Credit Card Data Exploration

We will explore data that has been provided to us.

In [1]:

```
# Load the Packages and Check the Versions

import sys
import numpy as np
import pandas as pd
import matplotlib as mpl
import sklearn
```

In [2]:

```
print('The Python version is {}.\n'.format(sys.version))
print('The Numpy version is {}.\n'.format(np.__version__))
print('The Pandas version is {}.\n'.format(pd.__version__))
print('The Matplotlib version is {}.\n'.format(mpl.__version__))
print('The Scikit-Learn version is {}.\n'.format(sklearn.__version__))
```

```
The Python version is 3.8.8 (default, Apr 13 2021, 15:08:03) [MSC v.1916 64 bit (AMD6
4)].

The Numpy version is 1.20.1.

The Pandas version is 1.2.4.

The Matplotlib version is 3.3.4.

The Scikit-Learn version is 0.24.1.
```

Loading the Data

In [3]:

```
df = pd.read_excel('ClientCreditCard.xls')
```

In [4]:

```
df.shape
```

Out[4]:

```
(30000, 25)
```

Verifying Basic Data Integrity

In [5]:

```
df.columns
```

Out[5]:

```
Index(['ID', 'LIMIT_BAL', 'SEX', 'EDUCATION', 'MARRIAGE', 'AGE', 'PAY_1',
       'PAY_2', 'PAY_3', 'PAY_4', 'PAY_5', 'PAY_6', 'BILL_AMT1', 'BILL_AMT2',
       'BILL_AMT3', 'BILL_AMT4', 'BILL_AMT5', 'BILL_AMT6', 'PAY_AMT1',
       'PAY_AMT2', 'PAY_AMT3', 'PAY_AMT4', 'PAY_AMT5', 'PAY_AMT6',
       'default payment next month'],
      dtype='object')
```

In [6]:

```
df.head()
```

Out[6]:

	ID	LIMIT_BAL	SEX	EDUCATION	MARRIAGE	AGE	PAY_1	PAY_2	PAY_3	PAY_4	...	BILL_AM
0	798fc410-45c1	20000	2	2	1	24	2	2	-1	-1	...	
1	8a8c8f3b-8eb4	120000	2	2	2	26	-1	2	0	0	...	3
2	85698822-43f5	90000	2	2	2	34	0	0	0	0	...	14
3	0737c11b-be42	50000	2	2	1	37	0	0	0	0	...	28
4	3b7f77cc-dbc0	50000	1	2	1	57	-1	0	-1	0	...	20

5 rows × 25 columns

In [7]:

```
df.shape
```

Out[7]:

```
(30000, 25)
```

In [8]:

```
df['ID'].nunique()
```

Out[8]:

```
29687
```

Has less than the number of rows, so there are duplicates.

In [9]:

```
id_counts = df['ID'].value_counts()
id_counts.head()
```

Out[9]:

```
20b16b21-8b23    2
37a1d9c2-701c    2
5f79f818-18af    2
45cceda0-6fb7    2
a53a8d32-2c61    2
Name: ID, dtype: int64
```

In [10]:

```
id_counts.head(15)
```

Out[10]:

```
20b16b21-8b23    2
37a1d9c2-701c    2
5f79f818-18af    2
45cceda0-6fb7    2
a53a8d32-2c61    2
87dec940-75b7    2
0913d642-c5d4    2
```

```
89d3cebd-346f    2
dbf9fb14-2656    2
b4937915-ad67    2
659da309-053c    2
129c43ca-42ee    2
ff6e1bd3-4e91    2
af1e3f79-f628    2
f9bcd13e-96bc    2
Name: ID, dtype: int64
```

In [11]:

```
id_counts.value_counts()
```

Out[11]:

```
1    29374
2      313
Name: ID, dtype: int64
```

Boolean Masks

In [12]:

```
np.random.seed(seed = 24)
random_integers = np.random.randint(low = 1, high = 5, size = 100)
```

In [13]:

```
random_integers[:5]
```

Out[13]:

```
array([3, 4, 1, 4, 2])
```

In [14]:

```
is_equal_to_3 = random_integers == 3
```

In [15]:

```
is_equal_to_3[:5]
```

Out[15]:

```
array([ True, False, False, False, False])
```

In [16]:

```
sum(is_equal_to_3)
```

Out[16]:

```
22
```

In [17]:

```
random_integers[is_equal_to_3]
```

Out[17]:

```
array([3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3])
```

Continuing Verification of Data Integrity

In [18]:

```
dupe_mask = id_counts == 2
```

In [19]:

```
dupe_mask[:5]
```

Out[19]:
```
20b16b21-8b23    True
37a1d9c2-701c    True
5f79f818-18af    True
45cceda0-6fb7    True
a53a8d32-2c61    True
Name: ID, dtype: bool
```

In [20]:
```
id_counts.index[0:5]
```

Out[20]:
```
Index(['20b16b21-8b23', '37a1d9c2-701c', '5f79f818-18af', '45cceda0-6fb7',
       'a53a8d32-2c61'],
      dtype='object')
```

In [21]:
```
dupe_ids = id_counts.index[dupe_mask]
```

In [22]:
```
dupe_ids = list(dupe_ids)
len(dupe_ids)
```

Out[22]:
```
313
```

In [23]:
```
dupe_ids[:5]
```

Out[23]:
```
['20b16b21-8b23',
 '37a1d9c2-701c',
 '5f79f818-18af',
 '45cceda0-6fb7',
 'a53a8d32-2c61']
```

In [24]:
```
df.loc[df['ID'].isin(dupe_ids[0:3]), :].head(10)
```

Out[24]:

	ID	LIMIT_BAL	SEX	EDUCATION	MARRIAGE	AGE	PAY_1	PAY_2	PAY_3	PAY_4	...
5998	5f79f818-18af	200000	1	3	2	33	0	0	0	0	...
6098	5f79f818-18af	0	0	0	0	0	0	0	0	0	...
13038	37a1d9c2-701c	190000	1	2	2	33	Not available	0	0	0	...
13138	37a1d9c2-701c	0	0	0	0	0	0	0	0	0	...
13186	20b16b21-8b23	750000	2	1	2	28	1	-1	-1	0	...
13286	20b16b21-8b23	0	0	0	0	0	0	0	0	0	...

