anomaly-detection

July 4, 2024

1 IMPORTING DEPENDENCIES

[298]:
```
from sklearn.preprocessing import StandardScaler
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib
from sklearn.preprocessing import StandardScaler
```

[299]:
```
df = pd.read_csv("/content/HealthcareProviders.csv")
```

[300]:
```
df_org = df
```

2 BASIC EXPLORATION OF THE DATASET

[301]:
```
df.describe(include='all')
```

[301]:

	index	National Provider Identifier	\
count	1.000000e+05	1.000000e+05	
unique	NaN	NaN	
top	NaN	NaN	
freq	NaN	NaN	
mean	4.907646e+06	1.498227e+09	
std	2.839633e+06	2.874125e+08	
min	2.090000e+02	1.003001e+09	
25%	2.458791e+06	1.245669e+09	
50%	4.901266e+06	1.497847e+09	
75%	7.349450e+06	1.740374e+09	
max	9.847440e+06	1.993000e+09	

	Last Name/Organization Name of the Provider	First Name of the Provider	\
count	100000	95745	
unique	42820	13022	
top	PATEL	MICHAEL	
freq	557	2350	

mean	NaN	NaN
std	NaN	NaN
min	NaN	NaN
25%	NaN	NaN
50%	NaN	NaN
75%	NaN	NaN
max	NaN	NaN

	Middle Initial of the Provider	Credentials of the Provider
count	70669	92791
unique	29	1854
top	A	MD
freq	8152	32874
mean	NaN	NaN
std	NaN	NaN
min	NaN	NaN
25%	NaN	NaN
50%	NaN	NaN
75%	NaN	NaN
max	NaN	NaN

	Gender of the Provider	Entity Type of the Provider
count	95746	100000
unique	2	2
top	M	I
freq	66641	95746
mean	NaN	NaN
std	NaN	NaN
min	NaN	NaN
25%	NaN	NaN
50%	NaN	NaN
75%	NaN	NaN
max	NaN	NaN

	Street Address 1 of the Provider	Street Address 2 of the Provider	…
count	100000	40637	…
unique	51928	10024	…
top	200 1ST ST SW	SUITE 200	…
freq	244	1624	…
mean	NaN	NaN	…
std	NaN	NaN	…
min	NaN	NaN	…
25%	NaN	NaN	…
50%	NaN	NaN	…
75%	NaN	NaN	…
max	NaN	NaN	…

	HCPCS Code	HCPCS Description
count	100000	100000
unique	2631	2455
top	99213	Established patient office or other outpatient…
freq	4578	4578
mean	NaN	NaN
std	NaN	NaN
min	NaN	NaN
25%	NaN	NaN
50%	NaN	NaN
75%	NaN	NaN
max	NaN	NaN

	HCPCS Drug Indicator	Number of Services
count	100000	100000
unique	2	2748
top	N	13
freq	93802	3018
mean	NaN	NaN
std	NaN	NaN
min	NaN	NaN
25%	NaN	NaN
50%	NaN	NaN
75%	NaN	NaN
max	NaN	NaN

	Number of Medicare Beneficiaries
count	100000
unique	1274
top	11
freq	4791
mean	NaN
std	NaN
min	NaN
25%	NaN
50%	NaN
75%	NaN
max	NaN

	Number of Distinct Medicare Beneficiary/Per Day Services
count	100000
unique	1979
top	12
freq	3210
mean	NaN
std	NaN
min	NaN

```
25%                                                    NaN
50%                                                    NaN
75%                                                    NaN
max                                                    NaN

       Average Medicare Allowed Amount Average Submitted Charge Amount  \
count                           100000                           100000
unique                           49629                            38088
top                                  3                              150
freq                              1017                              970
mean                               NaN                              NaN
std                                NaN                              NaN
min                                NaN                              NaN
25%                                NaN                              NaN
50%                                NaN                              NaN
75%                                NaN                              NaN
max                                NaN                              NaN

       Average Medicare Payment Amount Average Medicare Standardized Amount
count                           100000                              100000
unique                           83367                               76237
top                               2.94                               25.32
freq                               623                                1630
mean                               NaN                                 NaN
std                                NaN                                 NaN
min                                NaN                                 NaN
25%                                NaN                                 NaN
50%                                NaN                                 NaN
75%                                NaN                                 NaN
max                                NaN                                 NaN

[11 rows x 27 columns]
```

** ADDING A NEW COLUMN "MONEY DIFFERENCE" IN THE DATASET WHICH CALCULATES THE DIFFERENCE BETWEEN "AVERAGE SUBMITTED CHARGE AMOUNT" COLUMN AND THE "AVERAGE MEDICARE PAYMENT AMOUNT" COLUMN**

[302]:
```
df["Average Submitted Charge Amount"] = df["Average Submitted Charge Amount"].
↪replace(',', '', regex=True)
```

[303]:
```
df["Average Medicare Payment Amount"] = df["Average Medicare Payment Amount"].
↪replace(',', '', regex=True)
```

[304]:
```
df["Money difference"] = df["Average Submitted Charge Amount"].astype(float) -␣
↪df["Average Medicare Payment Amount"].astype(float)
```

3 Basic exploration of the dataset with the new column

[305]:
```
df.nunique()
```

[305]:
```
index                                                  100000
National Provider Identifier                            89508
Last Name/Organization Name of the Provider             42820
First Name of the Provider                              13022
Middle Initial of the Provider                             29
Credentials of the Provider                              1854
Gender of the Provider                                      2
Entity Type of the Provider                                 2
Street Address 1 of the Provider                        51928
Street Address 2 of the Provider                        10024
City of the Provider                                     5846
Zip Code of the Provider                                47827
State Code of the Provider                                 58
Country Code of the Provider                                4
Provider Type                                              90
Medicare Participation Indicator                            2
Place of Service                                            2
HCPCS Code                                               2631
HCPCS Description                                        2455
HCPCS Drug Indicator                                        2
Number of Services                                       2748
Number of Medicare Beneficiaries                         1274
Number of Distinct Medicare Beneficiary/Per Day Services 1979
Average Medicare Allowed Amount                         49629
Average Submitted Charge Amount                         38088
Average Medicare Payment Amount                         83367
Average Medicare Standardized Amount                    76237
Money difference                                        92772
dtype: int64
```

[306]:
```
(df.isnull().sum()/(len(df)))*100
```

[306]:
```
index                                                   0.000
National Provider Identifier                            0.000
Last Name/Organization Name of the Provider             0.000
First Name of the Provider                              4.255
Middle Initial of the Provider                         29.331
Credentials of the Provider                             7.209
Gender of the Provider                                  4.254
Entity Type of the Provider                             0.000
Street Address 1 of the Provider                        0.000
Street Address 2 of the Provider                       59.363
City of the Provider                                    0.000
```

```
Zip Code of the Provider                                    0.000
State Code of the Provider                                  0.000
Country Code of the Provider                                0.000
Provider Type                                               0.000
Medicare Participation Indicator                            0.000
Place of Service                                            0.000
HCPCS Code                                                  0.000
HCPCS Description                                           0.000
HCPCS Drug Indicator                                        0.000
Number of Services                                          0.000
Number of Medicare Beneficiaries                            0.000
Number of Distinct Medicare Beneficiary/Per Day Services    0.000
Average Medicare Allowed Amount                             0.000
Average Submitted Charge Amount                             0.000
Average Medicare Payment Amount                             0.000
Average Medicare Standardized Amount                        0.000
Money difference                                            0.000
dtype: float64
```

[307]:
```
df.describe(include='all').T
```

[307]:

	count	unique	\
index	100000.0	NaN	
National Provider Identifier	100000.0	NaN	
Last Name/Organization Name of the Provider	100000	42820	
First Name of the Provider	95745	13022	
Middle Initial of the Provider	70669	29	
Credentials of the Provider	92791	1854	
Gender of the Provider	95746	2	
Entity Type of the Provider	100000	2	
Street Address 1 of the Provider	100000	51928	
Street Address 2 of the Provider	40637	10024	
City of the Provider	100000	5846	
Zip Code of the Provider	100000.0	NaN	
State Code of the Provider	100000	58	
Country Code of the Provider	100000	4	
Provider Type	100000	90	
Medicare Participation Indicator	100000	2	
Place of Service	100000	2	
HCPCS Code	100000	2631	
HCPCS Description	100000	2455	
HCPCS Drug Indicator	100000	2	
Number of Services	100000	2748	
Number of Medicare Beneficiaries	100000	1274	
Number of Distinct Medicare Beneficiary/Per Day…	100000	1979	
Average Medicare Allowed Amount	100000	49629	
Average Submitted Charge Amount	100000	38088	

```
Average Medicare Payment Amount                        100000  83367
Average Medicare Standardized Amount                   100000  76237
Money difference                                     100000.0    NaN

                   top  \
index
NaN
National Provider Identifier
NaN
Last Name/Organization Name of the Provider
PATEL
First Name of the Provider
MICHAEL
Middle Initial of the Provider
A
Credentials of the Provider
MD
Gender of the Provider
M
Entity Type of the Provider
I
Street Address 1 of the Provider
200 1ST ST SW
Street Address 2 of the Provider
SUITE 200
City of the Provider
NEW YORK
Zip Code of the Provider
NaN
State Code of the Provider
CA
Country Code of the Provider
US
Provider Type
Diagnostic Radiology
Medicare Participation Indicator
Y
Place of Service
O
HCPCS Code
99213
HCPCS Description                                    Established patient office
or other outpatient…
HCPCS Drug Indicator
N
Number of Services
13
```

```
Number of Medicare Beneficiaries
11
Number of Distinct Medicare Beneficiary/Per Day…
12
Average Medicare Allowed Amount
3
Average Submitted Charge Amount
150
Average Medicare Payment Amount
2.94
Average Medicare Standardized Amount
25.32
Money difference
NaN
```

	freq	mean	std
index	NaN	4907645.74603	2839632.695465
National Provider Identifier	NaN	1498226858.04662	
Last Name/Organization Name of the Provider	557	NaN	
First Name of the Provider	2350	NaN	
Middle Initial of the Provider	8152	NaN	
Credentials of the Provider	32874	NaN	
Gender of the Provider	66641	NaN	
Entity Type of the Provider	95746	NaN	
Street Address 1 of the Provider	244	NaN	
Street Address 2 of the Provider	1624	NaN	
City of the Provider	1061	NaN	
Zip Code of the Provider	NaN	416381950.78367	
State Code of the Provider	7775	NaN	
Country Code of the Provider	99994	NaN	
Provider Type	12537	NaN	
Medicare Participation Indicator	99969	NaN	
Place of Service	61616	NaN	
HCPCS Code	4578	NaN	
HCPCS Description	4578	NaN	
HCPCS Drug Indicator	93802	NaN	
Number of Services	3018	NaN	
Number of Medicare Beneficiaries	4791	NaN	
Number of Distinct Medicare Beneficiary/Per Day…	3210	NaN	
Average Medicare Allowed Amount	1017	NaN	
Average Submitted Charge Amount	970	NaN	
Average Medicare Payment Amount	623	NaN	
Average Medicare Standardized Amount	1630	NaN	
Money difference	NaN	277.191655	

```
National Provider Identifier                          287412506.095332
Last Name/Organization Name of the Provider                        NaN
First Name of the Provider                                         NaN
Middle Initial of the Provider                                     NaN
Credentials of the Provider                                        NaN
Gender of the Provider                                             NaN
Entity Type of the Provider                                        NaN
Street Address 1 of the Provider                                   NaN
Street Address 2 of the Provider                                   NaN
City of the Provider                                               NaN
Zip Code of the Provider                              308256603.986241
State Code of the Provider                                         NaN
Country Code of the Provider                                       NaN
Provider Type                                                      NaN
Medicare Participation Indicator                                   NaN
Place of Service                                                   NaN
HCPCS Code                                                         NaN
HCPCS Description                                                  NaN
HCPCS Drug Indicator                                               NaN
Number of Services                                                 NaN
Number of Medicare Beneficiaries                                   NaN
Number of Distinct Medicare Beneficiary/Per Day…                   NaN
Average Medicare Allowed Amount                                    NaN
Average Submitted Charge Amount                                    NaN
Average Medicare Payment Amount                                    NaN
Average Medicare Standardized Amount                               NaN
Money difference                                           924.898491

                                                                  min  \
index                                                           209.0
National Provider Identifier                                1003001298.0
Last Name/Organization Name of the Provider                          NaN
First Name of the Provider                                           NaN
Middle Initial of the Provider                                       NaN
Credentials of the Provider                                          NaN
Gender of the Provider                                               NaN
Entity Type of the Provider                                          NaN
Street Address 1 of the Provider                                     NaN
Street Address 2 of the Provider                                     NaN
City of the Provider                                                 NaN
Zip Code of the Provider                                           601.0
State Code of the Provider                                           NaN
Country Code of the Provider                                         NaN
Provider Type                                                        NaN
Medicare Participation Indicator                                     NaN
Place of Service                                                     NaN
HCPCS Code                                                           NaN
```

```
HCPCS Description                                        NaN
HCPCS Drug Indicator                                     NaN
Number of Services                                       NaN
Number of Medicare Beneficiaries                         NaN
Number of Distinct Medicare Beneficiary/Per Day…         NaN
Average Medicare Allowed Amount                          NaN
Average Submitted Charge Amount                          NaN
Average Medicare Payment Amount                          NaN
Average Medicare Standardized Amount                     NaN
Money difference                                  -16.984065

                                                         25%  \
index                                            2458790.75
National Provider Identifier                    1245669407.25
Last Name/Organization Name of the Provider              NaN
First Name of the Provider                               NaN
Middle Initial of the Provider                           NaN
Credentials of the Provider                              NaN
Gender of the Provider                                   NaN
Entity Type of the Provider                              NaN
Street Address 1 of the Provider                         NaN
Street Address 2 of the Provider                         NaN
City of the Provider                                     NaN
Zip Code of the Provider                         142630001.0
State Code of the Provider                               NaN
Country Code of the Provider                             NaN
Provider Type                                            NaN
Medicare Participation Indicator                         NaN
Place of Service                                         NaN
HCPCS Code                                               NaN
HCPCS Description                                        NaN
HCPCS Drug Indicator                                     NaN
Number of Services                                       NaN
Number of Medicare Beneficiaries                         NaN
Number of Distinct Medicare Beneficiary/Per Day…         NaN
Average Medicare Allowed Amount                          NaN
Average Submitted Charge Amount                          NaN
Average Medicare Payment Amount                          NaN
Average Medicare Standardized Amount                     NaN
Money difference                                   33.911165

                                                         50%  \
index                                            4901266.0
National Provider Identifier                    1497846612.0
Last Name/Organization Name of the Provider              NaN
First Name of the Provider                               NaN
Middle Initial of the Provider                           NaN
```

Credentials of the Provider	NaN
Gender of the Provider	NaN
Entity Type of the Provider	NaN
Street Address 1 of the Provider	NaN
Street Address 2 of the Provider	NaN
City of the Provider	NaN
Zip Code of the Provider	363302500.0
State Code of the Provider	NaN
Country Code of the Provider	NaN
Provider Type	NaN
Medicare Participation Indicator	NaN
Place of Service	NaN
HCPCS Code	NaN
HCPCS Description	NaN
HCPCS Drug Indicator	NaN
Number of Services	NaN
Number of Medicare Beneficiaries	NaN
Number of Distinct Medicare Beneficiary/Per Day…	NaN
Average Medicare Allowed Amount	NaN
Average Submitted Charge Amount	NaN
Average Medicare Payment Amount	NaN
Average Medicare Standardized Amount	NaN
Money difference	89.912401

	75% \
index	7349450.5
National Provider Identifier	1740373949.25
Last Name/Organization Name of the Provider	NaN
First Name of the Provider	NaN
Middle Initial of the Provider	NaN
Credentials of the Provider	NaN
Gender of the Provider	NaN
Entity Type of the Provider	NaN
Street Address 1 of the Provider	NaN
Street Address 2 of the Provider	NaN
City of the Provider	NaN
Zip Code of the Provider	681988102.0
State Code of the Provider	NaN
Country Code of the Provider	NaN
Provider Type	NaN
Medicare Participation Indicator	NaN
Place of Service	NaN
HCPCS Code	NaN
HCPCS Description	NaN
HCPCS Drug Indicator	NaN
Number of Services	NaN
Number of Medicare Beneficiaries	NaN

```
Number of Distinct Medicare Beneficiary/Per Day…            NaN
Average Medicare Allowed Amount                             NaN
Average Submitted Charge Amount                             NaN
Average Medicare Payment Amount                             NaN
Average Medicare Standardized Amount                        NaN
Money difference                                     211.301618

                                                            max
index                                                9847440.0
National Provider Identifier                      1992999874.0
Last Name/Organization Name of the Provider                 NaN
First Name of the Provider                                  NaN
Middle Initial of the Provider                              NaN
Credentials of the Provider                                 NaN
Gender of the Provider                                      NaN
Entity Type of the Provider                                 NaN
Street Address 1 of the Provider                            NaN
Street Address 2 of the Provider                            NaN
City of the Provider                                        NaN
Zip Code of the Provider                          999016573.0
State Code of the Provider                                  NaN
Country Code of the Provider                                NaN
Provider Type                                               NaN
Medicare Participation Indicator                            NaN
Place of Service                                            NaN
HCPCS Code                                                  NaN
HCPCS Description                                           NaN
HCPCS Drug Indicator                                        NaN
Number of Services                                          NaN
Number of Medicare Beneficiaries                            NaN
Number of Distinct Medicare Beneficiary/Per Day…            NaN
Average Medicare Allowed Amount                             NaN
Average Submitted Charge Amount                             NaN
Average Medicare Payment Amount                             NaN
Average Medicare Standardized Amount                        NaN
Money difference                                  57038.775556
```

Dropping different irrelevant fields throughout the process

[308]:
```
df = df.drop(columns=['index', 'National Provider Identifier','Street Address 1␣
↪of the Provider','Street Address 2 of the Provider','Country Code of the␣
↪Provider'])
```

[309]:
```
df['Last Name/Organization Name of the Provider'] = df['First Name of the␣
↪Provider'].astype(str) + " " + df['Last Name/Organization Name of the␣
↪Provider']
```

[310]:
```
df.head()
```

[310]:

	Last Name/Organization Name of the Provider	First Name of the Provider	Middle Initial of the Provider	Credentials of the Provider	Gender of the Provider	Entity Type of the Provider	City of the Provider	Zip Code of the Provider	State Code of the Provider	Provider Type	…
0	SATYASREE UPADHYAYULA	SATYASREE	NaN	M.D.	F	I	SAINT LOUIS	631041004.0	MO	Internal Medicine	…
1	WENDY JONES	WENDY	P	M.D.	F	I	FAYETTEVILLE	283043815.0	NC	Obstetrics & Gynecology	…
2	RICHARD DUROCHER	RICHARD	W	DPM	M	I	NORTH HAVEN	64732343.0	CT	Podiatry	…
3	JASPER FULLARD	JASPER	NaN	MD	M	I	KANSAS CITY	641183998.0	MO	Internal Medicine	…
4	ANTHONY PERROTTI	ANTHONY	E	DO	M	I	JUPITER	334585700.0	FL	Internal Medicine	…

	HCPCS Description	HCPCS Drug Indicator	Number of Services	Number of Medicare Beneficiaries
0	Initial hospital inpatient care, typically 70 …	N	27	24
1	Screening mammography, bilateral (2-view study…	N	175	175
2	Established patient home visit, typically 25 m…	N		
3	Urinalysis, manual test	N		
4	Injection beneath the skin or into muscle for …	N		

```
2                 32                                  13
3                 20                                  18
4                 33                                  24

  Number of Distinct Medicare Beneficiary/Per Day Services  \
0                                                  27
1                                                 175
2                                                  32
3                                                  20
4                                                  31

  Average Medicare Allowed Amount Average Submitted Charge Amount  \
0                     200.58777778                     305.21111111
1                           123.73                            548.8
2                            90.65                              155
3                              3.5                                5
4                            26.52                               40

  Average Medicare Payment Amount Average Medicare Standardized Amount  \
0                     157.26222222                          160.90888889
1                           118.83                          135.31525714
2                        64.4396875                           60.5959375
3                             3.43                                3.43
4                     19.539393939                          19.057575758

  Money difference
0       147.948889
1       429.970000
2        90.560312
3         1.570000
4        20.460606

[5 rows x 23 columns]
```

