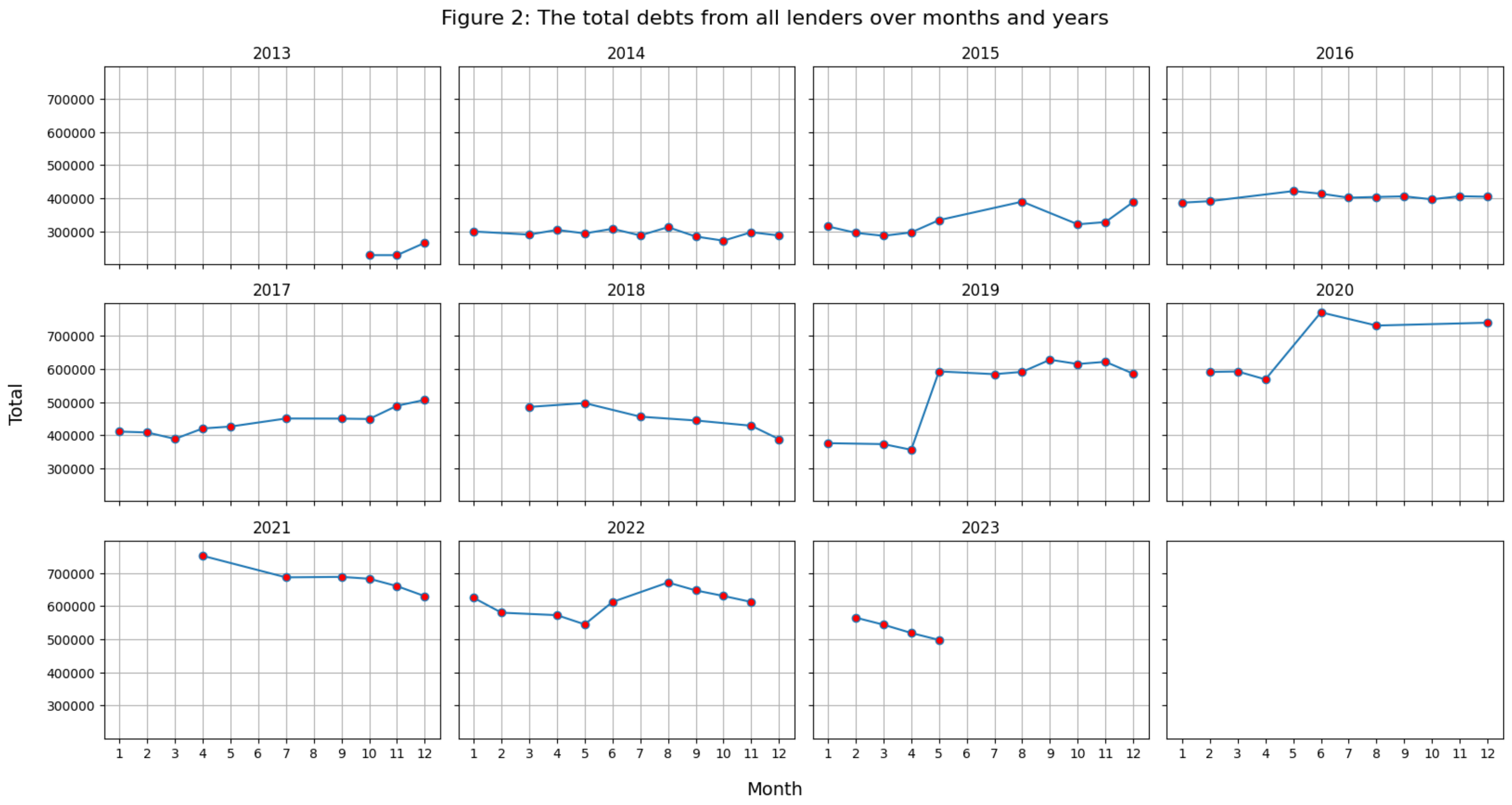
	Date_time	Total_debts
0	2013-10-13	228007.01
1	2013-11-13	227988.31
2	2013-12-10	265199.00
3	2014-01-23	299453.00
4	2014-03-05	290103.00

In [17]:
```
fig, ax = plt.subplots(3, 4, sharex=True, sharey=True, figsize=(16, 8))
ax = ax.ravel()

for i, year in enumerate(range(2013, 2024)):
    year_data = df1[df1['Date_time'].dt.year == year]
    # Plot the data on the corresponding subplot
    ax[i].plot(year_data['Date_time'].dt.month, year_data['Total_debts'], marker='o', markerfacecolor='re
    ax[i].grid(True)
    ax[i].set_title(year)
    ax[i].set_xticks(range(1, 13))
# Adjust the spacing between subplots
fig.tight_layout()

# Set labels
fig.text(0.5, -0.02, 'Month', ha='center', va='center', fontsize=14)
fig.text(-0.01, 0.5, 'Total', ha='center', va='center', rotation='vertical', fontsize=14)

fig.suptitle('Figure 2: The total debts from all lenders over months and years', fontsize=16, y=1.03)
plt.show()
```



In [18]:

```python
# Checking folder exists
def check_dir_exists(dir_path):
    if not os.path.exists(dir_path):
        os.makedirs(dir_path)
```

In [19]:

```python
# Save processed data file
save_path = '../data/processed'
check_dir_exists(save_path)

data.to_csv(os.path.join(save_path, 'processed_smedebtsu.csv'), index=False)
```

In [ ]:

```

```