6 rows × 25 columns

In [25]:

```
df.shape
```

Out[25]:

```
(30000, 25)
```

In [26]:

```
df_zero_mask = df == 0
```

In [27]:

```
df_zero_mask.shape
```

Out[27]:

```
(30000, 25)
```

In [28]:

```
feature_zero_mask = df_zero_mask.iloc[:, 1:].all(axis = 1)
```

In [29]:

```
sum(feature_zero_mask)
```

Out[29]:

```
315
```

In [30]:

```
df_clean_1 = df.loc[~feature_zero_mask, :].copy()
```

In [31]:

```
df_clean_1.shape
```

Out[31]:

```
(29685, 25)
```

In [32]:

```
df_clean_1['ID'].nunique()
```

Out[32]:

```
29685
```

Explore the Columns of Data

In [33]:

```
df_clean_1.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 29685 entries, 0 to 29999
Data columns (total 25 columns):
 #   Column                      Non-Null Count  Dtype 
---  ------                      --------------  ----- 
 0   ID                          29685 non-null  object
 1   LIMIT_BAL                   29685 non-null  int64 
 2   SEX                         29685 non-null  int64 
 3   EDUCATION                   29685 non-null  int64 
 4   MARRIAGE                    29685 non-null  int64 
 5   AGE                         29685 non-null  int64 
 6   PAY_1                       29685 non-null  object
 7   PAY_2                       29685 non-null  int64 
 8   PAY_3                       29685 non-null  int64 
 9   PAY_4                       29685 non-null  int64 
 10  PAY_5                       29685 non-null  int64 
 11  PAY_6                       29685 non-null  int64 
 12  BILL_AMT1                   29685 non-null  int64 
 13  BILL_AMT2                   29685 non-null  int64 
 14  BILL_AMT3                   29685 non-null  int64 
 15  BILL_AMT4                   29685 non-null  int64 
 16  BILL_AMT5                   29685 non-null  int64 
 17  BILL_AMT6                   29685 non-null  int64 
 18  PAY_AMT1                    29685 non-null  int64 
 19  PAY_AMT2                    29685 non-null  int64 
 20  PAY_AMT3                    29685 non-null  int64 
 21  PAY_AMT4                    29685 non-null  int64 
 22  PAY_AMT5                    29685 non-null  int64 
 23  PAY_AMT6                    29685 non-null  int64 
 24  default payment next month  29685 non-null  int64 
dtypes: int64(23), object(2)
memory usage: 5.9+ MB
```

In [34]:

```
df_clean_1.head()
```

Out[34]:

	ID	LIMIT_BAL	SEX	EDUCATION	MARRIAGE	AGE	PAY_1	PAY_2	PAY_3	PAY_4	...	BILL_AM
0	798fc410-45c1	20000	2	2	1	24	2	2	-1	-1	...	
1	8a8c8f3b-8eb4	120000	2	2	2	26	-1	2	0	0	...	3
2	85698822-43f5	90000	2	2	2	34	0	0	0	0	...	14
3	0737c11b-be42	50000	2	2	1	37	0	0	0	0	...	28
4	3b7f77cc-dbc0	50000	1	2	1	57	-1	0	-1	0	...	20

5 rows × 25 columns

In [35]:

```
df_clean_1['PAY_1'].head(5)
```

Out[35]:

```
0     2
1    -1
2     0
3     0
4    -1
Name: PAY_1, dtype: object
```

In [36]:

```
df_clean_1['PAY_1'].value_counts()
```

Out[36]:

```
0                13087
-1                5047
1                 3261
Not available     3021
-2                2476
2                 2378
3                  292
```

```
4                   63
5                   23
8                   17
6                   11
7                    9
Name: PAY_1, dtype: int64
```

In [37]:

```
valid_pay_1_mask = df_clean_1['PAY_1'] != 'Not available'
```

In [38]:

```
valid_pay_1_mask[0:5]
```

Out[38]:

```
0    True
1    True
2    True
3    True
4    True
Name: PAY_1, dtype: bool
```

In [39]:

```
sum(valid_pay_1_mask)
```

Out[39]:

```
26664
```

In [40]:

```
df_clean_2 = df_clean_1.loc[valid_pay_1_mask, :].copy()
```

In [41]:

```
df_clean_2['PAY_1'].value_counts()
```

Out[41]:

```
 0    13087
-1     5047
 1     3261
-2     2476
 2     2378
 3      292
 4       63
 5       23
 8       17
 6       11
 7        9
Name: PAY_1, dtype: int64
```

In [42]:

```
df_clean_2.shape
```

Out[42]:

```
(26664, 25)
```

In [43]:

```
df_clean_2.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 26664 entries, 0 to 29999
Data columns (total 25 columns):
 #   Column                      Non-Null Count  Dtype 
---  ------                      --------------  ----- 
 0   ID                          26664 non-null  object
 1   LIMIT_BAL                   26664 non-null  int64 
 2   SEX                         26664 non-null  int64 
 3   EDUCATION                   26664 non-null  int64 
 4   MARRIAGE                    26664 non-null  int64 
 5   AGE                         26664 non-null  int64 
 6   PAY_1                       26664 non-null  object
 7   PAY_2                       26664 non-null  int64 
 8   PAY_3                       26664 non-null  int64 
 9   PAY_4                       26664 non-null  int64 
 10  PAY_5                       26664 non-null  int64 
 11  PAY_6                       26664 non-null  int64 
 12  BILL_AMT1                   26664 non-null  int64 
 13  BILL_AMT2                   26664 non-null  int64 
 14  BILL_AMT3                   26664 non-null  int64 
 15  BILL_AMT4                   26664 non-null  int64 
 16  BILL_AMT5                   26664 non-null  int64 
 17  BILL_AMT6                   26664 non-null  int64 
 18  PAY_AMT1                    26664 non-null  int64 
 19  PAY_AMT2                    26664 non-null  int64 
 20  PAY_AMT3                    26664 non-null  int64 
 21  PAY_AMT4                    26664 non-null  int64 
 22  PAY_AMT5                    26664 non-null  int64 
 23  PAY_AMT6                    26664 non-null  int64 
 24  default payment next month  26664 non-null  int64 
dtypes: int64(23), object(2)
memory usage: 5.3+ MB
```