[311]:
```
df=df.drop(columns=['First Name of the Provider'])
```

[312]:
```
df.head()
```

[312]:
```
  Last Name/Organization Name of the Provider Middle Initial of the Provider  \
0                      SATYASREE UPADHYAYULA                                NaN
1                                WENDY JONES                                  P
2                           RICHARD DUROCHER                                  W
3                             JASPER FULLARD                                NaN
4                           ANTHONY PERROTTI                                  E

  Credentials of the Provider Gender of the Provider  \
0                      M.D.                      F
```

```
1                        M.D.                        F
2                         DPM                        M
3                          MD                        M
4                          DO                        M

  Entity Type of the Provider City of the Provider  Zip Code of the Provider  \
0                           I          SAINT LOUIS               631041004.0
1                           I         FAYETTEVILLE               283043815.0
2                           I          NORTH HAVEN                64732343.0
3                           I          KANSAS CITY               641183998.0
4                           I              JUPITER               334585700.0

  State Code of the Provider            Provider Type  \
0                         MO        Internal Medicine
1                         NC  Obstetrics & Gynecology
2                         CT                 Podiatry
3                         MO        Internal Medicine
4                         FL        Internal Medicine

  Medicare Participation Indicator  …  \
0                                Y  …
1                                Y  …
2                                Y  …
3                                Y  …
4                                Y  …

                                HCPCS Description HCPCS Drug Indicator  \
0  Initial hospital inpatient care, typically 70 …                    N
1  Screening mammography, bilateral (2-view study…                    N
2  Established patient home visit, typically 25 m…                    N
3                            Urinalysis, manual test                      N
4  Injection beneath the skin or into muscle for …                    N

  Number of Services Number of Medicare Beneficiaries  \
0                 27                                24
1                175                               175
2                 32                                13
3                 20                                18
4                 33                                24

  Number of Distinct Medicare Beneficiary/Per Day Services  \
0                                                 27
1                                                175
2                                                 32
3                                                 20
4                                                 31
```

```
  Average Medicare Allowed Amount Average Submitted Charge Amount  \
0                     200.58777778                     305.21111111
1                           123.73                            548.8
2                            90.65                              155
3                              3.5                                5
4                            26.52                               40

  Average Medicare Payment Amount Average Medicare Standardized Amount  \
0                     157.26222222                          160.90888889
1                           118.83                          135.31525714
2                        64.4396875                           60.5959375
3                             3.43                                 3.43
4                     19.539393939                          19.057575758

  Money difference
0       147.948889
1       429.970000
2        90.560312
3         1.570000
4        20.460606

[5 rows x 22 columns]
```

[313]:
```
df.rename(columns = {'Last Name/Organization Name of the Provider':'Full␣
↪name'}, inplace = True)
```

[314]:
```
df.head()
```

[314]:
```
              Full name Middle Initial of the Provider  \
0  SATYASREE UPADHYAYULA                           NaN
1            WENDY JONES                             P
2       RICHARD DUROCHER                             W
3         JASPER FULLARD                           NaN
4       ANTHONY PERROTTI                             E

  Credentials of the Provider Gender of the Provider  \
0                        M.D.                      F
1                        M.D.                      F
2                         DPM                      M
3                          MD                      M
4                          DO                      M

  Entity Type of the Provider City of the Provider  Zip Code of the Provider  \
0                           I          SAINT LOUIS                631041004.0
1                           I         FAYETTEVILLE                283043815.0
2                           I          NORTH HAVEN                 64732343.0
3                           I          KANSAS CITY                641183998.0
```

```
4                          I              JUPITER               334585700.0

  State Code of the Provider            Provider Type  \
0                         MO         Internal Medicine
1                         NC   Obstetrics & Gynecology
2                         CT                  Podiatry
3                         MO         Internal Medicine
4                         FL         Internal Medicine

  Medicare Participation Indicator  …  \
0                                Y  …
1                                Y  …
2                                Y  …
3                                Y  …
4                                Y  …

                                  HCPCS Description HCPCS Drug Indicator  \
0  Initial hospital inpatient care, typically 70 …                     N
1  Screening mammography, bilateral (2-view study…                     N
2  Established patient home visit, typically 25 m…                     N
3                            Urinalysis, manual test                       N
4  Injection beneath the skin or into muscle for …                     N

  Number of Services Number of Medicare Beneficiaries  \
0                 27                                24
1                175                               175
2                 32                                13
3                 20                                18
4                 33                                24

  Number of Distinct Medicare Beneficiary/Per Day Services  \
0                                                 27
1                                                175
2                                                 32
3                                                 20
4                                                 31

  Average Medicare Allowed Amount Average Submitted Charge Amount  \
0                    200.58777778                     305.21111111
1                          123.73                            548.8
2                           90.65                              155
3                             3.5                                5
4                           26.52                               40

  Average Medicare Payment Amount Average Medicare Standardized Amount  \
0                    157.26222222                          160.90888889
1                          118.83                          135.31525714
```

```
2                      64.4396875                              60.5959375
3                            3.43                                    3.43
4                     19.539393939                            19.057575758

  Money difference
0       147.948889
1       429.970000
2        90.560312
3         1.570000
4        20.460606

[5 rows x 22 columns]
```

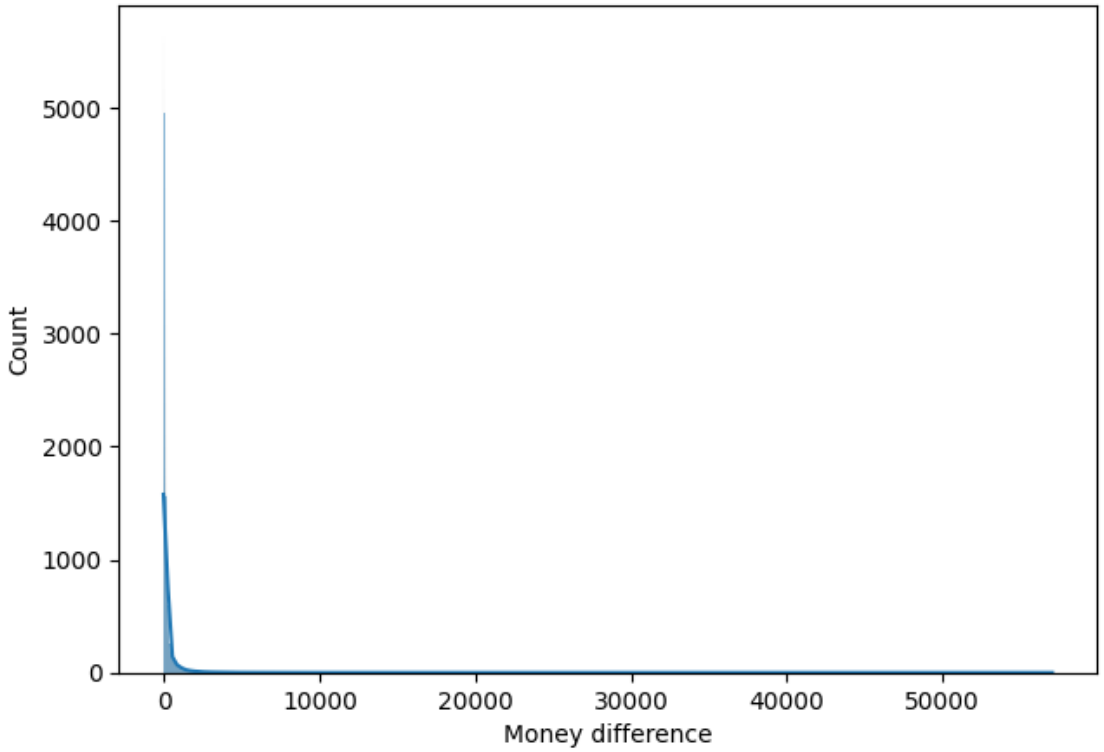
[315]:
```
df=df.drop(columns=['HCPCS Description'])
```

[316]:
```
df.head()
```

[316]:
```
               Full name Middle Initial of the Provider  \
0  SATYASREE UPADHYAYULA                             NaN
1            WENDY JONES                               P
2       RICHARD DUROCHER                               W
3         JASPER FULLARD                             NaN
4       ANTHONY PERROTTI                               E

  Credentials of the Provider Gender of the Provider  \
0                       M.D.                       F
1                       M.D.                       F
2                        DPM                       M
3                         MD                       M
4                         DO                       M

  Entity Type of the Provider City of the Provider  Zip Code of the Provider  \
0                           I          SAINT LOUIS                631041004.0
1                           I         FAYETTEVILLE                283043815.0
2                           I          NORTH HAVEN                 64732343.0
3                           I          KANSAS CITY                641183998.0
4                           I              JUPITER                334585700.0

  State Code of the Provider            Provider Type  \
0                         MO        Internal Medicine
1                         NC  Obstetrics & Gynecology
2                         CT                 Podiatry
3                         MO        Internal Medicine
4                         FL        Internal Medicine

  Medicare Participation Indicator  … HCPCS Code HCPCS Drug Indicator  \
0                                Y  …      99223                    N
```

```
1                                Y  …      G0202                    N
2                                Y  …      99348                    N
3                                Y  …      81002                    N
4                                Y  …      96372                    N

  Number of Services Number of Medicare Beneficiaries  \
0                 27                                24
1                175                               175
2                 32                                13
3                 20                                18
4                 33                                24

  Number of Distinct Medicare Beneficiary/Per Day Services  \
0                                                 27
1                                                175
2                                                 32
3                                                 20
4                                                 31

  Average Medicare Allowed Amount Average Submitted Charge Amount  \
0                    200.58777778                     305.21111111
1                          123.73                            548.8
2                           90.65                              155
3                             3.5                                5
4                           26.52                               40

  Average Medicare Payment Amount Average Medicare Standardized Amount  \
0                    157.26222222                          160.90888889
1                          118.83                          135.31525714
2                       64.4396875                           60.5959375
3                            3.43                                 3.43
4                    19.539393939                          19.057575758

  Money difference
0       147.948889
1       429.970000
2        90.560312
3         1.570000
4        20.460606

[5 rows x 21 columns]
```

[317]:
```
plt.figure(figsize=(16,5))
plt.subplot(1,2,1)
sns.histplot(df['Money difference'], kde=True)

plt.show()
```



3.0.1 Scaling the numerical fields using the formula of standard scaler

[318]:
```
scaler = StandardScaler()
```

[319]:
```
df['Money difference'] = scaler.fit_transform(df[['Money difference']])

display(df)
```

```
                   Full name Middle Initial of the Provider  \
0       SATYASREE UPADHYAYULA                              NaN
1                 WENDY JONES                                P
2            RICHARD DUROCHER                                W
3              JASPER FULLARD                              NaN
4            ANTHONY PERROTTI                                E
…                        …                                …
99995              JOAN PAPES                              NaN
99996         MARGARET HAYNER                                S
99997           DANA VALENCIA                              NaN
99998  RAFAELA GONZALEZ-LAMOS                              NaN
99999         ELIIAN RAMEZANI                              NaN

      Credentials of the Provider Gender of the Provider  \
```

```
0                            M.D.                        F
1                            M.D.                        F
2                             DPM                        M
3                              MD                        M
4                              DO                        M
…                             …                          …
99995                          PT                        F
99996                        ARNP                        F
99997                        M.D.                        M
99998                         NaN                        F
99999                         NaN                        F

      Entity Type of the Provider City of the Provider  \
0                                I          SAINT LOUIS
1                                I         FAYETTEVILLE
2                                I          NORTH HAVEN
3                                I          KANSAS CITY
4                                I              JUPITER
…                               …                   …
99995                            I           WILMINGTON
99996                            I              REDMOND
99997                            I          SAINT LOUIS
99998                            I            LARCHMONT
99999                            I           GREAT NECK

       Zip Code of the Provider State Code of the Provider  \
0                   631041004.0                         MO
1                   283043815.0                         NC
2                    64732343.0                         CT
3                   641183998.0                         MO
4                   334585700.0                         FL
…                          …                          …
99995               604811236.0                         IL
99996               977561502.0                         OR
99997               631312322.0                         MO
99998               105383500.0                         NY
99999                   11023.0                         NY

                                  Provider Type  \
0                                Internal Medicine
1                  Obstetrics & Gynecology
2                                     Podiatry
3                                Internal Medicine
4                                Internal Medicine
…                                            …
99995  Physical Therapist in Private Practice
99996                   Nurse Practitioner
99997                           Cardiology
```

```
99998                        Internal Medicine
99999  Physical Therapist in Private Practice

      Medicare Participation Indicator  … HCPCS Code HCPCS Drug Indicator  \
0                                    Y  …      99223                    N
1                                    Y  …      G0202                    N
2                                    Y  …      99348                    N
3                                    Y  …      81002                    N
4                                    Y  …      96372                    N
…                                  …  …        …                    …
99995                                Y  …      97162                    N
99996                                Y  …      99213                    N
99997                                Y  …      93320                    N
99998                                Y  …      G0008                    N
99999                                Y  …      97112                    N

      Number of Services Number of Medicare Beneficiaries  \
0                     27                                24
1                    175                               175
2                     32                                13
3                     20                                18
4                     33                                24
…                    …                                 …
99995                 20                                20
99996                136                               107
99997                 11                                11
99998                 12                                12
99999                589                                76

      Number of Distinct Medicare Beneficiary/Per Day Services  \
0                                                    27
1                                                   175
2                                                    32
3                                                    20
4                                                    31
…                                                   …
99995                                                20
99996                                               136
99997                                                11
99998                                                12
99999                                               587

      Average Medicare Allowed Amount Average Submitted Charge Amount  \
0                        200.58777778                     305.21111111
1                              123.73                            548.8
2                               90.65                              155
3                                 3.5                                5
4                               26.52                               40
```

```
…                                …                                …
99995                          85.3725                              214
99996                            61.27                      144.05147059
99997                            17.98                      109.54545455
99998                            30.54                               65
99999                      38.601052632                      46.867572156

      Average Medicare Payment Amount Average Medicare Standardized Amount  \
0                         157.26222222                        160.90888889
1                                118.83                        135.31525714
2                              64.4396875                         60.5959375
3                                   3.43                               3.43
4                         19.539393939                        19.057575758
…                                    …                                  …
99995                            60.7255                            62.2485
99996                      30.006176471                      37.040220588
99997                             14.09                              14.62
99998                             29.93                              25.32
99999                      29.736876061                      25.912139219

      Money difference
0            -0.139738
1             0.165185
2            -0.201787
3            -0.298004
4            -0.277579
…                  …
99995        -0.133980
99996        -0.176395
99997        -0.196494
99998        -0.261783
99999        -0.281179

[100000 rows x 21 columns]
```

[320]:
```
df['Average Medicare Payment Amount'] = scaler.fit_transform(df[['Average␣
 ↪Medicare Payment Amount']])

display(df)
```

```
                    Full name Middle Initial of the Provider  \
0       SATYASREE UPADHYAYULA                              NaN
1                 WENDY JONES                                P
2             RICHARD DUROCHER                                W
3               JASPER FULLARD                              NaN
4             ANTHONY PERROTTI                                E
…                         …                                …
99995              JOAN PAPES                              NaN
```

```
99996         MARGARET HAYNER                                S
99997           DANA VALENCIA                              NaN
99998  RAFAELA GONZALEZ-LAMOS                              NaN
99999         ELIIAN RAMEZANI                              NaN

      Credentials of the Provider Gender of the Provider  \
0                          M.D.                        F
1                          M.D.                        F
2                           DPM                        M
3                            MD                        M
4                            DO                        M
…                           …                        …
99995                        PT                        F
99996                      ARNP                        F
99997                      M.D.                        M
99998                       NaN                        F
99999                       NaN                        F

      Entity Type of the Provider City of the Provider  \
0                               I          SAINT LOUIS
1                               I         FAYETTEVILLE
2                               I          NORTH HAVEN
3                               I          KANSAS CITY
4                               I              JUPITER
…                              …                    …
99995                           I           WILMINGTON
99996                           I              REDMOND
99997                           I          SAINT LOUIS
99998                           I            LARCHMONT
99999                           I           GREAT NECK

       Zip Code of the Provider State Code of the Provider  \
0                   631041004.0                         MO
1                   283043815.0                         NC
2                    64732343.0                         CT
3                   641183998.0                         MO
4                   334585700.0                         FL
…                          …                        …
99995               604811236.0                         IL
99996               977561502.0                         OR
99997               631312322.0                         MO
99998               105383500.0                         NY
99999                   11023.0                         NY

                              Provider Type  \
0                         Internal Medicine
1                    Obstetrics & Gynecology
2                                  Podiatry
```

```
3                          Internal Medicine
4                          Internal Medicine
…                                        …
99995  Physical Therapist in Private Practice
99996                      Nurse Practitioner
99997                              Cardiology
99998                      Internal Medicine
99999  Physical Therapist in Private Practice

      Medicare Participation Indicator  … HCPCS Code HCPCS Drug Indicator  \
0                                    Y  …      99223                    N
1                                    Y  …      G0202                    N
2                                    Y  …      99348                    N
3                                    Y  …      81002                    N
4                                    Y  …      96372                    N
…                                  …  …        …                      …
99995                                Y  …      97162                    N
99996                                Y  …      99213                    N
99997                                Y  …      93320                    N
99998                                Y  …      G0008                    N
99999                                Y  …      97112                    N

      Number of Services Number of Medicare Beneficiaries  \
0                     27                                24
1                    175                               175
2                     32                                13
3                     20                                18
4                     33                                24
…                   …                                 …
99995                 20                                20
99996                136                               107
99997                 11                                11
99998                 12                                12
99999                589                                76

      Number of Distinct Medicare Beneficiary/Per Day Services  \
0                                                    27
1                                                   175
2                                                    32
3                                                    20
4                                                    31
…                                                   …
99995                                                20
99996                                               136
99997                                                11
99998                                                12
99999                                               587
```

```
      Average Medicare Allowed Amount Average Submitted Charge Amount  \
0                          200.58777778                    305.21111111
1                                123.73                           548.8
2                                 90.65                             155
3                                   3.5                               5
4                                 26.52                              40
…                                     …                               …
99995                           85.3725                             214
99996                             61.27                    144.05147059
99997                             17.98                    109.54545455
99998                             30.54                              65
99999                       38.601052632                    46.867572156

      Average Medicare Payment Amount  Average Medicare Standardized Amount  \
0                            0.400082                           160.90888889
1                            0.207649                           135.31525714
2                           -0.064687                            60.5959375
3                           -0.370166                                  3.43
4                           -0.289505                           19.057575758
…                                 …                                      …
99995                       -0.083284                              62.2485
99996                       -0.237098                           37.040220588
99997                       -0.316791                                 14.62
99998                       -0.237479                                 25.32
99999                       -0.238446                           25.912139219

      Money difference
0            -0.139738
1             0.165185
2            -0.201787
3            -0.298004
4            -0.277579
…                  …
99995        -0.133980
99996        -0.176395
99997        -0.196494
99998        -0.261783
99999        -0.281179

[100000 rows x 21 columns]
```

[321]:
```
df['Average Submitted Charge Amount'] = scaler.fit_transform(df[['Average␣
  ↪Submitted Charge Amount']])

display(df)
```

```
                   Full name Middle Initial of the Provider  \
0       SATYASREE UPADHYAYULA                             NaN
```

```
1                WENDY JONES                                P
2           RICHARD DUROCHER                                W
3             JASPER FULLARD                              NaN
4           ANTHONY PERROTTI                                E
…                       …                                 …
99995            JOAN PAPES                              NaN
99996         MARGARET HAYNER                                S
99997           DANA VALENCIA                             NaN
99998  RAFAELA GONZALEZ-LAMOS                             NaN
99999         ELIIAN RAMEZANI                             NaN

      Credentials of the Provider Gender of the Provider  \
0                          M.D.                         F
1                          M.D.                         F
2                           DPM                         M
3                            MD                         M
4                            DO                         M
…                           …                          …
99995                        PT                         F
99996                      ARNP                         F
99997                      M.D.                         M
99998                       NaN                         F
99999                       NaN                         F

      Entity Type of the Provider City of the Provider  \
0                               I          SAINT LOUIS
1                               I         FAYETTEVILLE
2                               I          NORTH HAVEN
3                               I          KANSAS CITY
4                               I              JUPITER
…                              …                    …
99995                           I           WILMINGTON
99996                           I              REDMOND
99997                           I          SAINT LOUIS
99998                           I            LARCHMONT
99999                           I           GREAT NECK

       Zip Code of the Provider State Code of the Provider  \
0                   631041004.0                          MO
1                   283043815.0                          NC
2                    64732343.0                          CT
3                   641183998.0                          MO
4                   334585700.0                          FL
…                           …                          …
99995               604811236.0                          IL
99996               977561502.0                          OR
99997               631312322.0                          MO
99998               105383500.0                          NY
```

```
99999                   11023.0                         NY

                               Provider Type  \
0                          Internal Medicine
1                    Obstetrics & Gynecology
2                                 Podiatry
3                          Internal Medicine
4                          Internal Medicine
…                                        …
99995  Physical Therapist in Private Practice
99996                      Nurse Practitioner
99997                               Cardiology
99998                      Internal Medicine
99999  Physical Therapist in Private Practice

      Medicare Participation Indicator  … HCPCS Code HCPCS Drug Indicator  \
0                                    Y  …      99223                    N
1                                    Y  …      G0202                    N
2                                    Y  …      99348                    N
3                                    Y  …      81002                    N
4                                    Y  …      96372                    N
…                                  …  …        …                      …
99995                                Y  …      97162                    N
99996                                Y  …      99213                    N
99997                                Y  …      93320                    N
99998                                Y  …      G0008                    N
99999                                Y  …      97112                    N

      Number of Services Number of Medicare Beneficiaries  \
0                     27                              24
1                    175                             175
2                     32                              13
3                     20                              18
4                     33                              24
…                   …                                 …
99995                 20                              20
99996                136                             107
99997                 11                              11
99998                 12                              12
99999                589                              76

      Number of Distinct Medicare Beneficiary/Per Day Services  \
0                                                    27
1                                                   175
2                                                    32
3                                                    20
4                                                    31
…                                                     …
```

```
99995                                                  20
99996                                                 136
99997                                                  11
99998                                                  12
99999                                                 587

      Average Medicare Allowed Amount Average Submitted Charge Amount  \
0                          200.58777778                      -0.046433
1                                123.73                       0.182805
2                                 90.65                      -0.187794
3                                   3.5                      -0.328957
4                                 26.52                      -0.296019
…                                     …                              …
99995                            85.3725                      -0.132270
99996                              61.27                      -0.198097
99997                              17.98                      -0.230571
99998                              30.54                      -0.272492
99999                      38.601052632                       -0.289556

       Average Medicare Payment Amount  Average Medicare Standardized Amount  \
0                             0.400082                           160.90888889
1                             0.207649                           135.31525714
2                            -0.064687                             60.5959375
3                            -0.370166                                   3.43
4                            -0.289505                           19.057575758
…                                  …                                      …
99995                        -0.083284                                62.2485
99996                        -0.237098                           37.040220588
99997                        -0.316791                                  14.62
99998                        -0.237479                                  25.32
99999                        -0.238446                           25.912139219

      Money difference
0            -0.139738
1             0.165185
2            -0.201787
3            -0.298004
4            -0.277579
…                  …
99995        -0.133980
99996        -0.176395
99997        -0.196494
99998        -0.261783
99999        -0.281179

[100000 rows x 21 columns]
```