In [44]:

```
df_clean_2['PAY_1'] = df_clean_2['PAY_1'].astype('int64')
```

In [45]:

```
df_clean_2.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 26664 entries, 0 to 29999
Data columns (total 25 columns):
 #   Column                      Non-Null Count  Dtype 
---  ------                      --------------  ----- 
 0   ID                          26664 non-null  object
 1   LIMIT_BAL                   26664 non-null  int64 
 2   SEX                         26664 non-null  int64 
 3   EDUCATION                   26664 non-null  int64 
 4   MARRIAGE                    26664 non-null  int64 
 5   AGE                         26664 non-null  int64 
 6   PAY_1                       26664 non-null  int64 
 7   PAY_2                       26664 non-null  int64 
 8   PAY_3                       26664 non-null  int64 
 9   PAY_4                       26664 non-null  int64 
 10  PAY_5                       26664 non-null  int64 
 11  PAY_6                       26664 non-null  int64 
 12  BILL_AMT1                   26664 non-null  int64 
 13  BILL_AMT2                   26664 non-null  int64 
 14  BILL_AMT3                   26664 non-null  int64 
 15  BILL_AMT4                   26664 non-null  int64 
 16  BILL_AMT5                   26664 non-null  int64 
 17  BILL_AMT6                   26664 non-null  int64 
 18  PAY_AMT1                    26664 non-null  int64 
 19  PAY_AMT2                    26664 non-null  int64 
 20  PAY_AMT3                    26664 non-null  int64 
 21  PAY_AMT4                    26664 non-null  int64 
 22  PAY_AMT5                    26664 non-null  int64 
 23  PAY_AMT6                    26664 non-null  int64 
 24  default payment next month  26664 non-null  int64 
dtypes: int64(24), object(1)
memory usage: 5.3+ MB
```

In [46]:

```
import matplotlib.pyplot as plt
```

In [47]:

```
# Render Plotting Automatically
%matplotlib inline
```

In [48]:

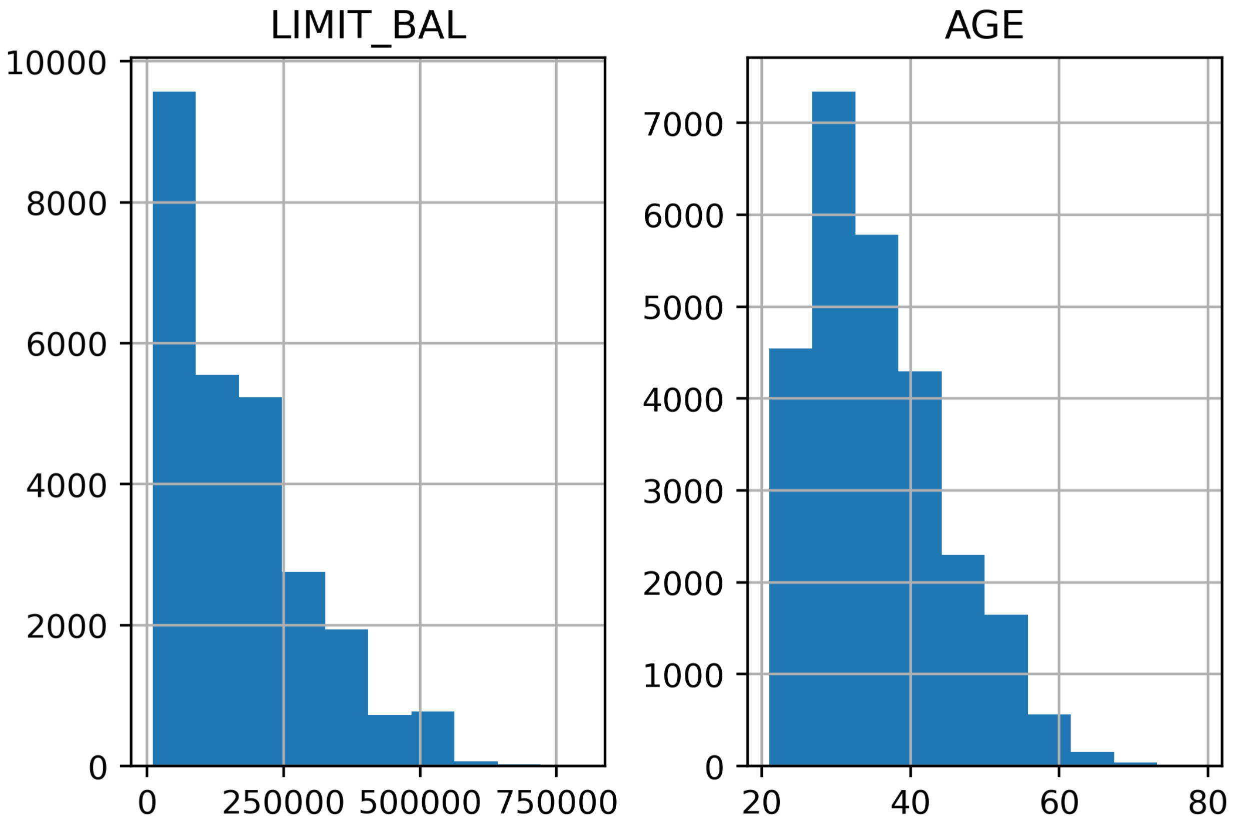
```
mpl.rcParams['figure.dpi'] = 400 # High resolution figures
```

In [49]:

```
df_clean_2[['LIMIT_BAL', 'AGE']].hist()
```

Out[49]:

```
array([[<AxesSubplot:title={'center':'LIMIT_BAL'}>,
        <AxesSubplot:title={'center':'AGE'}>]], dtype=object)
```



In [52]:

```
df_clean_2[['LIMIT_BAL', 'AGE']].describe()
```

Out[52]:

	LIMIT_BAL	AGE
count	26664.000000	26664.000000
mean	167919.054905	35.505213
std	129839.453081	9.227442
min	10000.000000	21.000000
25%	50000.000000	28.000000
50%	140000.000000	34.000000
75%	240000.000000	41.000000
max	800000.000000	79.000000

In [53]:

```
df_clean_2['EDUCATION'].value_counts()
```

Out[53]:

```
2    12458
1     9412
3     4380
5      245
4      115
6       43
0       11
Name: EDUCATION, dtype: int64
```

In [54]:

```
# Assign Unknown Categories to '4'
df_clean_2['EDUCATION'].replace(to_replace = [0, 5, 6], value = 4, inplace = True)
```

In [55]:

```
df_clean_2['EDUCATION'].value_counts()
```

Out[55]:

```
2    12458
1     9412
3     4380
4      414
Name: EDUCATION, dtype: int64
```

In [56]:

```
df_clean_2['MARRIAGE'].value_counts()
```

Out[56]:

```
2    14158
1    12172
3      286
0       48
Name: MARRIAGE, dtype: int64
```

In [57]:

```
df_clean_2['MARRIAGE'].replace(to_replace = [0], value = 3, inplace = True)
```