[322]:
```
df.head()
```

[322]:

	Full name	Middle Initial of the Provider	Credentials of the Provider	Gender of the Provider	Entity Type of the Provider	City of the Provider	Zip Code of the Provider	State Code of the Provider	Provider Type	Medicare Participation Indicator	…	HCPCS Code	HCPCS Drug Indicator	Number of Services	Number of Medicare Beneficiaries	Number of Distinct Medicare Beneficiary/Per Day Services
0	SATYASREE UPADHYAYULA	NaN	M.D.	F	I	SAINT LOUIS	631041004.0	MO	Internal Medicine	Y	…	99223	N	27	24	27
1	WENDY JONES	P	M.D.	F	I	FAYETTEVILLE	283043815.0	NC	Obstetrics & Gynecology	Y	…	G0202	N	175	175	175
2	RICHARD DUROCHER	W	DPM	M	I	NORTH HAVEN	64732343.0	CT	Podiatry	Y	…	99348	N	32	13	
3	JASPER FULLARD	NaN	MD	M	I	KANSAS CITY	641183998.0	MO	Internal Medicine	Y	…	81002	N	20	18	
4	ANTHONY PERROTTI	E	DO	M	I	JUPITER	334585700.0	FL	Internal Medicine	Y	…	96372	N	33	24	

```
2                                                    32
3                                                    20
4                                                    31

  Average Medicare Allowed Amount Average Submitted Charge Amount  \
0                     200.58777778                       -0.046433
1                           123.73                        0.182805
2                            90.65                       -0.187794
3                              3.5                       -0.328957
4                            26.52                       -0.296019

   Average Medicare Payment Amount  Average Medicare Standardized Amount  \
0                         0.400082                            160.90888889
1                         0.207649                            135.31525714
2                        -0.064687                              60.5959375
3                        -0.370166                                    3.43
4                        -0.289505                            19.057575758

  Money difference
0        -0.139738
1         0.165185
2        -0.201787
3        -0.298004
4        -0.277579

[5 rows x 21 columns]
```

[323]:
```
df["Average Medicare Allowed Amount"] = df["Average Medicare Allowed Amount"].
↪replace('.', '', regex=True)
```

[324]:
```
df["Number of Services"] = df["Number of Services"].replace(',', '', regex=True)
```

[325]:
```
df["Number of Medicare Beneficiaries"] = df["Number of Medicare Beneficiaries"].
↪replace(',', '', regex=True)
```

[326]:
```
df["Number of Distinct Medicare Beneficiary/Per Day Services"] = df["Number of␣
↪Distinct Medicare Beneficiary/Per Day Services"].replace(',', '', regex=True)
```

[327]:
```
df.drop(columns=['Average Medicare Allowed Amount','Average Medicare␣
↪Standardized Amount',], inplace=True)
```

[328]:
```
df.head()
```

[328]:
```
                Full name Middle Initial of the Provider  \
0  SATYASREE UPADHYAYULA                             NaN
1             WENDY JONES                               P
2       RICHARD DUROCHER                                W
```

```
3         JASPER FULLARD                              NaN
4       ANTHONY PERROTTI                                E

  Credentials of the Provider Gender of the Provider  \
0                        M.D.                       F
1                        M.D.                       F
2                         DPM                       M
3                          MD                       M
4                          DO                       M

  Entity Type of the Provider City of the Provider  Zip Code of the Provider  \
0                           I          SAINT LOUIS                631041004.0
1                           I         FAYETTEVILLE                283043815.0
2                           I          NORTH HAVEN                 64732343.0
3                           I          KANSAS CITY                641183998.0
4                           I              JUPITER                334585700.0

  State Code of the Provider            Provider Type  \
0                         MO        Internal Medicine
1                         NC  Obstetrics & Gynecology
2                         CT                 Podiatry
3                         MO        Internal Medicine
4                         FL        Internal Medicine

  Medicare Participation Indicator Place of Service HCPCS Code  \
0                                Y                F      99223
1                                Y                O      G0202
2                                Y                O      99348
3                                Y                O      81002
4                                Y                O      96372

  HCPCS Drug Indicator Number of Services Number of Medicare Beneficiaries  \
0                    N                27                                24
1                    N               175                               175
2                    N                32                                13
3                    N                20                                18
4                    N                33                                24

  Number of Distinct Medicare Beneficiary/Per Day Services  \
0                                                 27
1                                                175
2                                                 32
3                                                 20
4                                                 31

   Average Submitted Charge Amount  Average Medicare Payment Amount  \
0                        -0.046433                         0.400082
```

```
1                          0.182805                          0.207649
2                         -0.187794                         -0.064687
3                         -0.328957                         -0.370166
4                         -0.296019                         -0.289505

   Money difference
0         -0.139738
1          0.165185
2         -0.201787
3         -0.298004
4         -0.277579
```

[329]:
```
mean = np.mean(df["Money difference"])
std = np.std(df["Money difference"])
print('mean of the dataset is', mean)
print('std. deviation is', std)
```

```
mean of the dataset is -3.19211324040225e-17
std. deviation is 0.9999999999999999
```

[330]:
```
threshold = 3
outlier = []
for i in df["Money difference"]:
    z = (i-mean)/std
    if z > threshold:
        outlier.append(i)
print('outlier in dataset is', outlier)
```

```
outlier in dataset is [5.001480953472853, 7.460672545959053, 5.70618723372476,
5.472844079938339, 5.5955541655733585, 4.102689153875423, 3.125975413181884,
7.71562222857764, 7.4408227836147, 10.440100269481231, 4.9144463476674005,
14.65648528005027, 3.520356080519061, 9.839336685639676, 5.291678258126511,
12.288456819070694, 3.3148067941615165, 6.618849955479128, 5.087215423724219,
4.032193802311867, 6.61781104974683, 6.05097357153305, 5.551040769304619,
4.986930703016156, 31.079025660093187, 3.5079951528708033, 8.144963742937621,
3.6452169325732102, 5.282640091792032, 3.7323507792897472, 3.4044834638271375,
8.132835264219686, 5.934169435970785, 3.3895289080275064, 6.783230562633316,
4.36565587624966, 6.419579009759744, 5.385542319706993, 5.227544784104939,
10.285939937668005, 12.982379682037807, 4.163789831507433, 11.579963469712071,
5.543206894132582, 3.3951877693604637, 6.33314268937909, 3.8314872505974136,
5.379308938119263, 5.982010060303651, 6.12386259998153, 3.032327516620086,
9.853421941729525, 4.066363721557715, 3.718869232436207, 3.0758240989994223,
3.952362755338471, 3.228471343257186, 6.6943155789678706, 4.361554504799258,
4.980040823527655, 7.387769878918673, 4.485574500407166, 5.307126061363896,
4.987948538523319, 4.214340136085704, 23.274412827554034, 16.62027047040995,
4.131057893621092, 6.440416665853624, 3.627356975693066, 5.209639538060813,
48.799238014256694, 3.236222502884505, 3.0973498536123163, 5.991330364480495,
4.596385052490389, 3.683870812951039, 6.147252123154096, 5.568957526010002,
```

61.37091609842292, 5.826591069446645, 24.79156068183084, 6.781868244160666,
3.286072546932091, 4.355913099458368, 6.024402101668438, 9.904327591468782,
4.140542479490628, 4.25486226305052, 5.481015768681434, 10.821290983486758,
5.261054247084487, 5.506553517181567, 3.595362088428921, 7.0566192882296175,
3.2612286898642937, 15.207591756467998, 3.942020835453162, 4.875267665388059,
4.606371063168371, 3.032022245993767, 3.5063555282453045, 5.288482972239081,
6.625025473433072, 4.349071734057384, 11.325719328911216, 3.626594014887162,
5.389509961149619, 6.68300374743195, 3.9690114469478663, 4.2079689356902445,
4.89605691389529, 4.694130155354416, 15.350800013926037, 3.2399611136852373,
3.72098472259157, 11.13851106208972, 5.816454279868506, 4.138935808657011,
5.1904496109709655, 3.3112672821726674, 5.0794675077123115, 9.258271302049751,
4.275894225741565, 7.999327060856401, 3.175764538996557, 3.3068399536251145,
3.2461003930163477, 12.346431433363177, 3.907680034049186, 5.04864513946782,
5.24409315338187, 6.347318925129438, 4.482301016704186, 4.204448190319515,
3.4427824194922207, 3.315122537243484, 3.2497736072649235, 20.04754205241074,
4.4622288537619035, 3.6243606859570905, 4.087838509090286, 18.197298754770923,
5.763525532207272, 6.86295967571961, 3.8826923535928093, 6.16950324543789,
11.468576801255804, 12.708752109750089, 5.718620482860273, 9.986448545802356,
46.51604890924597, 3.3952567605412782, 7.291753774729393, 6.093118311755289,
3.185482626976711, 3.2765802866360576, 3.9414426903067983, 5.125595650562889,
3.542996852321498, 6.657399908786567, 4.166101775803666, 4.055598679105545,
3.9379053146819905, 6.016212826377757, 11.739276966954346, 12.012368924921573,
6.51380505453853, 4.158719490987006, 3.6134214906039452, 3.6181827248579586,
7.1768047748335695, 4.298006672870726, 3.2952848471815837, 7.377956962858079,
3.972370921984396, 7.173028560799377, 7.551233396890593, 7.731791768496339,
6.659306433819623, 3.9107313295450936, 5.331720389087539, 3.9468835025778715,
13.660637909829086, 7.021457896499301, 4.094091126593226, 4.011622134574951,
3.218713466895553, 4.803003354175504, 5.84740658520558, 5.569119238197061,
5.770448018332147, 3.447331881793767, 6.714336171302203, 5.534642920217079,
8.369775963929364, 5.834829852590762, 3.5311350631112437, 3.7468808657809674,
12.493567014323226, 10.147217373054154, 5.516957740363576, 9.26241736338456,
3.473369712818604, 15.223342802531468, 3.090787183096497, 3.447015595081857,
3.08706592941162, 4.121063622892661, 5.04636409552786, 24.004617615263072,
5.287721456528715, 4.850922365848368, 4.519922225200116, 5.069804764968876,
3.9277769499624005, 7.1184365912645875, 9.228128744432793, 4.046293827696323,
3.1949154660764636, 3.3246275112144827, 3.2902487789718906, 13.401773748663384,
3.4701801576643856, 3.7981725822277816, 8.423894485757652, 3.2258207453583747,
7.372776743687087, 3.1962892723536935, 13.291271108774433, 7.77017218129148,
3.481915738426095, 15.225492459017838, 25.35525755943711, 6.58993358271504,
3.8677290150989787, 3.8172340321871574, 9.097179060933147, 3.4169798747502838,
7.100872856891512, 3.603693314612252, 3.481837514867051, 3.0999044680765038,
24.796532585056713, 3.6333304087844045, 8.137710298039007, 4.331329963591836,
6.449677426355267, 15.891557573734584, 19.298013518084623, 6.016607852351124,
4.389779665151913, 4.124244393255141, 5.261697916895002, 5.71607604683962,
3.01731806177547, 3.0368704660770605, 7.113322490966469, 4.360064860841789,
3.5100044342885752, 5.046352511236534, 8.9390645351078, 3.994952002613629,
3.631263373150806, 3.701984360722436, 3.838231035948146, 9.044012741353786,
3.8301481343761465, 3.8639550685682, 3.3161817073225057, 8.087045025318105,

5.153724676523058, 4.840889527883977, 5.256826956818772, 17.665852192157836,
5.4203315298796735, 8.565435686210208, 4.118551397670534, 8.618099968035116,
8.033959880349903, 6.498790268703865, 4.706054392551485, 3.8581283557924233,
3.4670816039028898, 3.068250932767786, 8.549508898576995, 3.541885682351758,
5.849576814906546, 3.5693679252360906, 44.48671066045172, 4.3367131731347355,
9.449150860953328, 4.639186585099081, 6.4395715370901545, 3.0610403388398835,
6.335841778106534, 6.54766948063523, 3.014269370470257, 4.743055700310074,
3.0322170251100142, 8.234620180508868, 6.198635301673518, 5.074667970533745,
3.279787796347654, 3.7284102024130124, 4.4893931506617815, 3.792429934405607,
3.4713478592123708, 3.4376683191941013, 3.524656832997509, 3.03647153569895,
36.6703678785862, 17.340455642890134, 4.589843761411399, 4.3174411675138,
13.623520137475083, 3.588209015446836, 3.5491165150450703, 6.187151358541109,
4.602441698880855, 3.4026763624828957, 4.36985265935016, 6.2662044444285705,
13.377478086808239, 12.76785092320456, 4.83652071342322, 3.994731744455034,
4.589768297704152, 7.506282977829831, 5.346858085889697, 11.921435154055782,
6.8660029270601095, 4.563321499041436, 3.779939251134239, 6.286018620473587,
9.965748318903934, 4.4430737680415975, 3.0730828080351573, 5.695223189779983,
6.947471444793494, 13.190300199948172, 3.434851179116206, 4.0109690750600455,
3.808975787383011, 3.270153916742962, 3.0663052461603058, 3.5039173619962742,
7.2680645701772155, 5.565166479365829, 3.440141783871601, 10.298190260517517,
3.3408306725043615, 3.039439479133862, 13.602516301103105, 4.225985796649015,
5.830759115249869, 4.620344958772768, 4.258856398618449, 7.180427487795807,
6.125351835319143, 4.052256553926739, 9.63649598799689, 3.035580292293001,
3.7344915654610533, 4.210146141391626, 5.265843727065861, 3.3452387049460146,
10.942664151087865, 3.0012838346472352, 3.737809593226307, 3.532162321377398,
3.245560391165411, 3.3790222312414677, 13.707018098777453, 7.712824125148849,
9.384949688299246, 5.888613861529406, 4.004259970045243, 3.323997018451017,
8.165160744961602, 4.469095312311229, 16.284875722824793, 3.3515424667496108,
9.706554397642565, 4.177795571284504, 7.1706382564852005, 3.734635448910576,
3.2034252262580463, 10.39209037619155, 5.5006409884512815, 5.145856683144455,
12.9021959395123, 3.2453998858843973, 5.311707397830746, 4.773165286868304,
6.780846789782063, 3.626068314320377, 15.936226710359238, 20.166099477791644,
7.689189978546376, 26.90324721287978, 4.846861457635256, 4.739720417505542,
21.045739887564178, 3.206621362707933, 12.127580951115577, 4.839322898942007,
7.858867493200748, 4.09026350195755, 17.185711031172595, 6.002140400916832,
3.4715332408828004, 5.884262551455458, 8.921442974305208, 3.652905988231564,
6.162434792867734, 5.76646525177679, 3.698337079308817, 7.592707224619772,
3.5528638068310356, 3.1401206654853433, 9.47223514509239, 25.96158339376447,
4.1171232558616255, 3.686075199425159, 7.271860583120944, 3.262253597763473,
3.3004576752775066, 3.6205698455960458, 4.165036235815391, 14.441242204987121,
7.991325258784238, 3.907635756103933, 5.125068509592997, 4.243525646984372,
15.514272504430156, 15.287270087835779, 4.721507233404716, 3.113793320398831,
8.305061814006187, 7.407788710034711, 3.3179619872865977, 4.028778431680334,
12.94974211443884, 5.650787114166689, 3.3238931026251604, 5.906551144849444,
6.914988923643794, 5.769328537387196, 4.18861507917515, 3.1124311079275335,
4.645828969863903, 4.101260593110335, 7.124837325675765, 4.578264054393883,
4.7495481020930885, 17.28809497496091, 3.417769904618811, 4.729616139690189,
7.712193699398478, 3.3542209067186577, 3.6777965318236756, 9.013308961180787,

14.33484161835653, 5.096163022196799, 30.288498141601842, 4.611259534410565,
10.522143343960064, 4.794769885478998, 7.940836945286304, 3.953588843182373,
5.56781362993937, 29.43625971470472, 3.4389415972449733, 7.1028287397932255,
4.700468855026193, 3.3494952085636274, 3.366206714385642, 9.231041642130211,
3.9580409035405917, 5.583158118987496, 8.293813712798814, 5.1951692553124715,
7.999656620118212, 14.075393053531775, 8.62040207784079, 3.1922563771925976,
3.5384202608855713, 12.389395968361018, 3.49626051495241, 3.419685605839865,
6.330162362015155, 6.7324247332446, 3.2853683220222174, 30.996614177289654,
3.8300700995738954, 3.5339661727271188, 6.203161754113323, 3.6962399138722217,
3.1369534852659613, 4.722227941038228, 5.799496068669598, 3.404208881619262,
10.959082666946681, 36.00795193383489, 6.108450436617197, 6.960894190748951,
4.014038054606617, 3.201542265928771, 9.529232296378101, 8.295686186378907,
3.7852332948571887, 3.658679099440957, 40.69931958944351, 17.939363135279905,
5.215598606303949, 6.4705420206427, 3.6084516211898077, 3.5557536828437377,
4.33800705827436, 3.928931338880211, 3.1002616777433145, 3.066634640040978,
6.75303250315626, 3.7007832653861388, 4.8934432735342295, 8.204133054416072,
3.332558661461237, 4.489852108330581, 10.99809156508577, 7.09550285004185,
4.3631317537597525, 3.1540573997015713, 8.232265670615208, 3.029510534719258,
3.3068811934055575, 3.20552802416793, 16.735057105727098, 14.972236340770474,
6.324210092681846, 4.618376764977439, 6.602206294544243, 7.884946161105747,
6.065461119651585, 3.1070357882924364, 11.363582746668161, 3.713907221621051,
3.8894503181812587, 4.238029961746982, 7.944195758282549, 3.151856912226169,
3.045493591893081, 12.862331373054502, 3.0483263493520822, 3.2026956973183367,
21.756054314627427, 3.5711663392700492, 3.551573771895341, 3.0990835245096315,
9.264334835608818, 17.648257223909138, 12.886527104049128, 3.5800812455050823,
5.238314787677692, 4.305023260744054, 18.747433255892613, 3.9374803446674806,
3.9366890896421647, 3.1498345213474788, 7.873375300259983, 3.147488052062871,
5.043917482806991, 3.2842072759838223, 3.060355914937084, 6.343540113175542,
7.0913415905307895, 3.1848933702094704, 7.423340043886186, 4.550769007759385,
3.3600279267159943, 11.549771462280772, 4.476112393765513, 6.760642642711244,
3.5785801213114667, 3.04236645179217, 3.1356825534518604, 5.859621629001818,
3.1686861052054938, 5.08513012186505, 4.415961540141988, 6.165951242675327,
11.528185030576143, 3.055385717928602, 5.122944207875256, 6.331368554466018,
4.139128533472685, 4.766054369944768, 25.004048115418307, 13.624934816582545,
3.5366634615399364, 15.701505920839983, 4.042600791313925, 4.835602924690417,
7.117550003052229, 4.560398941473492, 8.688934625816673, 7.915112685429367,
3.0715527981056123, 4.22688062259575, 11.806315688071194, 3.559462216388043,
5.239171335589216, 12.63563997913021, 4.672926567501072, 4.76000798438567,
3.905814182882992, 3.449527594970022, 10.133996781547665, 4.427981946373356,
16.518475127526592, 3.273180650047664, 6.986583251940217, 3.1653287888566486,
22.62877892862111, 3.4388694398630357, 3.4005358733294533, 4.86152767767057,
3.1535288567005413, 6.035217917600341, 4.160317555081746, 3.659194531705247,
3.406836901100432, 3.046985654982173, 5.897894468989344, 7.148313109729566,
7.385239501148884, 7.0345910132122995, 7.1817648553840066, 3.4965242123221847,
3.0047099935220016, 18.635152597499047, 7.222513397754432, 8.251619190864691,
4.596385052490389, 3.1626421684895347, 3.756230208370719, 5.288181320103619,
4.529987917388208, 43.87112273176157, 4.903099417736773, 4.668434400411335,
3.212118115559712, 8.11718614128857, 3.2918780494472064, 4.088272698346382,