In [58]:

```
df_clean_2['MARRIAGE'].value_counts()
```

Out[58]:

```
2    14158
1    12172
3      334
Name: MARRIAGE, dtype: int64
```

Categorical Features

In [59]:

```
from scipy import stats
import numpy as np
```

In [60]:

```
X = np.array(range(1, 11))
```

In [61]:

```
X
```

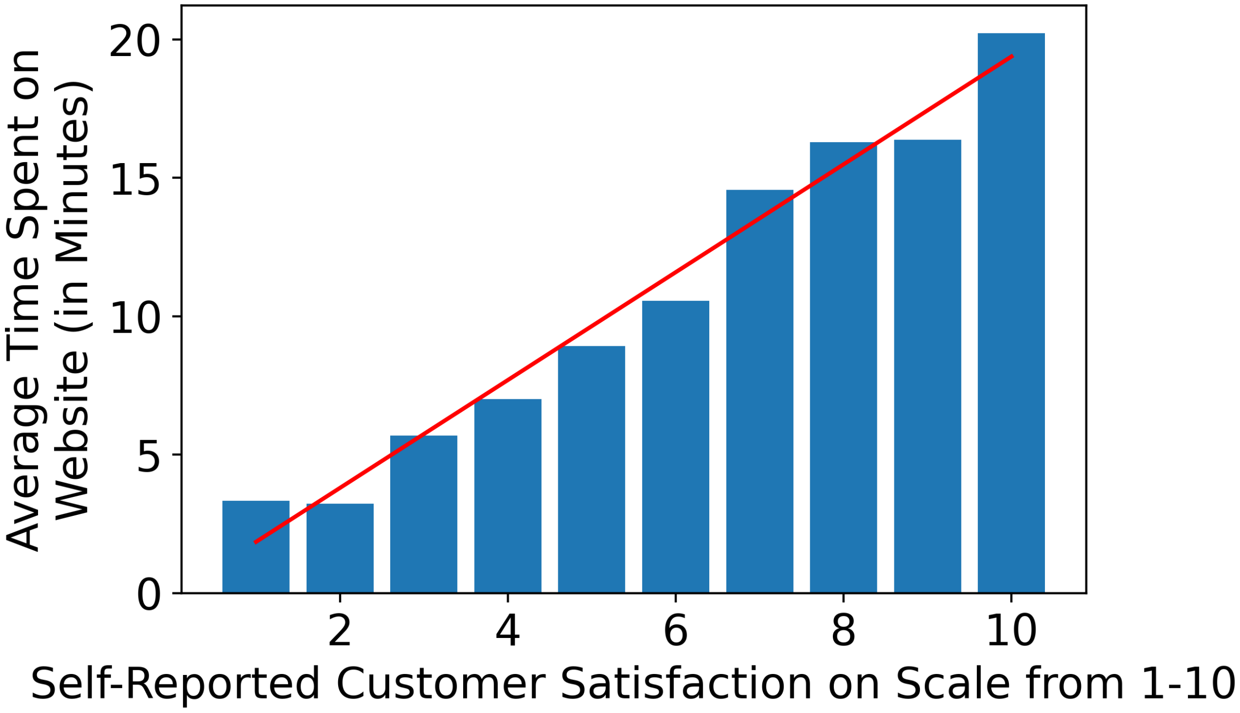
Out[61]:
```
array([ 1,  2,  3,  4,  5,  6,  7,  8,  9, 10])
```

In [62]:
```
np.random.seed(seed = 24)
Y = 2 * X + np.random.normal(0, 1, 10)
```

In [63]:
```
slope_line, intercept_line, r_value, p_value, std_err = stats.linregress(X, Y)
```

In [66]:
```
mpl.rcParams['figure.dpi'] = 400
mpl.rcParams['font.size'] = 16
plt.plot(X, intercept_line + slope_line * X, 'r-')
plt.bar(X, Y, align = 'center')
plt.xlabel('Self-Reported Customer Satisfaction on Scale from 1-10')
plt.ylabel('Average Time Spent on\nWebsite (in Minutes)')
plt.yticks(range(0, 25, 5))
```

Out[66]:
```
([<matplotlib.axis.YTick at 0x1ebe3888b80>,
  <matplotlib.axis.YTick at 0x1ebe3888760>,
  <matplotlib.axis.YTick at 0x1ebe38865e0>,
  <matplotlib.axis.YTick at 0x1ebe38c5a60>,
  <matplotlib.axis.YTick at 0x1ebe38c5fa0>],
 [Text(0, 0, ''),
  Text(0, 0, ''),
  Text(0, 0, ''),
  Text(0, 0, ''),
  Text(0, 0, '')])
```

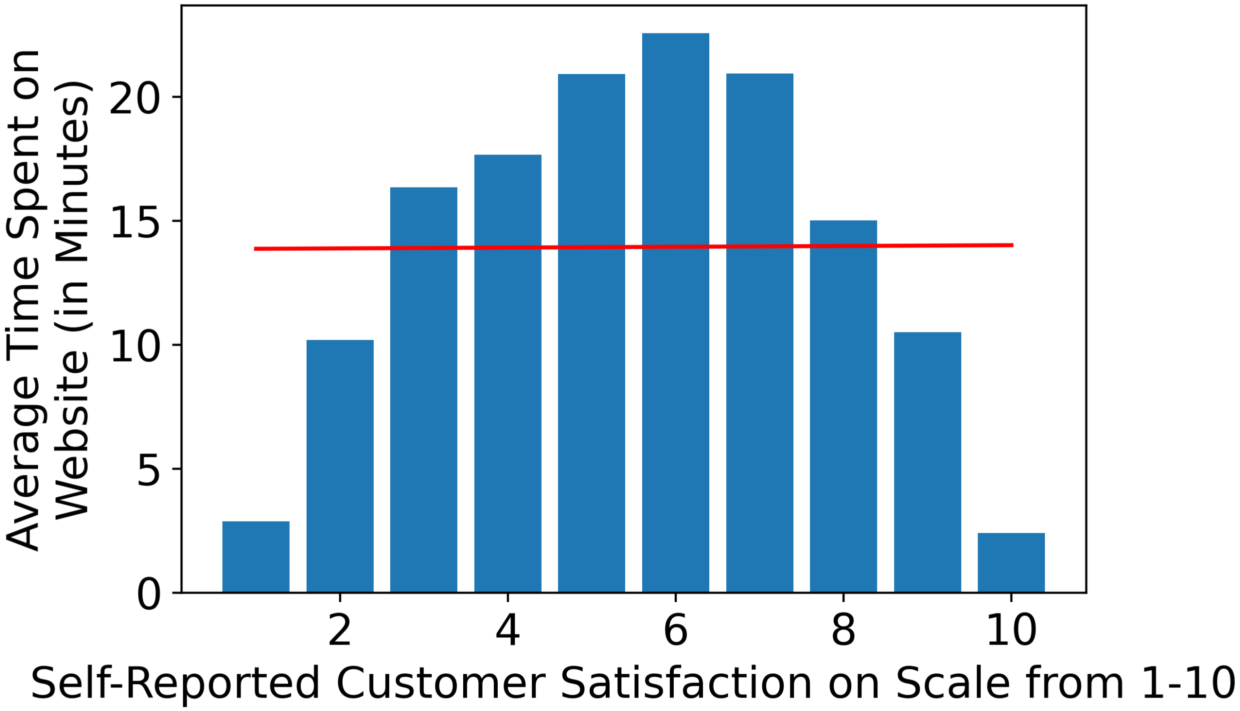


In [67]:
```
np.random.seed(seed = 20)
noise = np.random.normal(0, 1, 10)
Y_poly = -1 * (X - 2) * (X - 9) + 10 + noise
```

In [68]:
```
slope_poly, intercept_poly, r_value, p_value, std_err = stats.linregress(X, Y_poly)
```

In [69]:
```
plt.plot(X, intercept_poly + slope_poly * X, 'r-')
plt.bar(X, Y_poly, align = 'center')
plt.xlabel('Self-Reported Customer Satisfaction on Scale from 1-10')
plt.ylabel('Average Time Spent on\nWebsite (in Minutes)')
```

Out[69]:
```
Text(0, 0.5, 'Average Time Spent on\nWebsite (in Minutes)')
```



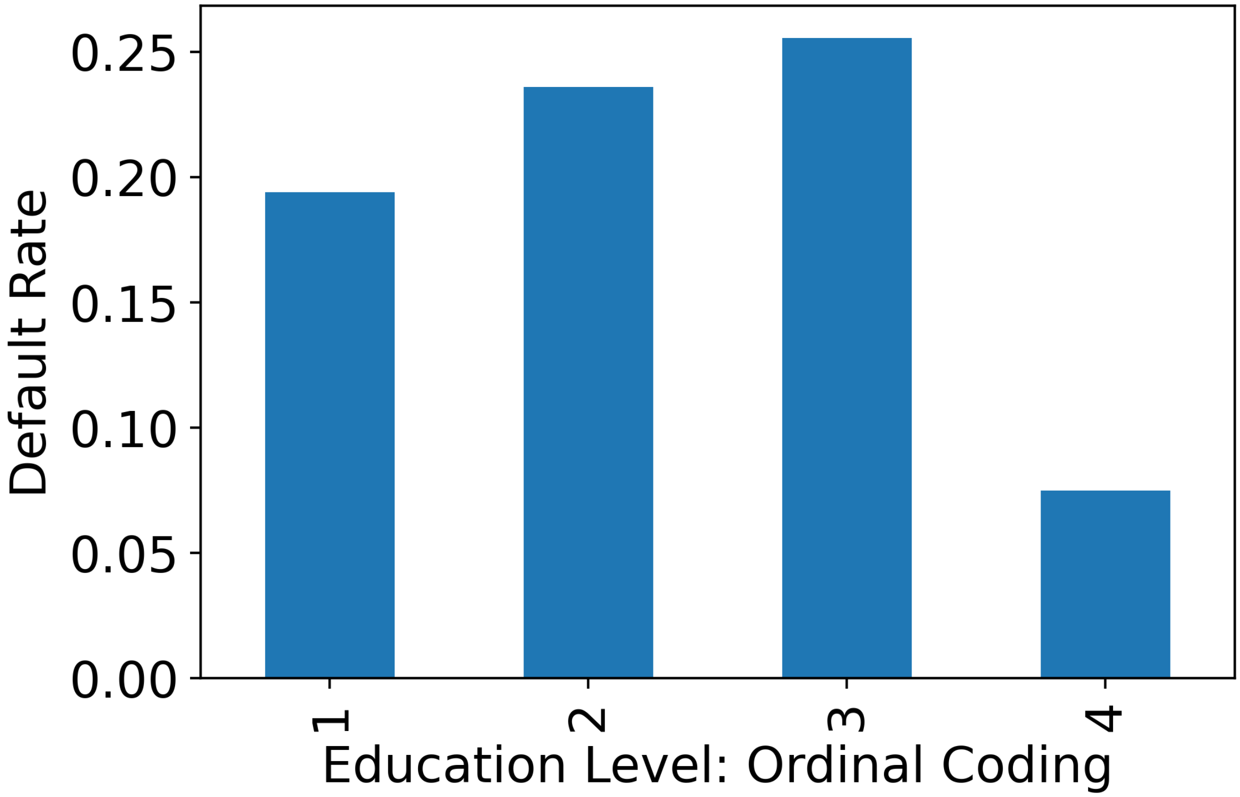
In [73]:
```
# Check Education for Ordinal Coding
df_clean_2.groupby('EDUCATION').agg({'default payment next month': 'mean'})
```

Out[73]:

	default payment next month
EDUCATION	
1	0.193901
2	0.235913
3	0.255479
4	0.074879

In [75]:
```
df_clean_2.groupby('EDUCATION').agg({'default payment next month': 'mean'}).plot.bar(le
plt.ylabel('Default Rate')
plt.xlabel('Education Level: Ordinal Coding')
```

Out[75]:
```
Text(0.5, 0, 'Education Level: Ordinal Coding')
```



Implementing One-Hot Encoding for a Categorical Feature

In [76]:

```
df_clean_2['EDUCATION'].head()
```

Out[76]:

```
0    2
1    2
2    2
3    2
4    2
Name: EDUCATION, dtype: int64
```

In [77]:

```
df_clean_2.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 26664 entries, 0 to 29999
Data columns (total 25 columns):
 #   Column                      Non-Null Count  Dtype 
---  ------                      --------------  ----- 
 0   ID                          26664 non-null  object
 1   LIMIT_BAL                   26664 non-null  int64 
 2   SEX                         26664 non-null  int64 
 3   EDUCATION                   26664 non-null  int64 
 4   MARRIAGE                    26664 non-null  int64 
 5   AGE                         26664 non-null  int64 
 6   PAY_1                       26664 non-null  int64 
 7   PAY_2                       26664 non-null  int64 
 8   PAY_3                       26664 non-null  int64 
 9   PAY_4                       26664 non-null  int64 
 10  PAY_5                       26664 non-null  int64 
 11  PAY_6                       26664 non-null  int64 
 12  BILL_AMT1                   26664 non-null  int64
 13  BILL_AMT2                   26664 non-null  int64
 14  BILL_AMT3                   26664 non-null  int64
 15  BILL_AMT4                   26664 non-null  int64
 16  BILL_AMT5                   26664 non-null  int64
 17  BILL_AMT6                   26664 non-null  int64
 18  PAY_AMT1                    26664 non-null  int64
 19  PAY_AMT2                    26664 non-null  int64
 20  PAY_AMT3                    26664 non-null  int64
 21  PAY_AMT4                    26664 non-null  int64
 22  PAY_AMT5                    26664 non-null  int64
 23  PAY_AMT6                    26664 non-null  int64
 24  default payment next month  26664 non-null  int64
dtypes: int64(24), object(1)
memory usage: 5.3+ MB
```