4.643336746006974, 3.047200015653288, 8.464437876340604, 6.262911079741773,
3.002646742863227, 10.507743313342619, 4.410371244341008, 3.208024672910942,
4.285062845335957, 3.716807207896493, 12.298931731001268, 3.8169480534284146,
3.771528806639889, 4.99354954149877, 4.116935446507242, 3.4506312479475434,
10.490445112355387, 15.117389269173513, 6.824277041285825, 3.3830422316581745,
17.08723757030537, 3.877199831496733, 11.293949705969252, 4.59089508596321,
3.247875477454583, 5.6327363944040885, 6.394530763121657, 3.179779269911351,
5.210299636318469, 11.128346028741202, 3.5084249782532217, 6.041352737922534,
6.715837399983483, 13.344651444585384, 3.287341944472855, 4.077379008203629,
4.24498846838318, 3.076294353896342, 26.9742444675445, 9.198687830824172,
15.65415110216128, 5.401925355473252, 11.310126643179949, 3.606257547057831,
3.637190500842642, 7.479646144043834, 4.4647516307449955, 4.719083972195599,
3.791004860527087, 5.079821988493041, 4.194003748695872, 3.9038299140216113,
12.264992123629726, 4.558871095651714, 4.366310323318365, 3.3719079314432987,
9.208573292073364, 5.636269232189311, 3.042880454227539, 3.2437635288338162,
5.354012242531254, 4.5733344797760855, 15.17951285905951, 3.7494446325060826,
5.442508390291414, 4.091596021205675, 3.7666851535454704, 6.698881630999926,
3.4974265270849316, 3.396325609049709, 3.5706781751506833, 3.331688591663097,
4.304786106279233, 6.53414756879351, 3.279865401049745, 3.8481484854730312,
4.687907681180349, 7.596385896435081, 3.3295372706830424, 5.724936594945788,
8.752498334377679, 12.230485420303914, 5.684806461498291, 9.690929052693756,
3.082071920114193, 6.833886120174648, 6.466579558730582, 12.733799433082238,
7.456116084562549, 39.79275100110514, 4.501843123802668, 9.727914377418474,
4.236105876731552, 18.305508768580186, 10.359434214275312, 3.4860764474199364,
5.458871400300486, 14.392440860184715, 3.622674039136333, 3.2809347630949355,
5.1859536415638745, 6.427627140953049, 3.189551285084441, 8.359198173729819,
9.037813574610738, 5.669892008937887, 4.259155324257293, 10.361086576243357,
5.253665224640707, 3.2121065874261796, 4.16217104220228, 5.074867655607489,
5.133688400832481, 6.359768938664148, 3.5539281451679217, 3.3527586586829354,
3.077169575626148, 7.301700861990003, 6.427728962073698, 14.103327216885036,
3.234823423437197, 3.096267613740353, 4.531791891779074, 3.57562622170414,
5.720688733390023, 5.553066592544702, 3.1935371138722353, 4.22551547241441,
5.263846500933999, 3.2608101889055474, 5.379553498406791, 4.990770072002603,
14.984052025328586, 3.925381772602611, 7.736245388687584, 5.184343685164087,
25.24303955284834, 3.910256932854031, 5.701517259195812, 3.5710390273651647,
16.810014513693105, 3.6415633354403387, 4.52913600098107, 3.069909698973346,
4.748667072021165, 4.099097225180463, 8.555517155523432, 5.157636322301903,
4.142134179752488, 18.81256754843317, 6.078082504211325, 4.362444047393843,
11.403791243852947, 6.266621901959487, 3.328434995896085, 14.594162748386623,
5.201304910622362, 3.032915244494066, 4.839243469936544, 3.0874630265415486,
9.084202166155642, 7.915863058142283, 3.054244545954312, 3.326293378029351,
3.9288827090140024, 17.433842203758537, 5.427432657964378, 3.8205317078550776,
8.361499120212827, 3.6761328424370205, 6.350769230926139, 5.6636997926788135,
3.253323757025687, 3.0620806302014376, 5.38206583105746, 4.982401825020206,
7.242404245526383, 3.057384353303241, 3.603300837147513, 3.0597263060155693,
8.213437365233537, 3.5671838552984667, 5.205992295289465, 3.2548444593575625,
3.5978416522094667, 3.438961212911863, 3.6560137649648046, 7.576647949568925,
8.222271351805583, 4.899086123008387, 5.2495332124530085, 31.89272540423009,

5.2594196867373535, 4.111840498990468, 9.724886102034134, 3.234334386039254,
3.8893603001770454, 3.088155784189739, 7.040714160043742, 8.549577702579578,
6.977764405213402, 4.103885300557433, 5.159109078105433, 12.818978934641066,
3.8592359261491485, 3.2799379553604693, 6.204223587654703, 12.334678338678433,
3.231316594690268, 3.1513886250577263, 3.702736401648382, 6.773042006261474,
3.9224054043740226, 3.068722683587697, 5.601030053760886, 3.21165804712887,
3.0320006666529196, 7.379110597365004, 4.156451528461503, 3.7810974880935673,
5.893637154446253, 16.475607517065953, 3.1999987888864605, 5.679382673126462,
8.233742629398279, 3.156346465480863, 4.140177452634991, 4.04051713939542,
4.862339892095331, 5.015466763164255, 12.717566924641321, 4.582152461203617,
3.5550539292577077, 7.088846580959636, 3.4270841525980726, 3.2470194173828175,
3.7244597838016444, 6.3363822403238075, 11.20530158099847, 4.119650956416127,
9.358553754261852, 3.2223541794689865, 3.734709772335638, 5.021074945086651,
4.928036772235037, 6.2959520485561535, 17.333442393767452, 6.142400277919723,
7.114738869695969, 4.770508382537793, 16.664591651323633, 4.95573884380166,
17.934453281335646, 8.814581354657424, 5.303482400052128, 4.715658515217584,
5.215737051042956, 3.0967405529777023, 5.481193828787474, 3.0881846093241214,
4.611961891754806, 3.5789181596326394, 3.244430346932767, 6.185386291154919,
4.107670419505254, 3.4089974203899414, 9.106192919127192, 3.1168934959247845,
3.200606979674814, 6.9595816077126065, 4.898400245825327, 4.971574047088776,
11.073928912922936, 7.418312214783999, 19.882512349807296, 4.472571232398228,
3.004635832677757, 7.9897481473314125, 4.881089190509152, 3.092576696844384,
4.245785134029302, 4.783121263678621, 3.5688491851652397, 29.644538321269238,
4.855753444797344, 4.0518616409825565, 3.9306494424886544, 3.6485869967847275,
3.847084406938928, 4.372058530600047, 4.819521465656375, 3.5442990867218076,
3.428953805789695, 3.911613046463392, 3.913487683059235, 19.668686499386922,
3.5059604792638916, 7.263183882984908, 8.110528800894246, 5.627335774744658,
5.2201431080903875, 3.045823359459874, 4.445609332698415, 4.194109166196731,
3.0983604320511375, 3.1660695887738983, 3.469176854741428, 3.900113271363095,
15.834939413122914, 3.6107097953489635, 5.198690106062859, 4.137059377141707,
6.160159072252079, 4.45173824921889, 5.28595133450851, 12.240662561711964,
11.259424463640627, 6.762381255570188, 3.2876874858062637, 9.85069348870313,
4.239961274045716, 5.536363174515533, 4.187927375825802, 4.266068566164744,
6.031836240607741, 4.000673458144771, 7.704849821431807, 3.1265018055794003,
3.2395873334036236, 5.339116842081187, 10.26612766897697, 5.378443553539779,
21.70893410765693, 3.5197464625939876, 4.26785005955455, 8.259095997445565,
25.75680378348063, 4.404488089305343, 3.507404969326954, 5.090567325949153,
11.417307849431781, 5.504272023103475, 6.213134069490195, 11.652721856284403,
5.282343398052517, 4.50968753740549, 3.012434497312489, 5.673794743651045,
4.007495862559387, 4.582337921539289, 5.448084438468453, 5.040187325084262,
3.3769823021126264, 4.822954046262556, 7.229996747550928, 4.308907022620836,
5.609127829731444, 6.4820927388097545, 5.075543634108843, 15.246830354281423,
6.942351522649005, 3.578445089515408, 6.970256526191647, 6.676678779249219,
4.0029589594177795, 11.370634470659445, 4.943045677254404, 5.279159338988372,
3.808790380704307, 3.134906580525937, 21.639129701998552, 7.2329628850056515,
4.646521154494995, 5.202269804251806, 3.451062713193793, 3.417037502540793,
3.0533431411878693, 6.872722743487708, 3.43000875309231, 16.284595124748282,
3.211505204337852, 3.720221974523588, 6.016207661385133, 8.753526901875134,

```
5.062145056807543, 6.642866709700375, 4.841062606694146, 24.55632015574802,
3.2231494488467956, 3.5075583202951996, 3.299468678579808, 10.719487608582362,
6.385340191797744, 9.478966894618905, 3.322492169667886, 4.685345947304696,
21.605673887779993, 7.787737366317487, 3.005474606708849, 4.721020800262338,
3.4694010540008677, 3.844071706098345, 3.190074370075443, 5.706339434106936,
5.539985211724561, 3.8193827471600947, 4.46755887591459, 3.3720067312226885,
3.954767490256503, 5.834224377714028, 4.091655887501675, 35.16340578255477]
```

3.0.2 Appending a column called Z-score to the dataset to store the Z-score of each row

[331]:
```
df["Z-score"] = (df["Money difference"] - mean)/std
```

3.0.3 Making a column called Fraud that represents if we consider the data to be a fraudulent data or not depending on the Z-score. If the Z-score is above 3 then we consider it to be anomalous/fraudulent or if the Z-score is less then we consider it normal.

[332]:
```
df['Fraud'] = df['Z-score'].apply(lambda x: 0 if x <= 3 else 1)
```

[333]:
```
df.head()
```

[333]:

	Full name	Middle Initial of the Provider	Credentials of the Provider	Gender of the Provider	Entity Type of the Provider	City of the Provider	Zip Code of the Provider	State Code of the Provider	Provider Type
0	SATYASREE UPADHYAYULA	NaN	M.D.	F	I	SAINT LOUIS	631041004.0	MO	Internal Medicine
1	WENDY JONES	P	M.D.	F	I	FAYETTEVILLE	283043815.0	NC	Obstetrics & Gynecology
2	RICHARD DUROCHER	W	DPM	M	I	NORTH HAVEN	64732343.0	CT	Podiatry
3	JASPER FULLARD	NaN	MD	M	I	KANSAS CITY	641183998.0		
4	ANTHONY PERROTTI	E	DO	M	I	JUPITER	334585700.0		

```
3                          MO        Internal Medicine
4                          FL        Internal Medicine

  Medicare Participation Indicator  … HCPCS Code HCPCS Drug Indicator  \
0                                Y  …      99223                    N
1                                Y  …      G0202                    N
2                                Y  …      99348                    N
3                                Y  …      81002                    N
4                                Y  …      96372                    N

  Number of Services Number of Medicare Beneficiaries  \
0                 27                                24
1                175                               175
2                 32                                13
3                 20                                18
4                 33                                24

  Number of Distinct Medicare Beneficiary/Per Day Services  \
0                                                 27
1                                                175
2                                                 32
3                                                 20
4                                                 31

  Average Submitted Charge Amount  Average Medicare Payment Amount  \
0                       -0.046433                         0.400082
1                        0.182805                         0.207649
2                       -0.187794                        -0.064687
3                       -0.328957                        -0.370166
4                       -0.296019                        -0.289505

   Money difference   Z-score  Fraud
0         -0.139738 -0.139738      0
1          0.165185  0.165185      0
2         -0.201787 -0.201787      0
3         -0.298004 -0.298004      0
4         -0.277579 -0.277579      0

[5 rows x 21 columns]
```

[334]:
```
df['Fraud'].value_counts()
```

[334]:
```
Fraud
0    98933
1     1067
Name: count, dtype: int64
```

[335]:
```
df.nunique()
```

[335]:
```
Full name                                                  84197
Middle Initial of the Provider                                29
Credentials of the Provider                                 1854
Gender of the Provider                                         2
Entity Type of the Provider                                    2
City of the Provider                                        5846
Zip Code of the Provider                                   47827
State Code of the Provider                                    58
Provider Type                                                 90
Medicare Participation Indicator                               2
Place of Service                                               2
HCPCS Code                                                  2631
HCPCS Drug Indicator                                           2
Number of Services                                          2748
Number of Medicare Beneficiaries                            1274
Number of Distinct Medicare Beneficiary/Per Day Services    1979
Average Submitted Charge Amount                            38088
Average Medicare Payment Amount                            83367
Money difference                                           91947
Z-score                                                    91947
Fraud                                                          2
dtype: int64
```

[336]:
```
df.drop(columns=['Zip Code of the Provider'], inplace=True)
```

[337]:
```
df.head()
```

[337]:

	Full name	Middle Initial of the Provider	Credentials of the Provider	Gender of the Provider	Entity Type of the Provider	City of the Provider	State Code of the Provider
0	SATYASREE UPADHYAYULA	NaN	M.D.	F	I	SAINT LOUIS	MO
1	WENDY JONES	P	M.D.	F	I	FAYETTEVILLE	NC
2	RICHARD DUROCHER	W	DPM	M	I	NORTH HAVEN	CT
3	JASPER FULLARD	NaN	MD	M			
4	ANTHONY PERROTTI	E	DO	M			

```
3                          I          KANSAS CITY                          MO
4                          I              JUPITER                          FL

            Provider Type Medicare Participation Indicator Place of Service  \
0        Internal Medicine                                Y                F
1  Obstetrics & Gynecology                                Y                O
2                 Podiatry                                Y                O
3        Internal Medicine                                Y                O
4        Internal Medicine                                Y                O

  HCPCS Code HCPCS Drug Indicator Number of Services  \
0      99223                    N                 27
1      G0202                    N                175
2      99348                    N                 32
3      81002                    N                 20
4      96372                    N                 33

  Number of Medicare Beneficiaries  \
0                               24
1                              175
2                               13
3                               18
4                               24

  Number of Distinct Medicare Beneficiary/Per Day Services  \
0                                                 27
1                                                175
2                                                 32
3                                                 20
4                                                 31

   Average Submitted Charge Amount  Average Medicare Payment Amount  \
0                        -0.046433                         0.400082
1                         0.182805                         0.207649
2                        -0.187794                        -0.064687
3                        -0.328957                        -0.370166
4                        -0.296019                        -0.289505

   Money difference   Z-score  Fraud
0         -0.139738 -0.139738      0
1          0.165185  0.165185      0
2         -0.201787 -0.201787      0
3         -0.298004 -0.298004      0
4         -0.277579 -0.277579      0
```

3.0.4 Applying One hot encoding the the columns with few categories

[338]:
```
df = pd.get_dummies(df, columns=['Gender of the Provider','Entity Type of the␣
↪Provider','Place of Service','Medicare Participation Indicator','HCPCS Drug␣
↪Indicator'], dtype='int')
```

[339]:
```
df.head()
```

[339]:

	Full name	Middle Initial of the Provider	Credentials of the Provider	City of the Provider	State Code of the Provider	Provider Type	HCPCS Code	Number of Services	Number of Medicare Beneficiaries	Number of Distinct Medicare Beneficiary/Per Day Services	…	Gender of the Provider_F	Gender of the Provider_M
0	SATYASREE UPADHYAYULA	NaN	M.D.	SAINT LOUIS	MO	Internal Medicine	99223	27	24	27	…	1	0
1	WENDY JONES	P	M.D.	FAYETTEVILLE	NC	Obstetrics & Gynecology	G0202	175	175	175	…	1	0
2	RICHARD DUROCHER	W	DPM	NORTH HAVEN	CT	Podiatry	99348	32	13	32	…	0	1
3	JASPER FULLARD	NaN	MD	KANSAS CITY	MO	Internal Medicine	81002	20	18	20	…		
4	ANTHONY PERROTTI	E	DO	JUPITER	FL	Internal Medicine	96372	33	24	31	…		

```
3                          0                          1
4                          0                          1

   Entity Type of the Provider_I  Entity Type of the Provider_O  \
0                              1                              0
1                              1                              0
2                              1                              0
3                              1                              0
4                              1                              0

   Place of Service_F  Place of Service_O  Medicare Participation Indicator_N  \
0                   1                   0                                   0
1                   0                   1                                   0
2                   0                   1                                   0
3                   0                   1                                   0
4                   0                   1                                   0

   Medicare Participation Indicator_Y  HCPCS Drug Indicator_N  \
0                                   1                       1
1                                   1                       1
2                                   1                       1
3                                   1                       1
4                                   1                       1

   HCPCS Drug Indicator_Y
0                       0
1                       0
2                       0
3                       0
4                       0

[5 rows x 25 columns]
```

[340]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 100000 entries, 0 to 99999
Data columns (total 25 columns):
 #   Column                                      Non-Null Count
Dtype
---  ------                                      --------------
-----
 0   Full name                                   100000 non-null
object
 1   Middle Initial of the Provider              70669 non-null
object
 2   Credentials of the Provider                 92791 non-null
```

```
object
 3   City of the Provider                                    100000 non-null
object
 4   State Code of the Provider                              100000 non-null
object
 5   Provider Type                                           100000 non-null
object
 6   HCPCS Code                                              100000 non-null
object
 7   Number of Services                                      100000 non-null
object
 8   Number of Medicare Beneficiaries                        100000 non-null
object
 9   Number of Distinct Medicare Beneficiary/Per Day Services  100000 non-null
object
 10  Average Submitted Charge Amount                         100000 non-null
float64
 11  Average Medicare Payment Amount                         100000 non-null
float64
 12  Money difference                                        100000 non-null
float64
 13  Z-score                                                 100000 non-null
float64
 14  Fraud                                                   100000 non-null
int64
 15  Gender of the Provider_F                                100000 non-null
int64
 16  Gender of the Provider_M                                100000 non-null
int64
 17  Entity Type of the Provider_I                           100000 non-null
int64
 18  Entity Type of the Provider_O                           100000 non-null
int64
 19  Place of Service_F                                      100000 non-null
int64
 20  Place of Service_O                                      100000 non-null
int64
 21  Medicare Participation Indicator_N                      100000 non-null
int64
 22  Medicare Participation Indicator_Y                      100000 non-null
int64
 23  HCPCS Drug Indicator_N                                  100000 non-null
int64
 24  HCPCS Drug Indicator_Y                                  100000 non-null
int64
dtypes: float64(4), int64(11), object(10)
memory usage: 19.1+ MB
```

[341]:
```
df.drop(columns=['State Code of the Provider'], inplace=True)
```

3.0.5 Applying label encoding the fields with large no. of categories

[342]:
```
from sklearn import preprocessing

label_encoder = preprocessing.LabelEncoder()

df['Provider Type'] = label_encoder.fit_transform(df['Provider Type'])
```

[343]:
```
df_frequencies = df['Provider Type'].value_counts()

df_frequency_map = df_frequencies.to_dict()

df['Provider Type'] = df['Provider Type'].map(df_frequency_map)
```

[344]:
```
df.head()
```

[344]:

	Full name	Middle Initial of the Provider	Credentials of the Provider	City of the Provider	Provider Type	HCPCS Code	Number of Services	Number of Medicare Beneficiaries	Number of Distinct Medicare Beneficiary/Per Day Services	Average Submitted Charge Amount	…	Gender of the Provider_F
0	SATYASREE UPADHYAYULA	NaN	M.D.	SAINT LOUIS	11366	99223	27	24	27		…	
1	WENDY JONES	P	M.D.	FAYETTEVILLE	1028	G0202	175	175	175		…	
2	RICHARD DUROCHER	W	DPM	NORTH HAVEN	2027	99348	32	13	32		…	
3	JASPER FULLARD	NaN	MD	KANSAS CITY	11366	81002	20	18	20		…	
4	ANTHONY PERROTTI	E	DO	JUPITER	11366	96372	33	24	31		…	

```
0                        -0.046433  …                          1
1                         0.182805  …                          1
2                        -0.187794  …                          0
3                        -0.328957  …                          0
4                        -0.296019  …                          0

   Gender of the Provider_M  Entity Type of the Provider_I  \
0                         0                              1
1                         0                              1
2                         1                              1
3                         1                              1
4                         1                              1

   Entity Type of the Provider_O  Place of Service_F  Place of Service_O  \
0                              0                   1                   0
1                              0                   0                   1
2                              0                   0                   1
3                              0                   0                   1
4                              0                   0                   1

   Medicare Participation Indicator_N  Medicare Participation Indicator_Y  \
0                                   0                                   1
1                                   0                                   1
2                                   0                                   1
3                                   0                                   1
4                                   0                                   1

   HCPCS Drug Indicator_N  HCPCS Drug Indicator_Y
0                       1                       0
1                       1                       0
2                       1                       0
3                       1                       0
4                       1                       0