In [78]:

```python
df_clean_2['EDUCATION_CAT'] = 'none'
```

In [79]:

```python
df_clean_2[['EDUCATION', 'EDUCATION_CAT']].head(10)
```

Out[79]:

	EDUCATION	EDUCATION_CAT
0	2	none
1	2	none
2	2	none
3	2	none
4	2	none
5	1	none
6	1	none
7	2	none
8	3	none
9	3	none

In [86]:

```python
# Education (1 = Graduate School; 2 = University; 3 = High School; 4 = Other)
cat_mapping = {
    1: "Graduate School",
    2: "University",
    3: "High School",
    4: "Other"
}
```

In [87]:

```python
df_clean_2['EDUCATION_CAT'] = df_clean_2['EDUCATION'].map(cat_mapping)
```

In [88]:

```python
df_clean_2[['EDUCATION', 'EDUCATION_CAT']].head(10)
```

Out[88]:

	EDUCATION	EDUCATION_CAT
0	2	University
1	2	University
2	2	University
3	2	University
4	2	University
5	1	Graduate School
6	1	Graduate School
7	2	University
8	3	High School
9	3	High School

In [89]:

```
edu_ohe = pd.get_dummies(df_clean_2['EDUCATION_CAT'])
edu_ohe.head(10)
```

Out[89]:

	Graduate School	High School	Other	University
0	0	0	0	1
1	0	0	0	1
2	0	0	0	1
3	0	0	0	1
4	0	0	0	1
5	1	0	0	0
6	1	0	0	0
7	0	0	0	1
8	0	1	0	0
9	0	1	0	0

In [90]:

```
df_with_ohe = pd.concat([df_clean_2, edu_ohe], axis = 1)
df_with_ohe[['EDUCATION_CAT', 'Graduate School',
            'High School', 'University', 'Other']].head(10)
```

Out[90]:

	EDUCATION_CAT	Graduate School	High School	University	Other
0	University	0	0	1	0
1	University	0	0	1	0
2	University	0	0	1	0
3	University	0	0	1	0
4	University	0	0	1	0

	EDUCATION_CAT	Graduate School	High School	University	Other
5	Graduate School	1	0	0	0
6	Graduate School	1	0	0	0
7	University	0	0	1	0
8	High School	0	1	0	0
9	High School	0	1	0	0

In [91]:

```
df_with_ohe.shape
```

Out[91]:

```
(26664, 30)
```

In [92]:

```
df_with_ohe.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 26664 entries, 0 to 29999
Data columns (total 30 columns):
 #   Column                      Non-Null Count  Dtype 
---  ------                      --------------  ----- 
 0   ID                          26664 non-null  object
 1   LIMIT_BAL                   26664 non-null  int64 
 2   SEX                         26664 non-null  int64 
 3   EDUCATION                   26664 non-null  int64 
 4   MARRIAGE                    26664 non-null  int64 
 5   AGE                         26664 non-null  int64 
 6   PAY_1                       26664 non-null  int64 
 7   PAY_2                       26664 non-null  int64 
 8   PAY_3                       26664 non-null  int64 
 9   PAY_4                       26664 non-null  int64 
 10  PAY_5                       26664 non-null  int64 
 11  PAY_6                       26664 non-null  int64 
 12  BILL_AMT1                   26664 non-null  int64 
 13  BILL_AMT2                   26664 non-null  int64 
 14  BILL_AMT3                   26664 non-null  int64 
 15  BILL_AMT4                   26664 non-null  int64 
 16  BILL_AMT5                   26664 non-null  int64 
 17  BILL_AMT6                   26664 non-null  int64 
 18  PAY_AMT1                    26664 non-null  int64 
 19  PAY_AMT2                    26664 non-null  int64 
 20  PAY_AMT3                    26664 non-null  int64 
 21  PAY_AMT4                    26664 non-null  int64 
 22  PAY_AMT5                    26664 non-null  int64 
 23  PAY_AMT6                    26664 non-null  int64 
 24  default payment next month  26664 non-null  int64 
 25  EDUCATION_CAT               26664 non-null  object
 26  Graduate School             26664 non-null  uint8 
 27  High School                 26664 non-null  uint8 
 28  Other                       26664 non-null  uint8 
 29  University                  26664 non-null  uint8 
dtypes: int64(24), object(2), uint8(4)
memory usage: 5.6+ MB
```

In [93]:

```
df_with_ohe.to_csv('ClientCreditCard_cleaned.csv', index = False)
```

In [94]:

```
df = pd.read_csv('ClientCreditCard_cleaned.csv')
```

In [95]:

```
df.shape
```

Out[95]:

```
(26664, 30)
```

In [96]:

```
df.head()
```

Out[96]:

	ID	LIMIT_BAL	SEX	EDUCATION	MARRIAGE	AGE	PAY_1	PAY_2	PAY_3	PAY_4	...	PAY_AM
0	798fc410-45c1	20000	2	2	1	24	2	2	-1	-1	...	
1	8a8c8f3b-8eb4	120000	2	2	2	26	-1	2	0	0	...	1(
2	85698822-43f5	90000	2	2	2	34	0	0	0	0	...	1(
3	0737c11b-be42	50000	2	2	1	37	0	0	0	0	...	1:
4	3b7f77cc-dbc0	50000	1	2	1	57	-1	0	-1	0	...	10(

5 rows × 30 columns

In [97]:

```
pay_feats = ['PAY_1', 'PAY_2', 'PAY_3', 'PAY_4', 'PAY_5', 'PAY_6']
```

In [98]:

```
pay_feats
```

Out[98]:

```
['PAY_1', 'PAY_2', 'PAY_3', 'PAY_4', 'PAY_5', 'PAY_6']
```

In [99]:

```
df[pay_feats].describe()
```

Out[99]:

	PAY_1	PAY_2	PAY_3	PAY_4	PAY_5	PAY_6
count	26664.000000	26664.000000	26664.000000	26664.000000	26664.000000	26664.000000
mean	-0.017777	-0.133363	-0.167679	-0.225023	-0.269764	-0.293579
std	1.126769	1.198640	1.199165	1.167897	1.131735	1.150229
min	-2.000000	-2.000000	-2.000000	-2.000000	-2.000000	-2.000000
25%	-1.000000	-1.000000	-1.000000	-1.000000	-1.000000	-1.000000
50%	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
75%	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
max	8.000000	8.000000	8.000000	8.000000	8.000000	8.000000

In [100…

```
df[pay_feats[0]].value_counts().sort_index()
```

Out[100…

```
-2     2476
-1     5047
 0    13087
 1     3261
 2     2378
 3      292
 4       63
 5       23
 6       11
 7        9
 8       17
Name: PAY_1, dtype: int64
```