[5 rows x 24 columns]
```

[345]:
```
df.drop(columns=['City of the Provider'], inplace=True)
```

[346]:
```
df.head()
```

[346]:
```
              Full name Middle Initial of the Provider  \
0  SATYASREE UPADHYAYULA                            NaN
1            WENDY JONES                              P
2       RICHARD DUROCHER                              W
3         JASPER FULLARD                            NaN
4       ANTHONY PERROTTI                              E
```

	Credentials of the Provider	Provider Type	HCPCS Code	Number of Services	\
0	M.D.	11366	99223	27	
1	M.D.	1028	G0202	175	
2	DPM	2027	99348	32	
3	MD	11366	81002	20	
4	DO	11366	96372	33	

	Number of Medicare Beneficiaries	\
0	24	
1	175	
2	13	
3	18	
4	24	

	Number of Distinct Medicare Beneficiary/Per Day Services	\
0	27	
1	175	
2	32	
3	20	
4	31	

	Average Submitted Charge Amount	Average Medicare Payment Amount	…	\
0	-0.046433	0.400082	…	
1	0.182805	0.207649	…	
2	-0.187794	-0.064687	…	
3	-0.328957	-0.370166	…	
4	-0.296019	-0.289505	…	

	Gender of the Provider_F	Gender of the Provider_M	\
0	1	0	
1	1	0	
2	0	1	
3	0	1	
4	0	1	

	Entity Type of the Provider_I	Entity Type of the Provider_O	\
0	1	0	
1	1	0	
2	1	0	
3	1	0	
4	1	0	

	Place of Service_F	Place of Service_O	Medicare Participation Indicator_N	\
0	1	0	0	
1	0	1	0	
2	0	1	0	
3	0	1	0	

```
4                    0                    1                                      0

   Medicare Participation Indicator_Y  HCPCS Drug Indicator_N  \
0                                   1                       1
1                                   1                       1
2                                   1                       1
3                                   1                       1
4                                   1                       1

   HCPCS Drug Indicator_Y
0                       0
1                       0
2                       0
3                       0
4                       0

[5 rows x 23 columns]
```

[347]:
```
df.drop(columns=['Full name','Middle Initial of the Provider','Credentials of the Provider'], inplace=True)
```

[348]:
```
df.head()
```

[348]:
```
   Provider Type HCPCS Code Number of Services  \
0          11366      99223                 27
1           1028      G0202                175
2           2027      99348                 32
3          11366      81002                 20
4          11366      96372                 33

  Number of Medicare Beneficiaries  \
0                               24
1                              175
2                               13
3                               18
4                               24

  Number of Distinct Medicare Beneficiary/Per Day Services  \
0                                                 27
1                                                175
2                                                 32
3                                                 20
4                                                 31

   Average Submitted Charge Amount  Average Medicare Payment Amount  \
0                        -0.046433                         0.400082
1                         0.182805                         0.207649
```

```
2                        -0.187794                          -0.064687
3                        -0.328957                          -0.370166
4                        -0.296019                          -0.289505

   Money difference   Z-score  Fraud  Gender of the Provider_F  \
0         -0.139738 -0.139738      0                         1
1          0.165185  0.165185      0                         1
2         -0.201787 -0.201787      0                         0
3         -0.298004 -0.298004      0                         0
4         -0.277579 -0.277579      0                         0

   Gender of the Provider_M  Entity Type of the Provider_I  \
0                         0                              1
1                         0                              1
2                         1                              1
3                         1                              1
4                         1                              1

   Entity Type of the Provider_O  Place of Service_F  Place of Service_O  \
0                              0                   1                   0
1                              0                   0                   1
2                              0                   0                   1
3                              0                   0                   1
4                              0                   0                   1

   Medicare Participation Indicator_N  Medicare Participation Indicator_Y  \
0                                   0                                   1
1                                   0                                   1
2                                   0                                   1
3                                   0                                   1
4                                   0                                   1

   HCPCS Drug Indicator_N  HCPCS Drug Indicator_Y
0                       1                       0
1                       1                       0
2                       1                       0
3                       1                       0
4                       1                       0
```

[349]:
```
df['Fraud'].value_counts()
```

[349]:
```
Fraud
0    98933
1     1067
Name: count, dtype: int64
```

[350]:
```
df['Number of Services'] = scaler.fit_transform(df[['Number of Services']])
```

[351]:
```
df['Number of Medicare Beneficiaries'] = scaler.fit_transform(df[['Number of␣
↪Medicare Beneficiaries']])
```

[352]:
```
df['Number of Distinct Medicare Beneficiary/Per Day Services'] = scaler.
↪fit_transform(df[['Number of Distinct Medicare Beneficiary/Per Day␣
↪Services']])
```

[353]:
```
df.head()
```

[353]:

	Provider Type	HCPCS Code	Number of Services	Number of Medicare Beneficiaries	Number of Distinct Medicare Beneficiary/Per Day Services	Average Submitted Charge Amount	Average Medicare Payment Amount	Money difference	Z-score	Fraud	Gender of the Provider_F	Gender of the Provider_M	Entity Type of the Provider_I
0	11366	99223	-0.085301	-0.059308	-0.070183	-0.046433	0.400082	-0.139738	-0.139738	0	1	0	1
1	1028	G0202	-0.025939	0.076775	0.020049	0.182805	0.207649	0.165185	0.165185	0	1	0	1
2	2027	99348	-0.083296	-0.069222	-0.067135	-0.187794	-0.064687	-0.201787	-0.201787	0	0	0	1
3	11366	81002	-0.088109	-0.064716	-0.074451	-0.328957	-0.370166	-0.298004	-0.298004	0	0	0	1
4	11366	96372	-0.082895	-0.059308	-0.067744	-0.296019	-0.289505	-0.277579	-0.277579	0	0	0	1

```
2                          1                                1
3                          1                                1
4                          1                                1

   Entity Type of the Provider_0  Place of Service_F  Place of Service_O  \
0                              0                   1                   0
1                              0                   0                   1
2                              0                   0                   1
3                              0                   0                   1
4                              0                   0                   1

   Medicare Participation Indicator_N  Medicare Participation Indicator_Y  \
0                                   0                                   1
1                                   0                                   1
2                                   0                                   1
3                                   0                                   1
4                                   0                                   1

   HCPCS Drug Indicator_N  HCPCS Drug Indicator_Y
0                       1                       0
1                       1                       0
2                       1                       0
3                       1                       0
4                       1                       0
```

3.0.6 Dropping the Fraud column to avoid bias in the model while training

[354]:
```
df.drop(columns=['Fraud'], inplace=True)
```

[355]:
```
df.drop(columns=['HCPCS Code'], inplace=True)
```

[356]:
```
df.head()
```

[356]:
```
   Provider Type  Number of Services  Number of Medicare Beneficiaries  \
0          11366           -0.085301                         -0.059308
1           1028           -0.025939                          0.076775
2           2027           -0.083296                         -0.069222
3          11366           -0.088109                         -0.064716
4          11366           -0.082895                         -0.059308

   Number of Distinct Medicare Beneficiary/Per Day Services  \
0                                          -0.070183
1                                           0.020049
2                                          -0.067135
3                                          -0.074451
4                                          -0.067744
```

```
   Average Submitted Charge Amount  Average Medicare Payment Amount  \
0                         -0.046433                         0.400082
1                          0.182805                         0.207649
2                         -0.187794                        -0.064687
3                         -0.328957                        -0.370166
4                         -0.296019                        -0.289505

   Money difference   Z-score  Gender of the Provider_F  \
0         -0.139738 -0.139738                         1
1          0.165185  0.165185                         1
2         -0.201787 -0.201787                         0
3         -0.298004 -0.298004                         0
4         -0.277579 -0.277579                         0

   Gender of the Provider_M  Entity Type of the Provider_I  \
0                         0                              1
1                         0                              1
2                         1                              1
3                         1                              1
4                         1                              1

   Entity Type of the Provider_O  Place of Service_F  Place of Service_O  \
0                              0                   1                   0
1                              0                   0                   1
2                              0                   0                   1
3                              0                   0                   1
4                              0                   0                   1

   Medicare Participation Indicator_N  Medicare Participation Indicator_Y  \
0                                   0                                   1
1                                   0                                   1
2                                   0                                   1
3                                   0                                   1
4                                   0                                   1

   HCPCS Drug Indicator_N  HCPCS Drug Indicator_Y
0                       1                       0
1                       1                       0
2                       1                       0
3                       1                       0
4                       1                       0
```

3.0.7 Fitting Isolation Forest model to our dataset and predicting anomalies

[357]:
```
from sklearn.metrics import classification_report,accuracy_score
from sklearn.ensemble import IsolationForest
from sklearn.neighbors import LocalOutlierFactor
from sklearn.svm import OneClassSVM
from pylab import rcParams
```

[358]:
```
from sklearn.decomposition import PCA
```

[359]:
```
X = df

iso_forest = IsolationForest(contamination=0.01, random_state=42)

iso_forest.fit(X)
```

```
/usr/local/lib/python3.10/dist-packages/sklearn/base.py:439: UserWarning: X does
not have valid feature names, but IsolationForest was fitted with feature names
  warnings.warn(
```

[359]:
```
IsolationForest(contamination=0.01, random_state=42)
```

[360]:
```
labels = iso_forest.predict(X)
scores = iso_forest.decision_function(X)
```

[361]:
```
df_org['Anomaly'] = labels
```

[362]:
```
list(labels).count(-1)
```

[362]:
```
1000
```

[363]:
```
list(labels).count(1)
```

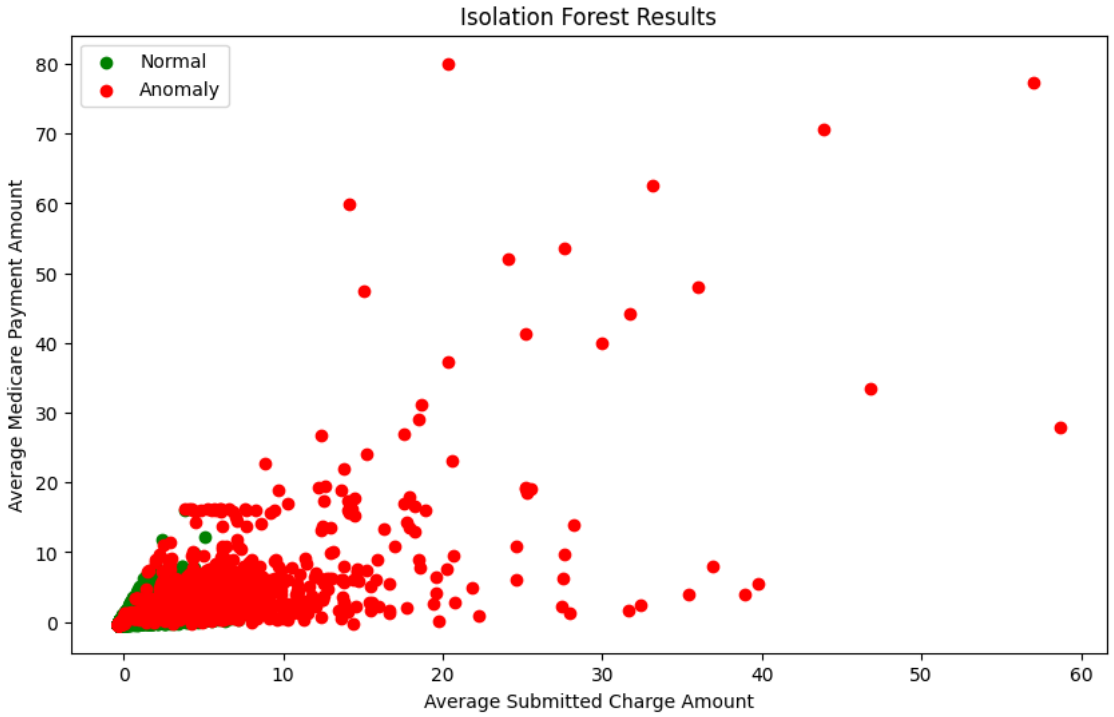
[363]:
```
99000
```

[364]:
```
result = df.iloc[:, [4, 5]].to_numpy()
```

[365]:
```
result
```

[365]:
```
array([[-0.04643253,  0.40008162],
       [ 0.18280539,  0.207649  ],
       [-0.18779399, -0.06468681],
       …,
       [-0.23057059, -0.31679095],
       [-0.27249167, -0.23747904],
       [-0.28955583, -0.23844603]])
```

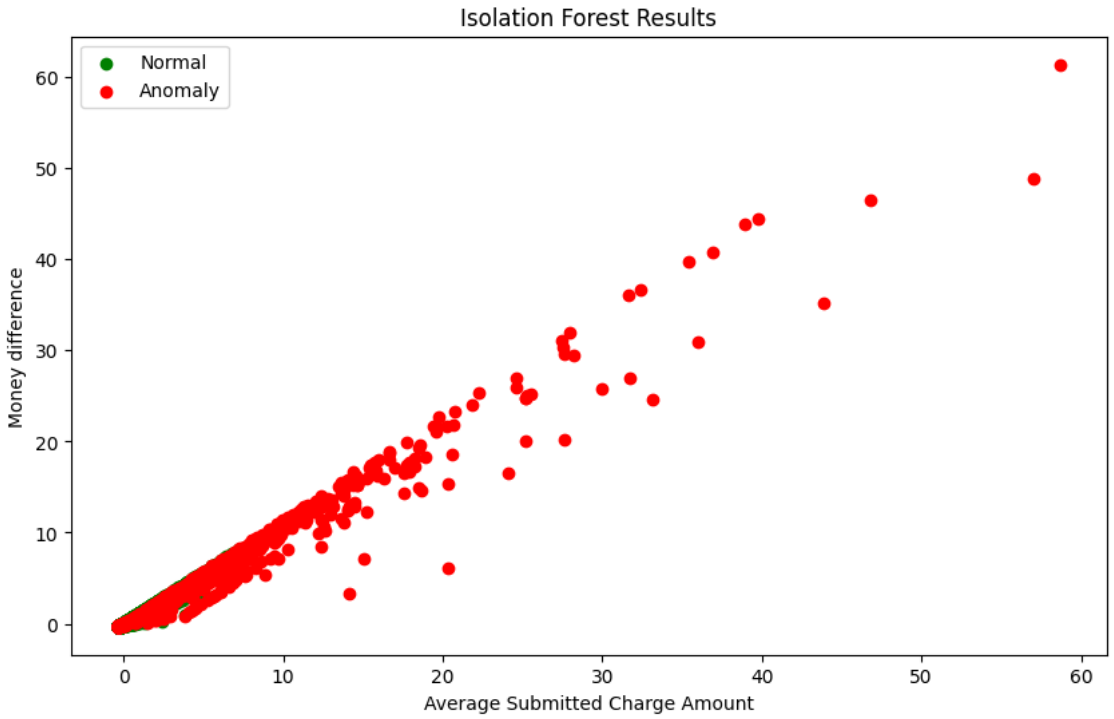
[366]:
```
X_transformed = result

plt.figure(figsize=(10, 6))

plt.scatter(X_transformed[labels == 1][:, 0], X_transformed[labels == 1][:, 1],␣
↪c='green', label='Normal')

plt.scatter(X_transformed[labels == -1][:, 0], X_transformed[labels == -1][:,␣
↪1], c='red', label='Anomaly')

plt.legend()
plt.title('Isolation Forest Results')
plt.xlabel('Average Submitted Charge Amount')
plt.ylabel('Average Medicare Payment Amount')
plt.show()
```



The above graph represents the distribution of anomalies on the basis of Avergae Medicare Payment Amount and Average Submitted Charge Amount columns

[367]:
```
result = df.iloc[:, [4, 6]].to_numpy()

X_transformed = result

plt.figure(figsize=(10, 6))
```

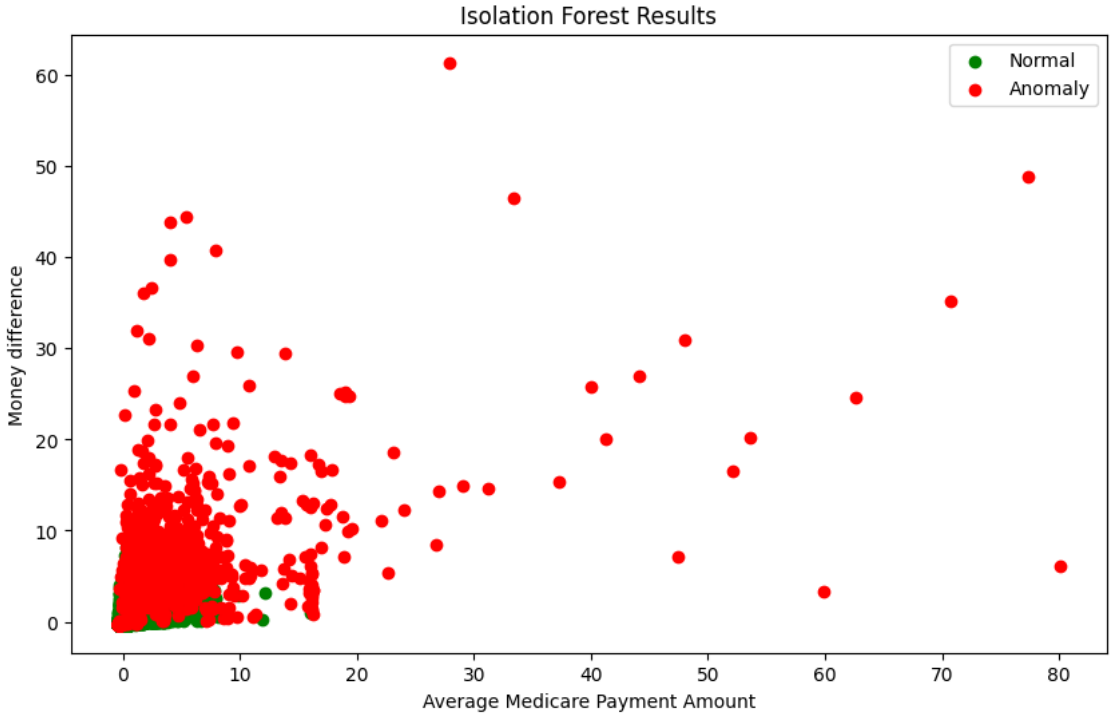
```
plt.scatter(X_transformed[labels == 1][:, 0], X_transformed[labels == 1][:, 1],␣
 ↪c='green', label='Normal')

plt.scatter(X_transformed[labels == -1][:, 0], X_transformed[labels == -1][:,␣
 ↪1], c='red', label='Anomaly')

plt.legend()
plt.title('Isolation Forest Results')
plt.xlabel('Average Submitted Charge Amount')
plt.ylabel('Money difference')
plt.show()
```



The above graph represents the distribution of anomalies on the basis of Money difference and Average Submitted Charge Amount columns

[368]:
```
result = df.iloc[:, [5, 6]].to_numpy()

X_transformed = result

plt.figure(figsize=(10, 6))

plt.scatter(X_transformed[labels == 1][:, 0], X_transformed[labels == 1][:, 1],␣
 ↪c='green', label='Normal')
```

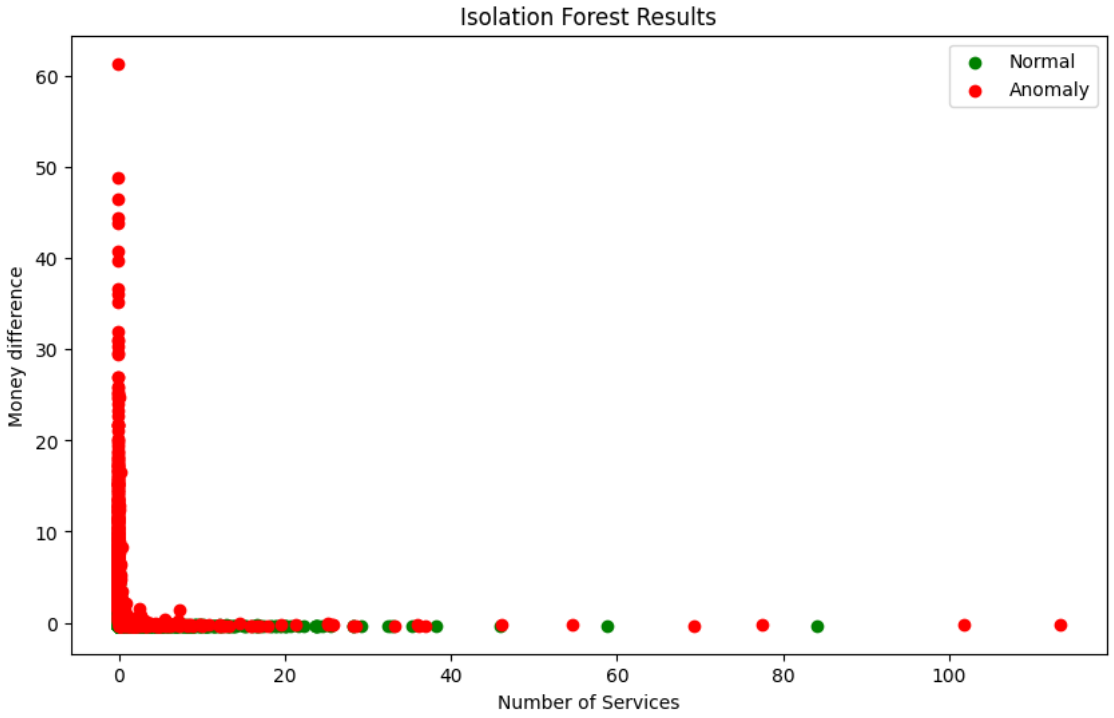
```
plt.scatter(X_transformed[labels == -1][:, 0], X_transformed[labels == -1][:,␣
↪1], c='red', label='Anomaly')

plt.legend()
plt.title('Isolation Forest Results')
plt.xlabel('Average Medicare Payment Amount')
plt.ylabel('Money difference')
plt.show()
```



The above graph represents the distribution of anomalies on the basis of Money difference and Average Medicare Payment Amount columns

[369]:
```
result = df.iloc[:, [1, 6]].to_numpy()

X_transformed = result

plt.figure(figsize=(10, 6))

plt.scatter(X_transformed[labels == 1][:, 0], X_transformed[labels == 1][:, 1],␣
↪c='green', label='Normal')

plt.scatter(X_transformed[labels == -1][:, 0], X_transformed[labels == -1][:,␣
↪1], c='red', label='Anomaly')
```

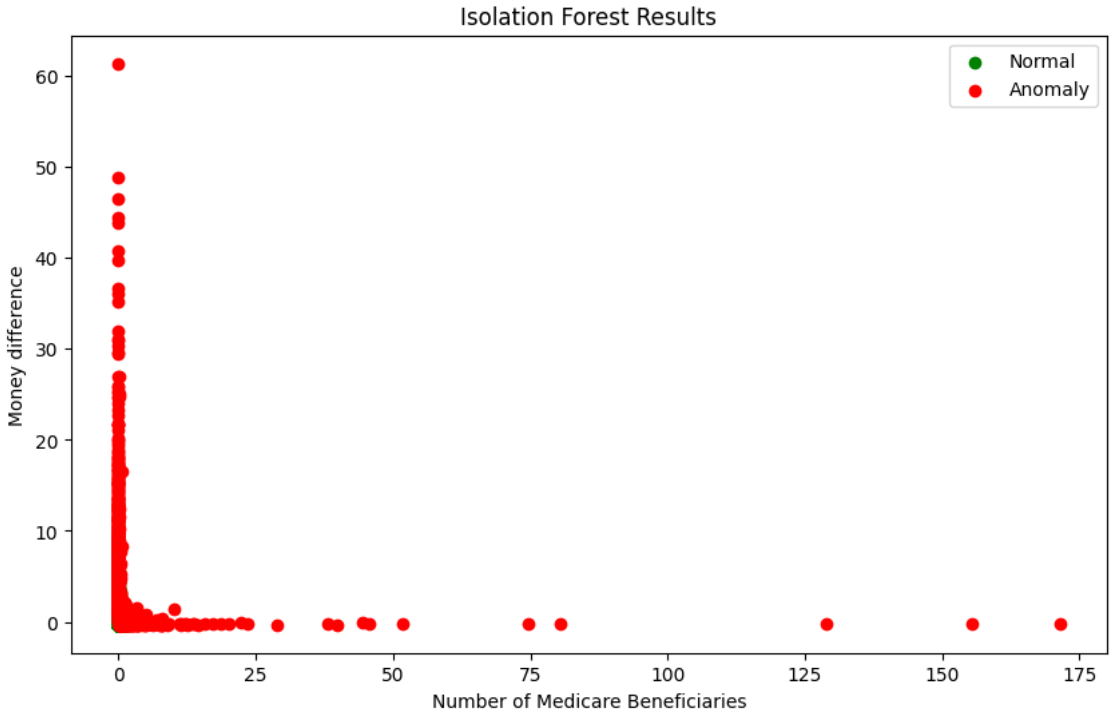
```
plt.legend()
plt.title('Isolation Forest Results')
plt.xlabel('Number of Services')
plt.ylabel('Money difference')
plt.show()
```



The above graph represents the distribution of anomalies on the basis of Money difference and Number of Services columns

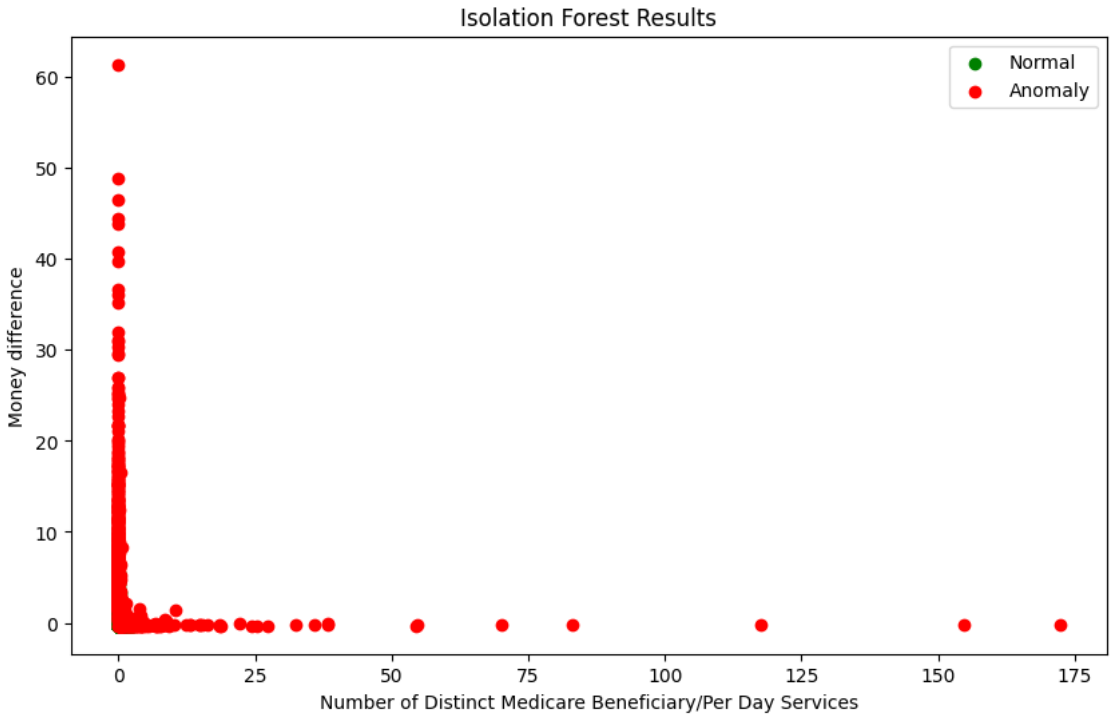
[370]:
```
result = df.iloc[:, [2, 6]].to_numpy()

X_transformed = result

plt.figure(figsize=(10, 6))

plt.scatter(X_transformed[labels == 1][:, 0], X_transformed[labels == 1][:, 1],␣
↪c='green', label='Normal')

plt.scatter(X_transformed[labels == -1][:, 0], X_transformed[labels == -1][:,␣
↪1], c='red', label='Anomaly')

plt.legend()
plt.title('Isolation Forest Results')
```

```
plt.xlabel('Number of Medicare Beneficiaries')
plt.ylabel('Money difference')
plt.show()
```



The above graph represents the distribution of anomalies on the basis of Money difference and Number of Medicare Beneficiaries columns

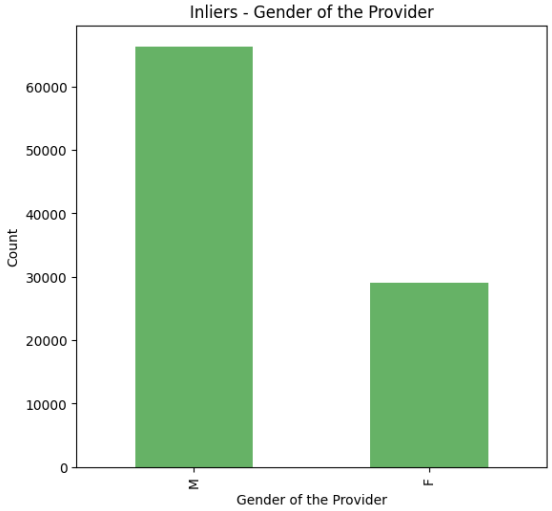
[371]:
```
result = df.iloc[:, [3, 6]].to_numpy()

X_transformed = result

plt.figure(figsize=(10, 6))

plt.scatter(X_transformed[labels == 1][:, 0], X_transformed[labels == 1][:, 1],␣
↪c='green', label='Normal')

plt.scatter(X_transformed[labels == -1][:, 0], X_transformed[labels == -1][:,␣
↪1], c='red', label='Anomaly')

plt.legend()
plt.title('Isolation Forest Results')
plt.xlabel('Number of Distinct Medicare Beneficiary/Per Day Services')
plt.ylabel('Money difference')
plt.show()
```

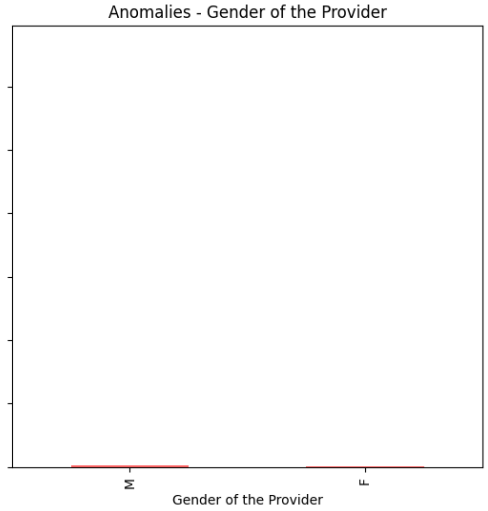


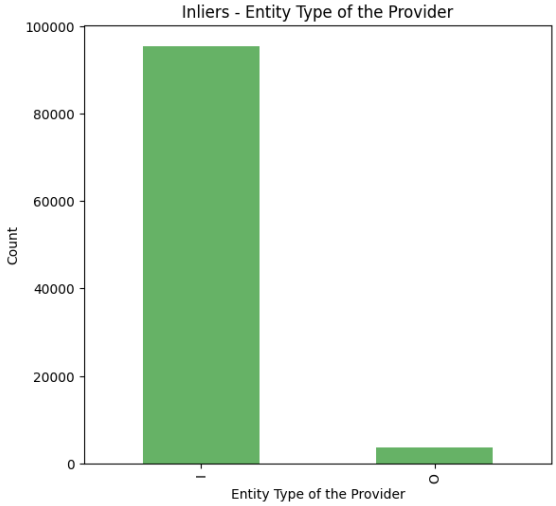
The above graph represents the distribution of anomalies on the basis of Money difference and Number of Medicare Benficiary/Per Day Services columns

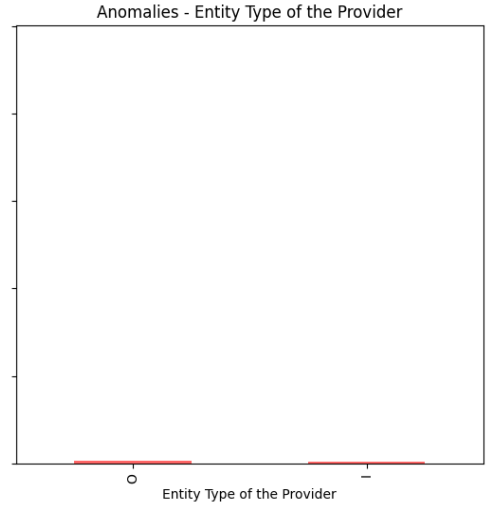
[372]:
```
inliers = df_org[df_org['Anomaly'] == 1]
anomalies = df_org[df_org['Anomaly'] == -1]

# Function to plot categorical feature distributions
def plot_categorical_feature(df_org, feature):
    fig, ax = plt.subplots(1, 2, figsize=(14, 6), sharey=True)

    # Plot for inliers
    inliers[feature].value_counts().plot(kind='bar', ax=ax[0], color='green',␣
 ↪alpha=0.6)
    ax[0].set_title(f'Inliers - {feature}')
    ax[0].set_ylabel('Count')

    # Plot for anomalies
    anomalies[feature].value_counts().plot(kind='bar', ax=ax[1], color='red',␣
 ↪alpha=0.6)
    ax[1].set_title(f'Anomalies - {feature}')

    plt.show()

# Plot the categorical features
```

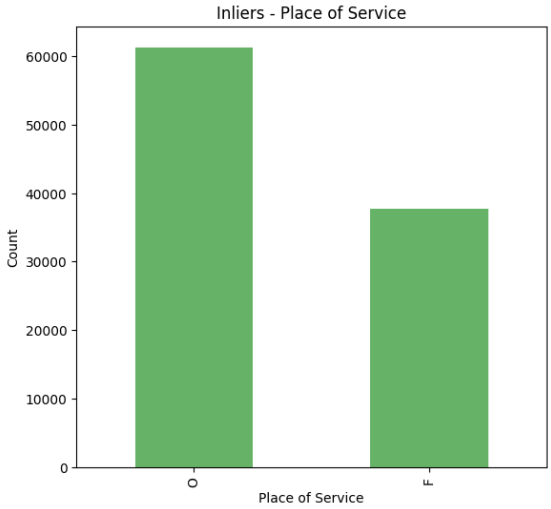
```
plot_categorical_feature(df_org, 'Gender of the Provider')
plot_categorical_feature(df_org, 'Entity Type of the Provider')
plot_categorical_feature(df_org, 'Place of Service')
plot_categorical_feature(df_org, 'Medicare Participation Indicator')
plot_categorical_feature(df_org, 'HCPCS Drug Indicator')
```

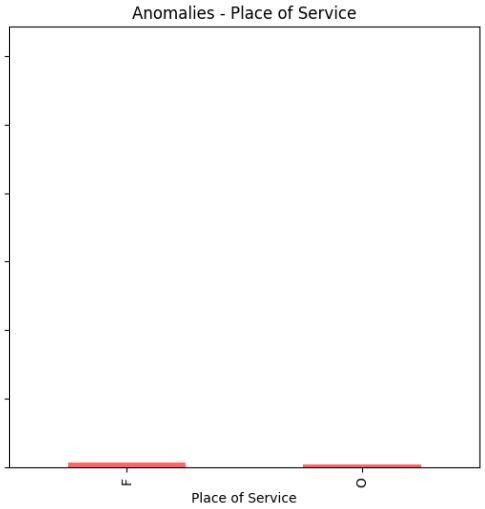


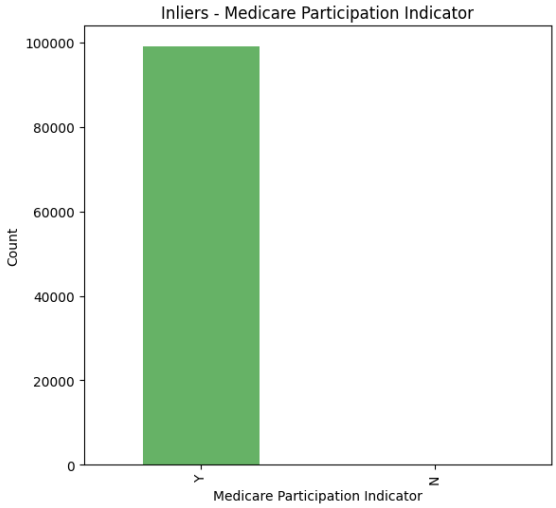


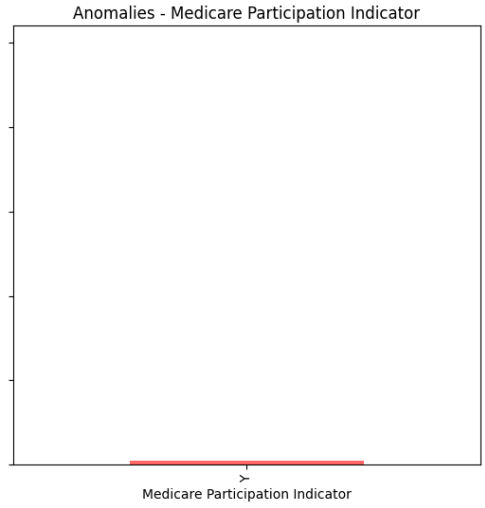


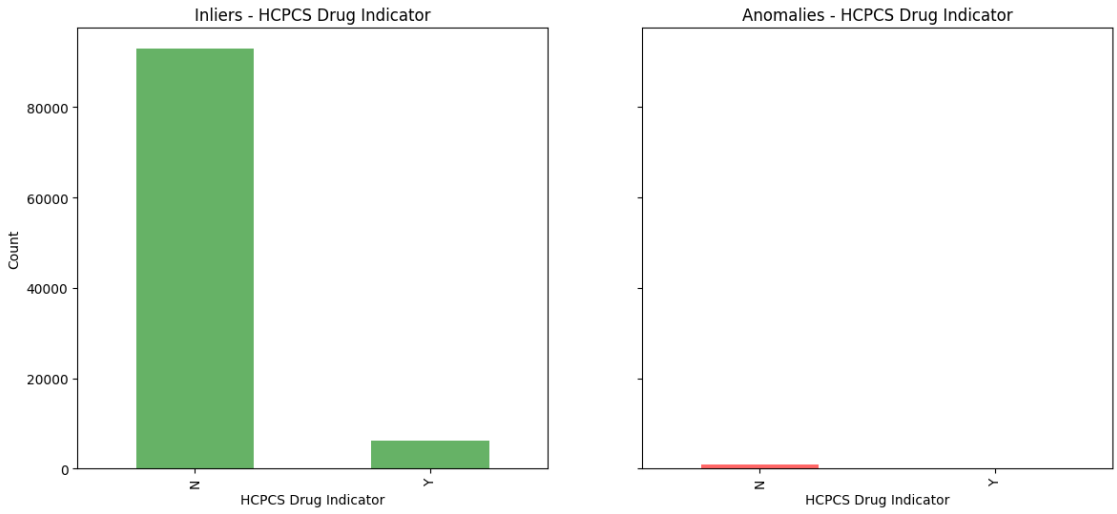



Inliers - Place of Service
Count
60000
50000
40000
30000
20000
10000
0
O
F
Place of Service


Anomalies - Place of Service
F
O
Place of Service


Inliers - Medicare Participation Indicator
Count
100000
80000
60000
40000
20000
0
Y
N
Medicare Participation Indicator


Anomalies - Medicare Participation Indicator
Y
Medicare Participation Indicator



The above bar graphs shows us the distribution of anomalies in the categorical columns

3.0.8 Using Elliptic Envelope to fit on the dataset and predicting anomalies

[373]:
```
from sklearn.covariance import EllipticEnvelope
```

[374]:
```
elliptic_env = EllipticEnvelope(contamination=0.0127, random_state=42)

elliptic_env.fit(X)

labels = elliptic_env.predict(X)