In [101…

```
df['PAY_1'].value_counts().sort_index()
```

Out[101…

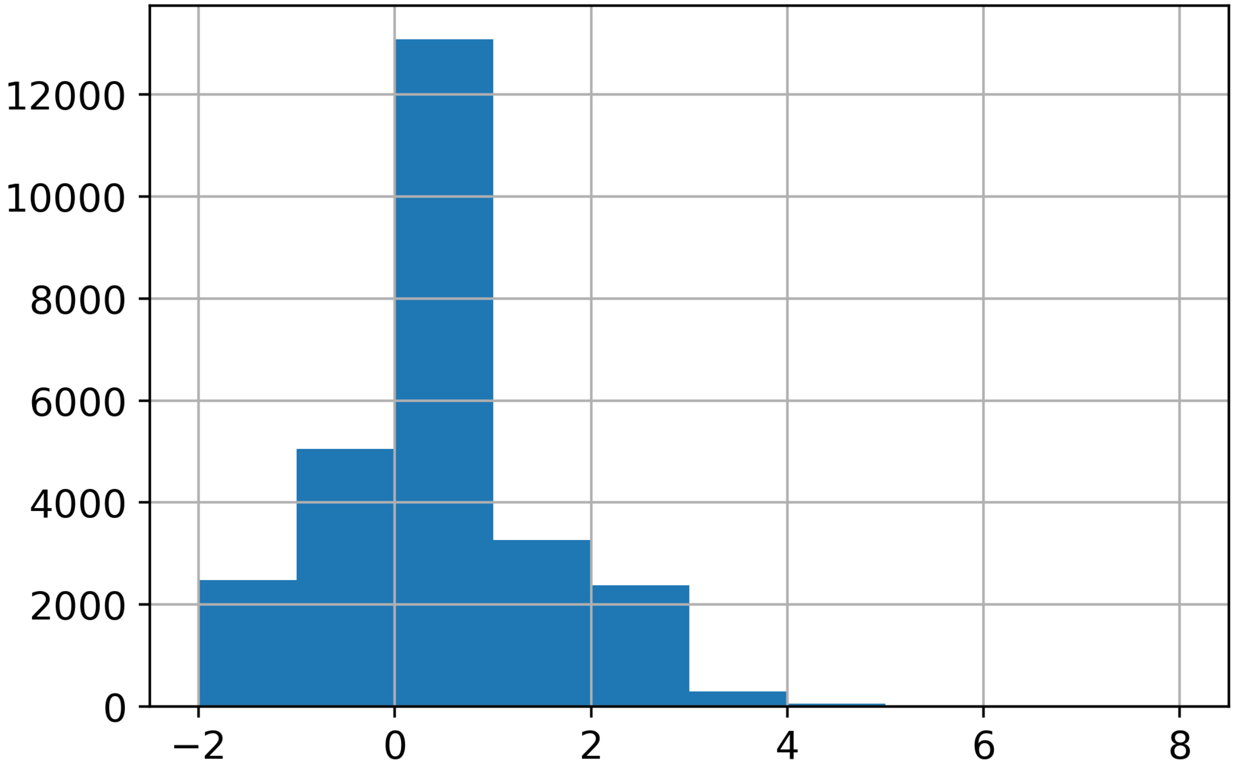
```
-2     2476
-1     5047
 0    13087
 1     3261
 2     2378
 3      292
 4       63
 5       23
 6       11
 7        9
 8       17
Name: PAY_1, dtype: int64
```

In [102…

```
mpl.rcParams['figure.dpi'] = 400
mpl.rcParams['font.size'] = 12
df[pay_feats[0]].hist()
```

Out[102…

```
<AxesSubplot:>
```



In [103…

```
pay_1_bins = np.array(range(-2, 10)) - 0.5
pay_1_bins
```

Out[103…

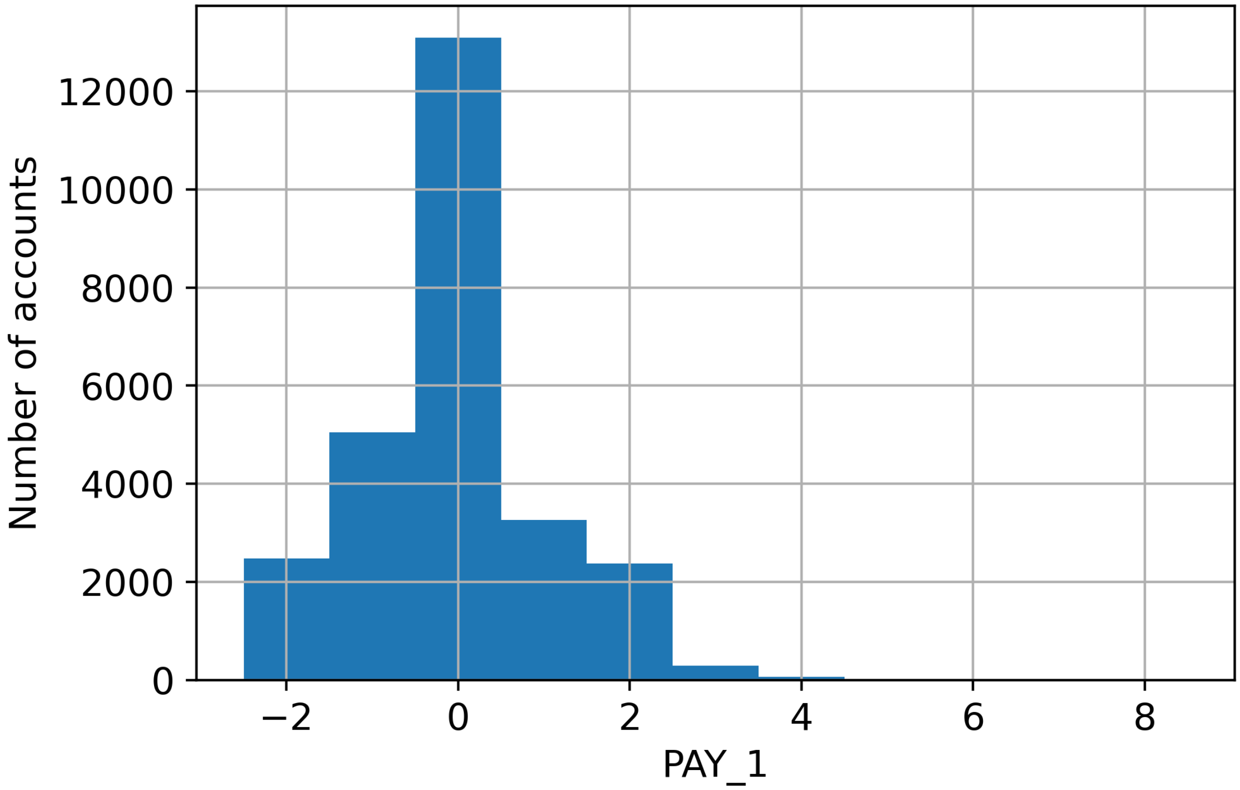
```
array([-2.5, -1.5, -0.5,  0.5,  1.5,  2.5,  3.5,  4.5,  5.5,  6.5,  7.5,
        8.5])
```