scores = elliptic_env.decision_function(X)
```

```
/usr/local/lib/python3.10/dist-
packages/sklearn/covariance/_robust_covariance.py:745: UserWarning: The
covariance matrix associated to your dataset is not full rank
  warnings.warn(
```

[375]:
```
df_org['Anomaly'] = labels
```

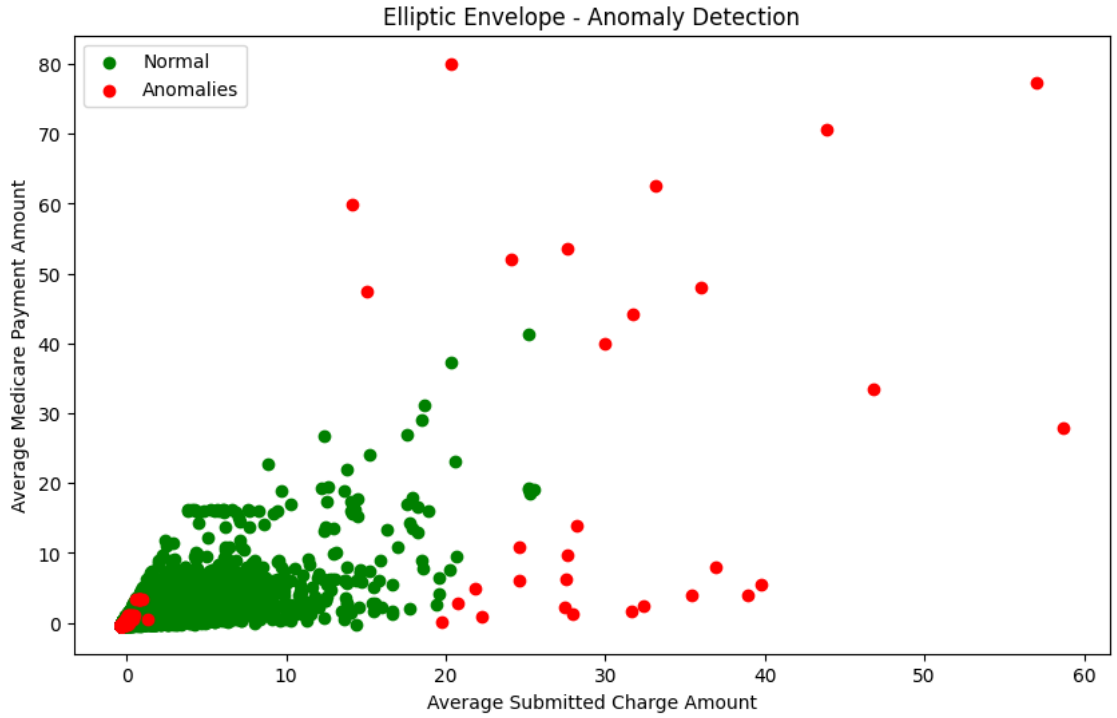
[376]:
```
list(labels).count(-1)
```

[376]: 1270

[377]:
```
list(labels).count(1)
```

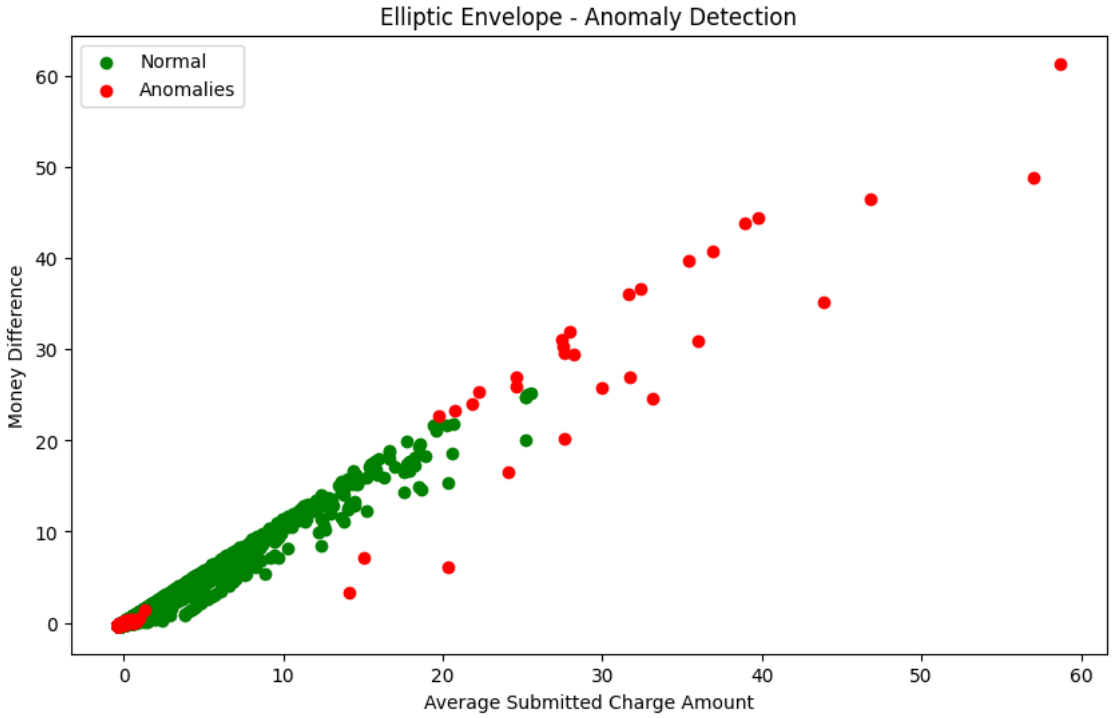
[377]: 98730

[378]:
```
result = df.iloc[:, [4, 5]].to_numpy()

X_transformed = result

plt.figure(figsize=(10, 6))

# Plot inliers
plt.scatter(X_transformed[labels == 1][:, 0], X_transformed[labels == 1][:, 1],␣
 ↪c='green', label='Normal')

# Plot anomalies
plt.scatter(X_transformed[labels == -1][:, 0], X_transformed[labels == -1][:,␣
 ↪1], c='red', label='Anomalies')

plt.legend()
plt.title('Elliptic Envelope - Anomaly Detection')
plt.xlabel('Average Submitted Charge Amount')
plt.ylabel('Average Medicare Payment Amount')
plt.show()
```



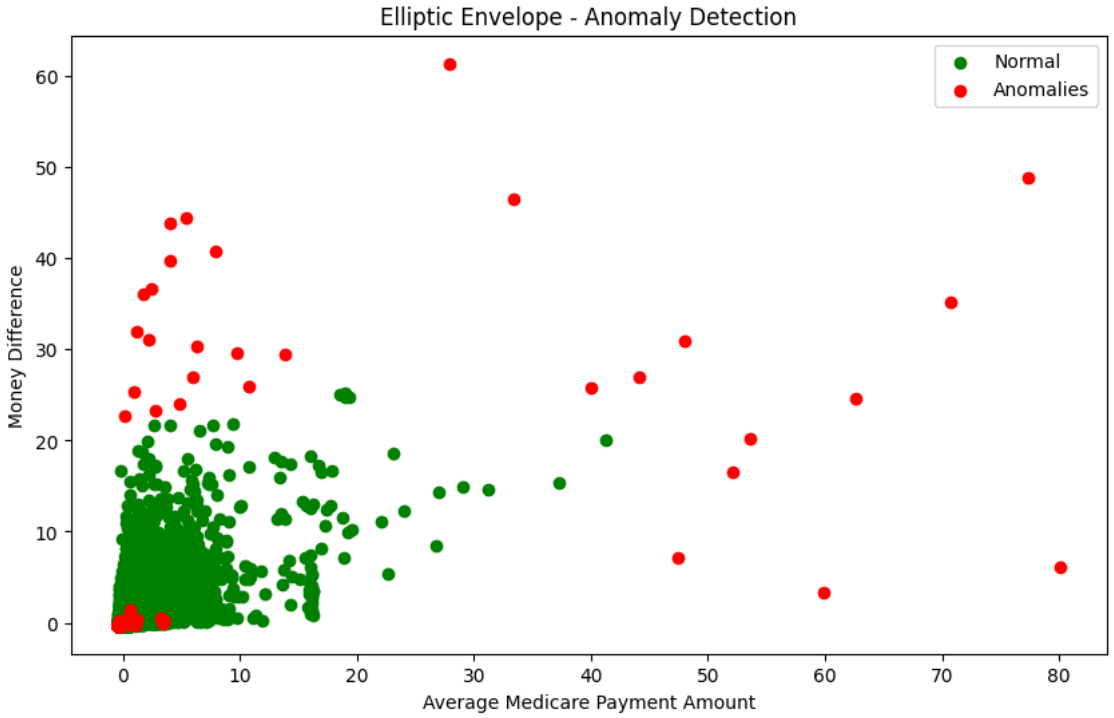
The above graph represents the distribution of anomalies on the basis of Avergae Medicare Payment Amount and Average Submitted Charge Amount columns

[379]:
```
result = df.iloc[:, [4, 6]].to_numpy()

X_transformed = result

plt.figure(figsize=(10, 6))

# Plot inliers
plt.scatter(X_transformed[labels == 1][:, 0], X_transformed[labels == 1][:, 1],␣
 ↪c='green', label='Normal')

# Plot anomalies
plt.scatter(X_transformed[labels == -1][:, 0], X_transformed[labels == -1][:,␣
 ↪1], c='red', label='Anomalies')

plt.legend()
plt.title('Elliptic Envelope - Anomaly Detection')
plt.xlabel('Average Submitted Charge Amount')
plt.ylabel('Money Difference')
plt.show()
```



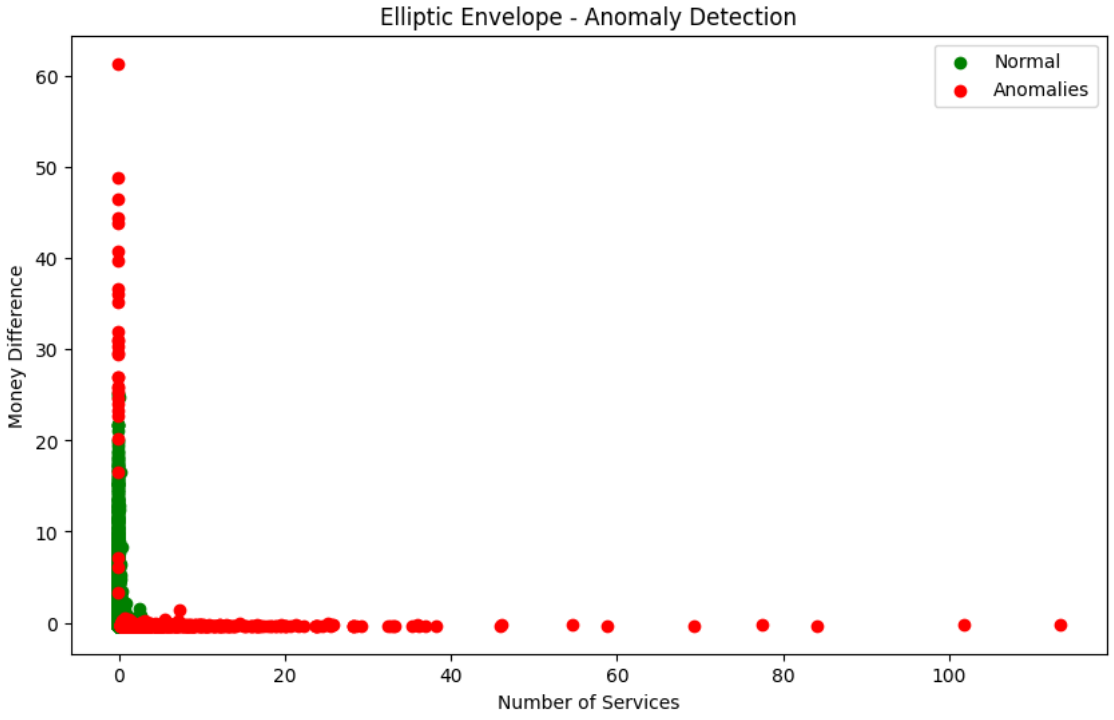
The above graph represents the distribution of anomalies on the basis of Money difference and Average Submitted Charge Amount columns

[380]:
```
result = df.iloc[:, [5, 6]].to_numpy()

X_transformed = result

plt.figure(figsize=(10, 6))

# Plot inliers
plt.scatter(X_transformed[labels == 1][:, 0], X_transformed[labels == 1][:, 1],␣
 ↪c='green', label='Normal')

# Plot anomalies
plt.scatter(X_transformed[labels == -1][:, 0], X_transformed[labels == -1][:,␣
 ↪1], c='red', label='Anomalies')

plt.legend()
plt.title('Elliptic Envelope - Anomaly Detection')
plt.xlabel('Average Medicare Payment Amount')
plt.ylabel('Money Difference')
plt.show()
```



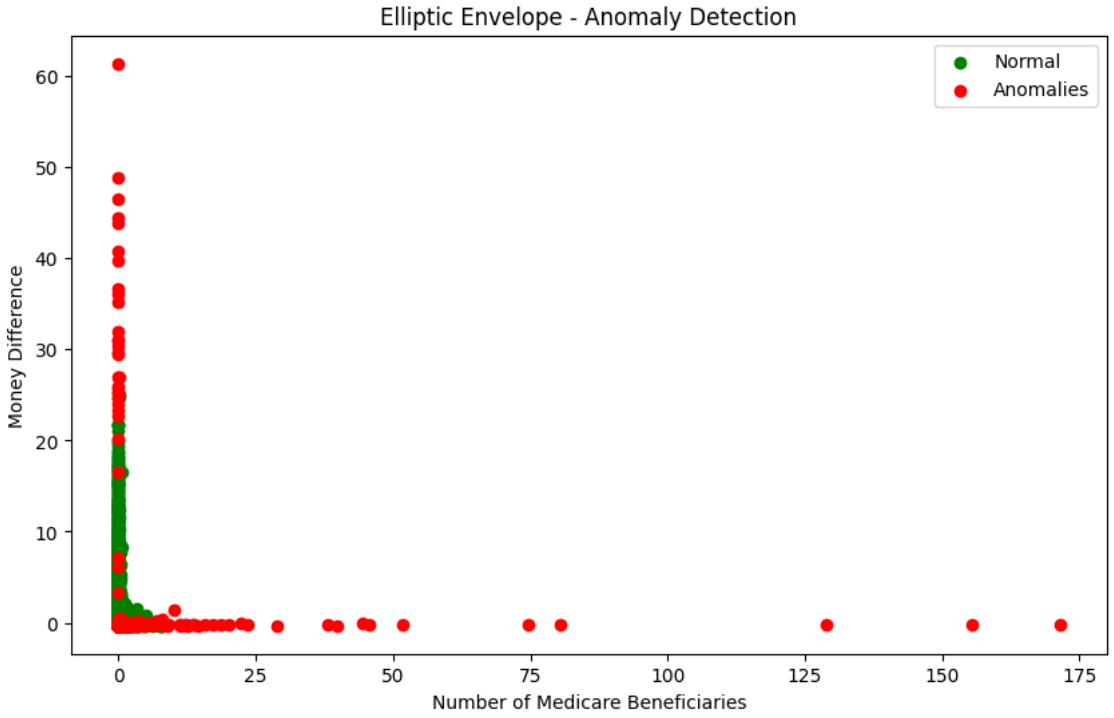
The above graph represents the distribution of anomalies on the basis of Money difference and Average Medicare Payment Amount columns

[381]:
```
result = df.iloc[:, [1, 6]].to_numpy()

X_transformed = result

plt.figure(figsize=(10, 6))

# Plot inliers
plt.scatter(X_transformed[labels == 1][:, 0], X_transformed[labels == 1][:, 1],␣
 ↪c='green', label='Normal')

# Plot anomalies
plt.scatter(X_transformed[labels == -1][:, 0], X_transformed[labels == -1][:,␣
 ↪1], c='red', label='Anomalies')


plt.legend()
plt.title('Elliptic Envelope - Anomaly Detection')
plt.xlabel('Number of Services')
plt.ylabel('Money Difference')
plt.show()
```



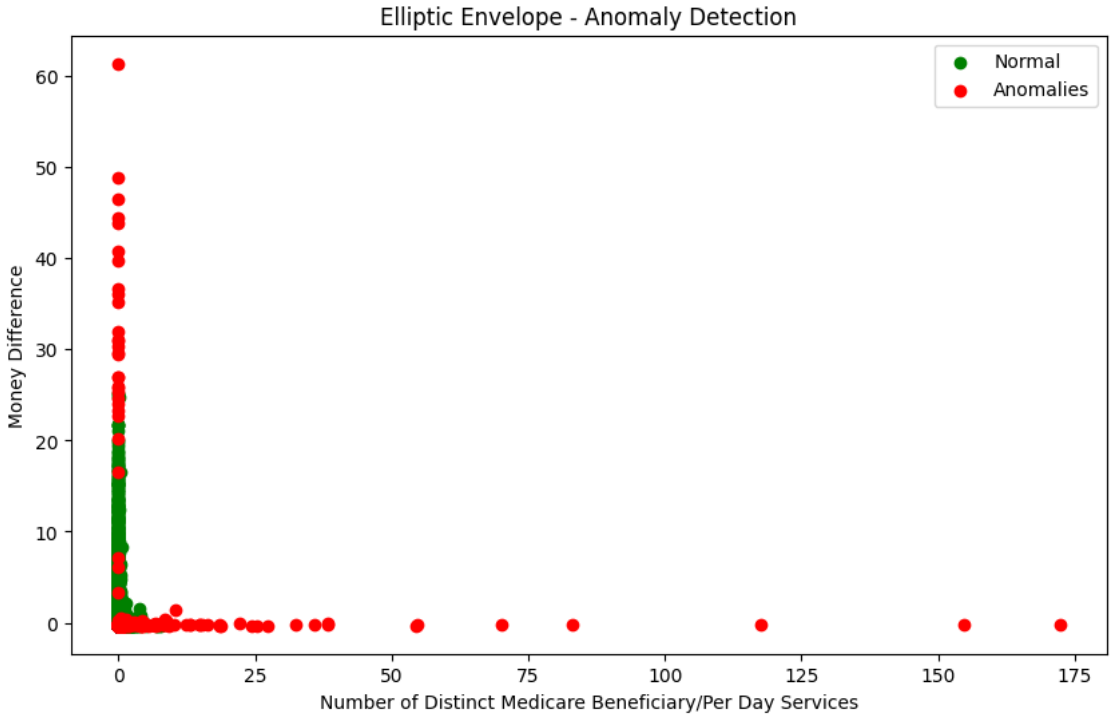
The above graph represents the distribution of anomalies on the basis of Money difference and Number of Services columns

[382]:
```
result = df.iloc[:, [2, 6]].to_numpy()

X_transformed = result

plt.figure(figsize=(10, 6))

# Plot inliers
plt.scatter(X_transformed[labels == 1][:, 0], X_transformed[labels == 1][:, 1],␣
 ↪c='green', label='Normal')

# Plot anomalies
plt.scatter(X_transformed[labels == -1][:, 0], X_transformed[labels == -1][:,␣
 ↪1], c='red', label='Anomalies')

plt.legend()
plt.title('Elliptic Envelope - Anomaly Detection')
plt.xlabel('Number of Medicare Beneficiaries')
plt.ylabel('Money Difference')
plt.show()
```



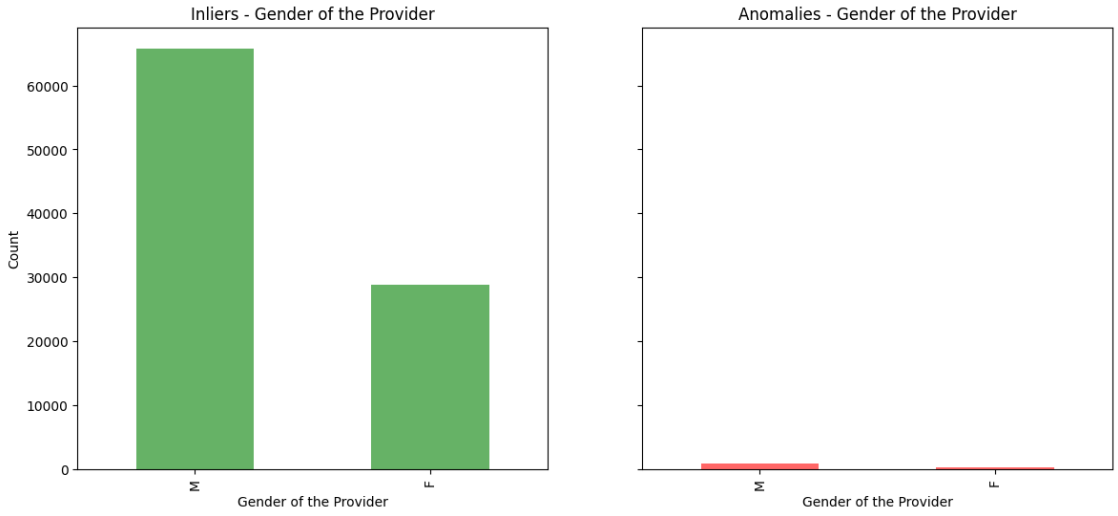
The above graph represents the distribution of anomalies on the basis of Money difference and Number of Medicare Benficiary columns

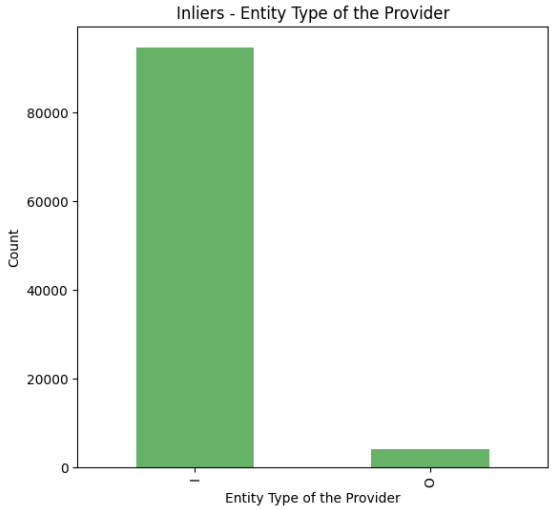
[383]:
```
result = df.iloc[:, [3, 6]].to_numpy()

X_transformed = result

plt.figure(figsize=(10, 6))

# Plot inliers
plt.scatter(X_transformed[labels == 1][:, 0], X_transformed[labels == 1][:, 1],␣
 ↪c='green', label='Normal')