In [104…

```
df[pay_feats[0]].hist(bins = pay_1_bins)
plt.xlabel('PAY_1')
plt.ylabel('Number of accounts')
```

Out[104…

```
Text(0, 0.5, 'Number of accounts')
```



In [105…

```
for feat in pay_feats:
    print(df[feat].value_counts().sort_index())
```

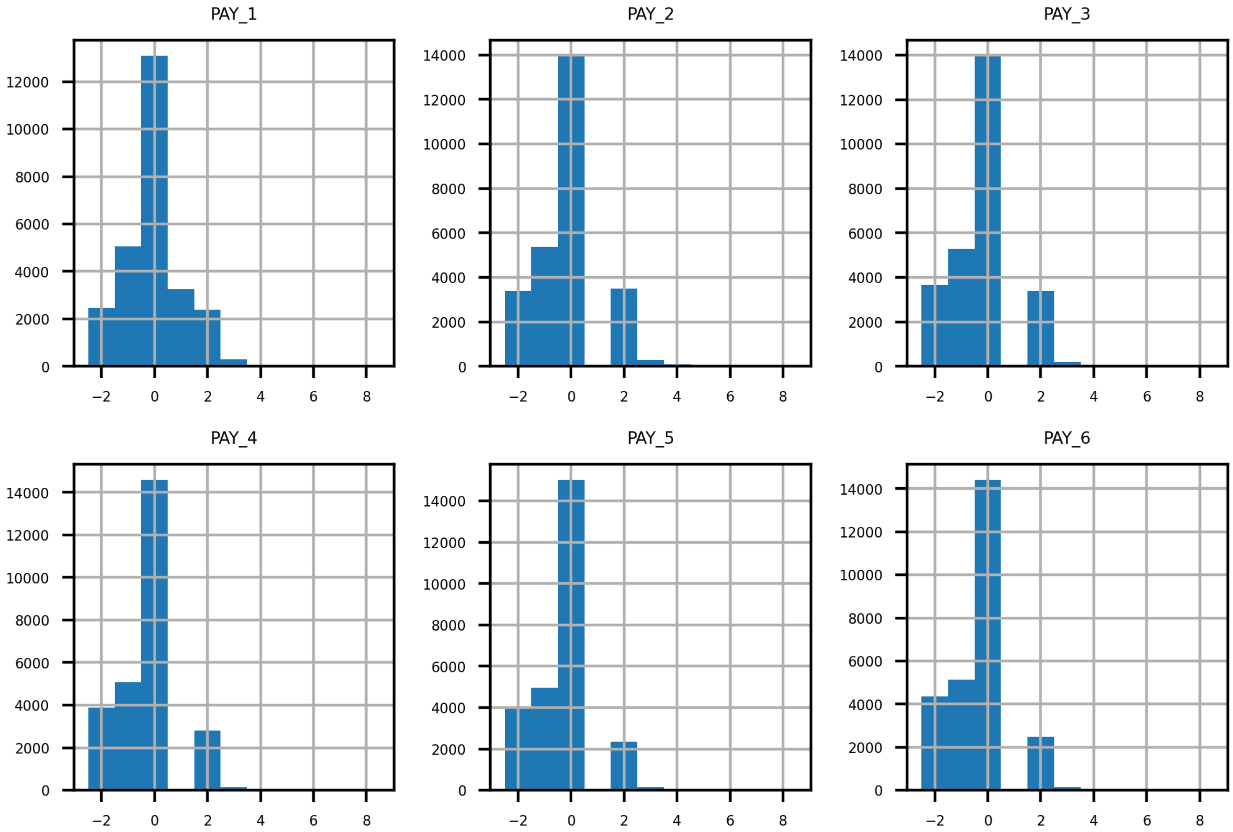
```
-2     2476
-1     5047
 0    13087
 1     3261
 2     2378
 3      292
 4       63
 5       23
 6       11
 7        9
 8       17
Name: PAY_1, dtype: int64
-2     3375
-1     5368
 0    13961
 1       24
 2     3509
 3      289
 4       85
 5       24
 6       11
 7       17
 8        1
Name: PAY_2, dtype: int64
-2     3654
-1     5290
 0    13968
 1        3
 2     3400
 3      214
 4       69
 5       20
 6       19
 7       24
 8        3
Name: PAY_3, dtype: int64
-2     3893
-1     5070
 0    14596
 1        2
 2     2798
 3      161
 4       57
 5       30
 6        4
 7       51
 8        2
Name: PAY_4, dtype: int64
-2     4056
-1     4949
 0    15032
 2     2335
 3      151
 4       71
 5       14
 6        2
 7       53
 8        1
Name: PAY_5, dtype: int64
-2     4366
-1     5138
 0    14416
 2     2476
 3      156
 4       43
 5       10
 6       15
 7       42
 8        2
Name: PAY_6, dtype: int64
```

In [104…

```
mpl.rcParams['font.size'] = 4
df[pay_feats].hist(bins = pay_1_bins, layout = (2, 3))
```

Out[104…

```
array([[<AxesSubplot:title={'center':'PAY_1'}>,
        <AxesSubplot:title={'center':'PAY_2'}>,
        <AxesSubplot:title={'center':'PAY_3'}>],
       [<AxesSubplot:title={'center':'PAY_4'}>,
        <AxesSubplot:title={'center':'PAY_5'}>,
        <AxesSubplot:title={'center':'PAY_6'}>]], dtype=object)
```


PAY_1
0
2000
4000
6000
8000
10000
12000
−2
0
2
4
6
8
PAY_2
0
2000
4000
6000
8000
10000
12000
14000
−2
0
2
4
6
8
PAY_3
0
2000
4000
6000
8000
10000
12000
14000
−2
0
2
4
6
8
PAY_4
0
2000
4000
6000
8000
10000
12000
14000
−2
0
2
4
6
8
PAY_5
0
2000
4000
6000
8000
10000
12000
14000
−2
0
2
4
6
8
PAY_6
0
2000
4000
6000
8000
10000
12000
14000
−2
0
2
4
6
8