# Plot anomalies
plt.scatter(X_transformed[labels == -1][:, 0], X_transformed[labels == -1][:,␣
 ↪1], c='red', label='Anomalies')

plt.legend()
plt.title('Elliptic Envelope - Anomaly Detection')
plt.xlabel('Number of Distinct Medicare Beneficiary/Per Day Services')
plt.ylabel('Money Difference')
plt.show()
```

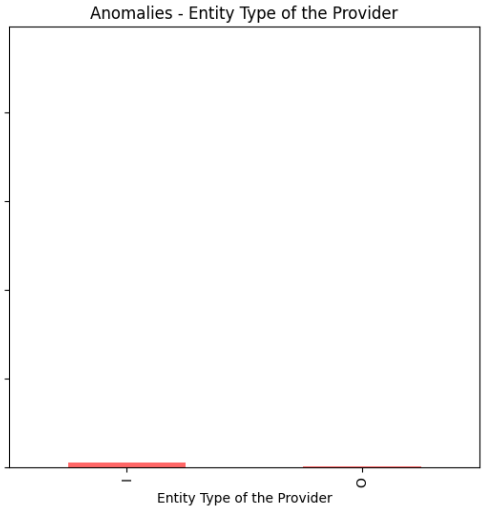


The above graph represents the distribution of anomalies on the basis of Money difference and Number of Medicare Benficiary/Per Day Services columns

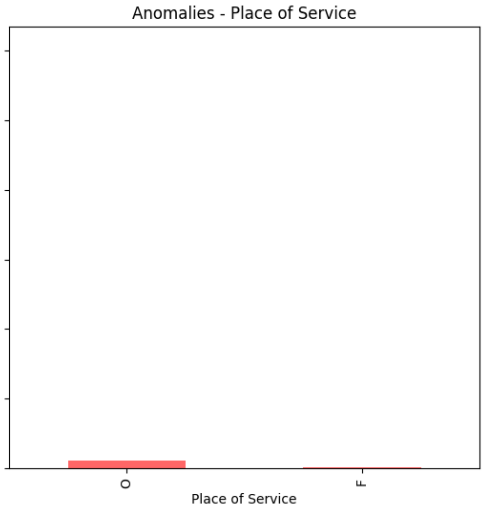
[384]:
```
inliers = df_org[df_org['Anomaly'] == 1]
anomalies = df_org[df_org['Anomaly'] == -1]

# Function to plot categorical feature distributions
def plot_categorical_feature(df_org, feature):
    fig, ax = plt.subplots(1, 2, figsize=(14, 6), sharey=True)

    # Plot for inliers
    inliers[feature].value_counts().plot(kind='bar', ax=ax[0], color='green',␣
 ↪alpha=0.6)
    ax[0].set_title(f'Inliers - {feature}')
    ax[0].set_ylabel('Count')

    # Plot for anomalies
    anomalies[feature].value_counts().plot(kind='bar', ax=ax[1], color='red',␣
 ↪alpha=0.6)
    ax[1].set_title(f'Anomalies - {feature}')

    plt.show()

# Plot the categorical features
plot_categorical_feature(df_org, 'Gender of the Provider')
plot_categorical_feature(df_org, 'Entity Type of the Provider')
plot_categorical_feature(df_org, 'Place of Service')
plot_categorical_feature(df_org, 'Medicare Participation Indicator')
plot_categorical_feature(df_org, 'HCPCS Drug Indicator')
```

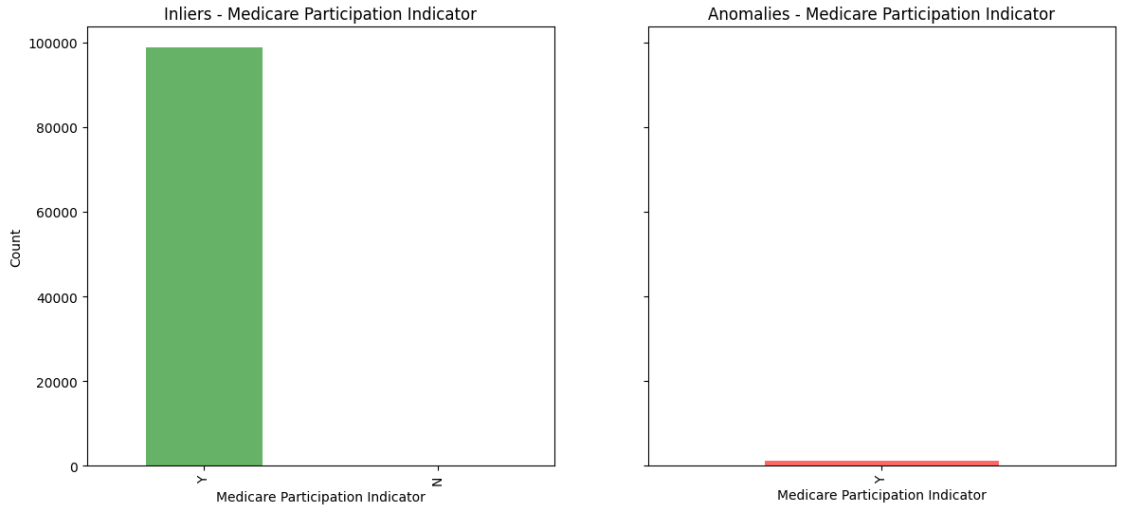


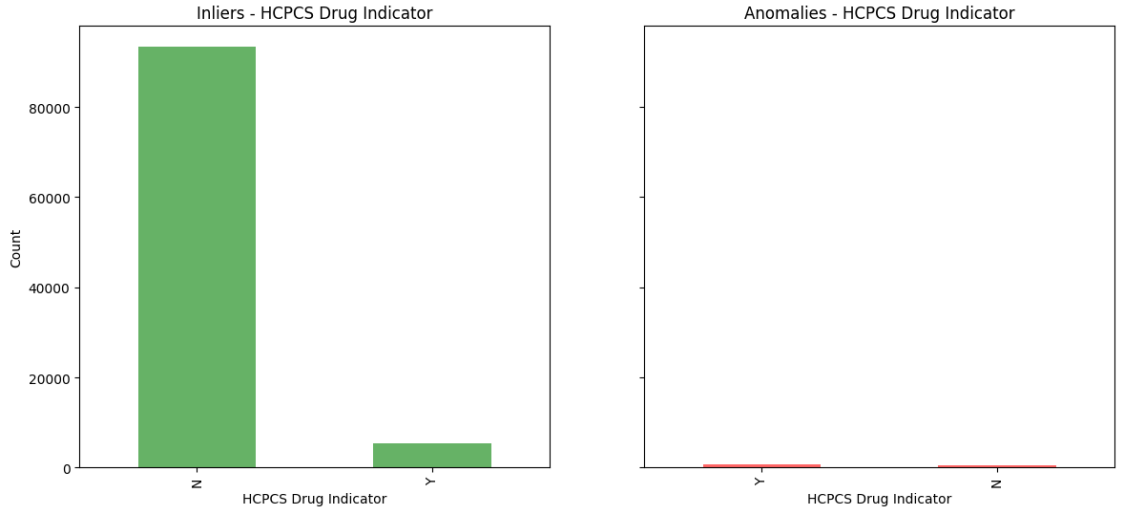

Inliers - Entity Type of the Provider
Count
80000
60000
40000
20000
0
I
O
Entity Type of the Provider


Anomalies - Entity Type of the Provider
I
O
Entity Type of the Provider


Inliers - Place of Service
Count
60000
50000
40000
30000
20000
10000
0
O
F
Place of Service


Anomalies - Place of Service
O
F
Place of Service





The above bar graphs shows us the distribution of anomalies in the categorical columns

[385]:
```
df.drop(columns=['Number of Distinct Medicare Beneficiary/Per Day␣
↪Services','Number of Medicare Beneficiaries','Number of Services'],␣
↪inplace=True)
```

3.0.9 Using One Class SVM to fit on the dataset and predicting anomalies

[386]:
```
ocsvm = OneClassSVM(kernel='rbf', gamma=0.1, nu=0.01)
```

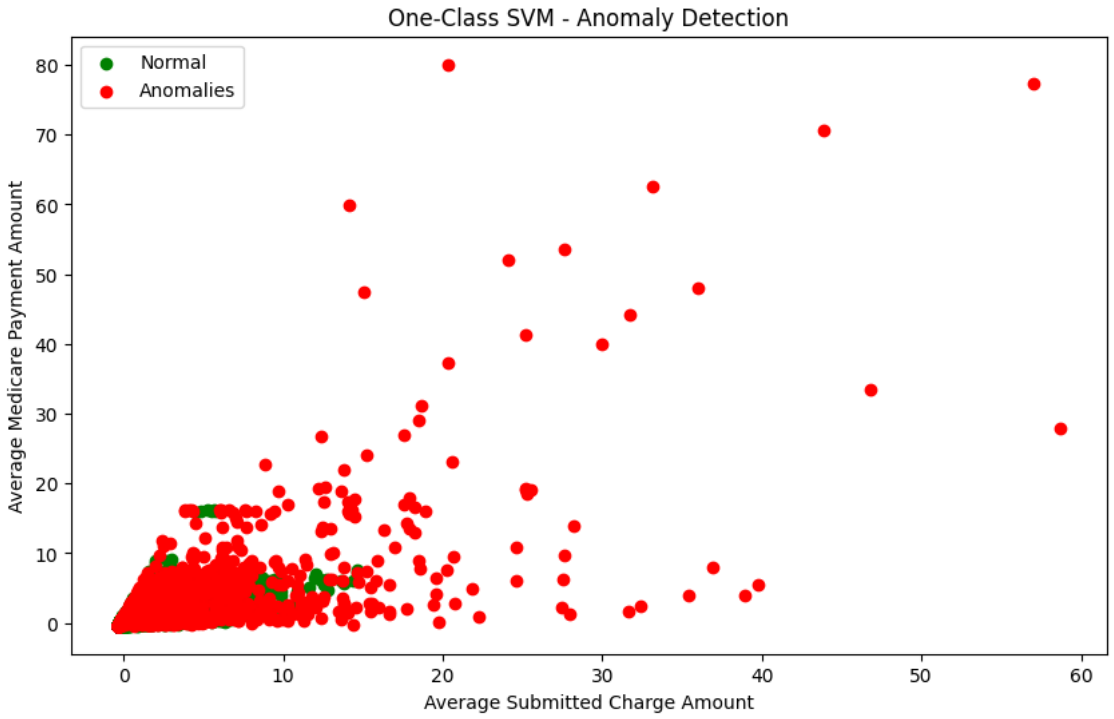
[387]:
```
ocsvm.fit(X)
```

[387]:
```
OneClassSVM(gamma=0.1, nu=0.01)
```

[388]:
```
labels = ocsvm.predict(X)

scores = ocsvm.decision_function(X)
```

[389]:
```
df_org['Anomaly'] = labels
```

[390]:
```
result = df.iloc[:, [1, 2]].to_numpy()

X_transformed = result

plt.figure(figsize=(10, 6))

# Plot inliers
plt.scatter(X_transformed[labels == 1][:, 0], X_transformed[labels == 1][:, 1],␣
 ↪c='green', label='Normal')

# Plot anomalies
plt.scatter(X_transformed[labels == -1][:, 0], X_transformed[labels == -1][:,␣
 ↪1], c='red', label='Anomalies')

plt.legend()
plt.title('One-Class SVM - Anomaly Detection')
plt.xlabel('Average Submitted Charge Amount')
plt.ylabel('Average Medicare Payment Amount')
plt.show()
```



The above graph represents the distribution of anomalies on the basis of Average Medicare Payment Amount and Average Submitted Charge Amount columns

[391]:
```
list(labels).count(-1)
```

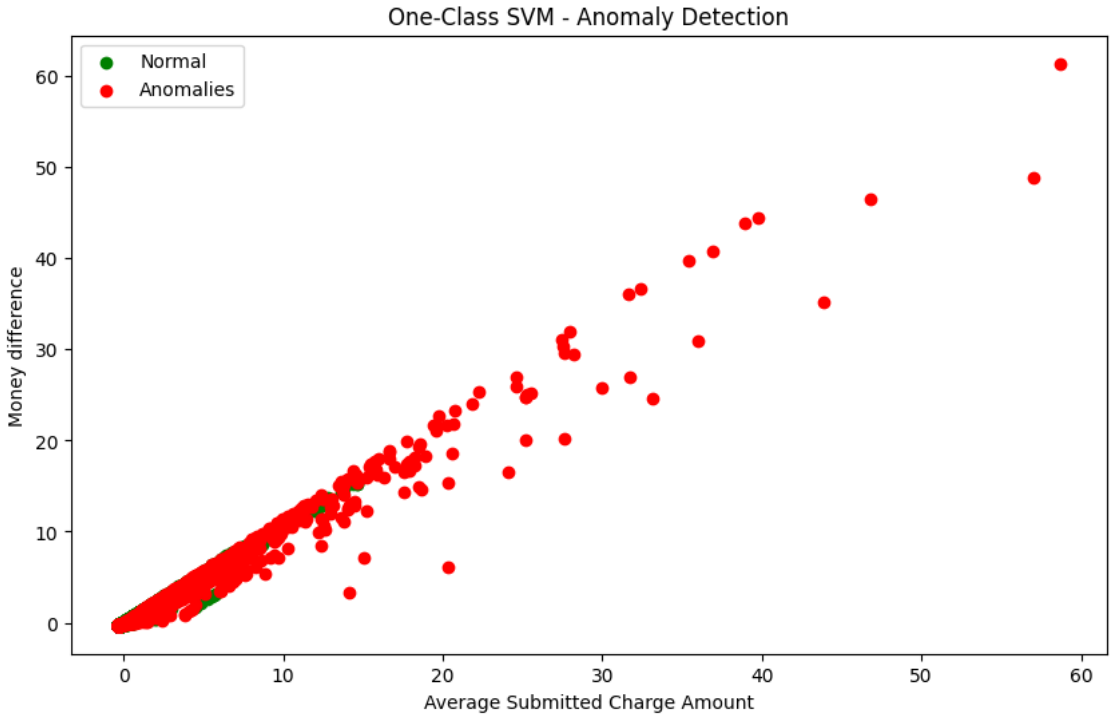
[391]: 1050

[392]:
```
list(labels).count(1)
```

[392]: 98950

[393]:
```
result = df.iloc[:, [1, 3]].to_numpy()

X_transformed = result

plt.figure(figsize=(10, 6))

# Plot inliers
plt.scatter(X_transformed[labels == 1][:, 0], X_transformed[labels == 1][:, 1],␣
↪c='green', label='Normal')

# Plot anomalies
plt.scatter(X_transformed[labels == -1][:, 0], X_transformed[labels == -1][:,␣
↪1], c='red', label='Anomalies')
```

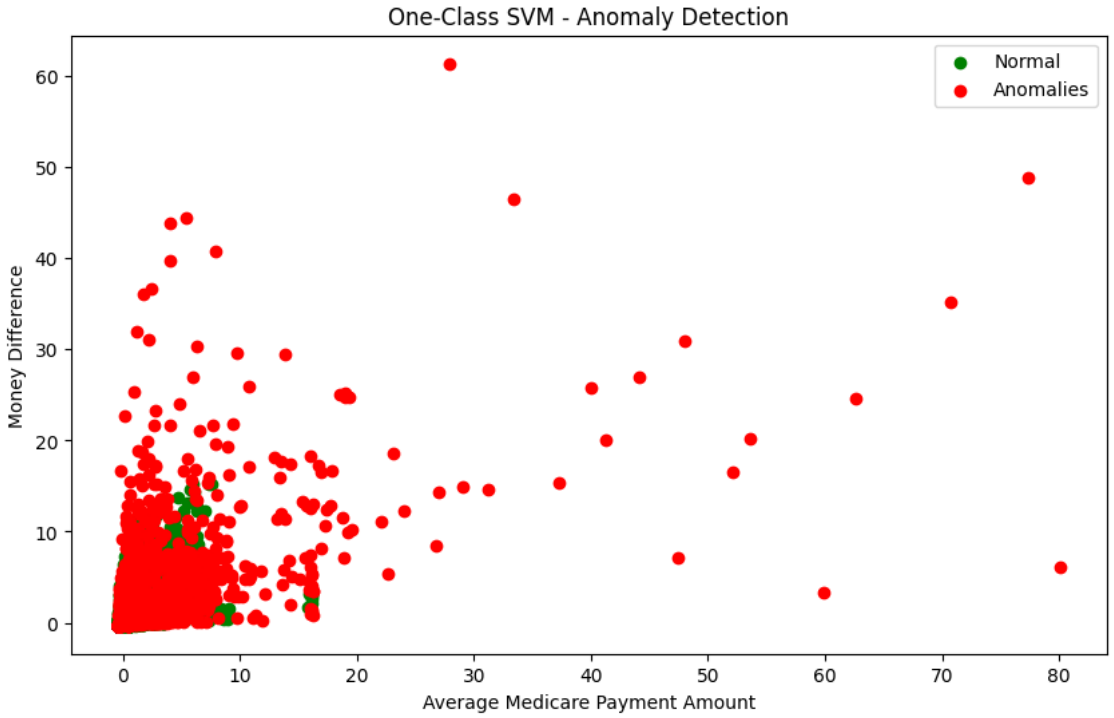
```
plt.legend()
plt.title('One-Class SVM - Anomaly Detection')
plt.xlabel('Average Submitted Charge Amount')
plt.ylabel('Money difference')
plt.show()
```



The above graph represents the distribution of anomalies on the basis of Money difference and Average Submitted Charge Amount columns

[394]:
```
result = df.iloc[:, [2, 3]].to_numpy()

X_transformed = result

plt.figure(figsize=(10, 6))

# Plot inliers
plt.scatter(X_transformed[labels == 1][:, 0], X_transformed[labels == 1][:, 1],␣
 ↪c='green', label='Normal')

# Plot anomalies
plt.scatter(X_transformed[labels == -1][:, 0], X_transformed[labels == -1][:,␣
 ↪1], c='red', label='Anomalies')
```

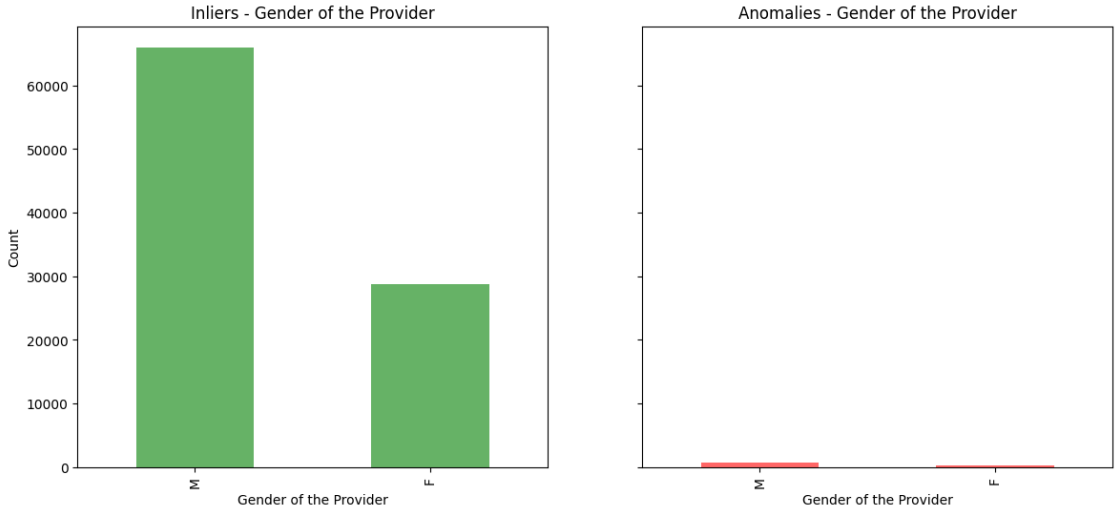
```
plt.legend()
plt.title('One-Class SVM - Anomaly Detection')
plt.xlabel('Average Medicare Payment Amount')
plt.ylabel('Money Difference')
plt.show()
```

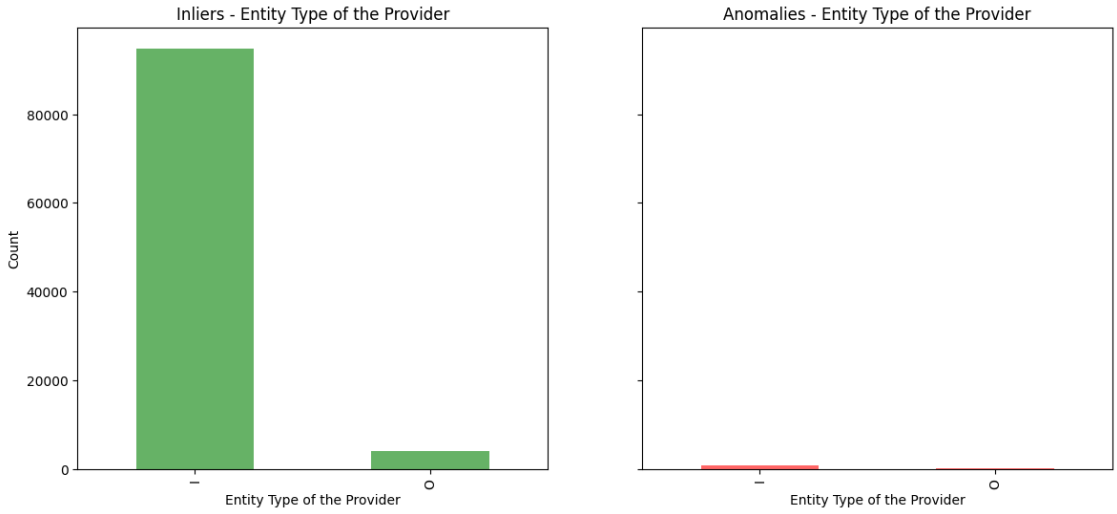


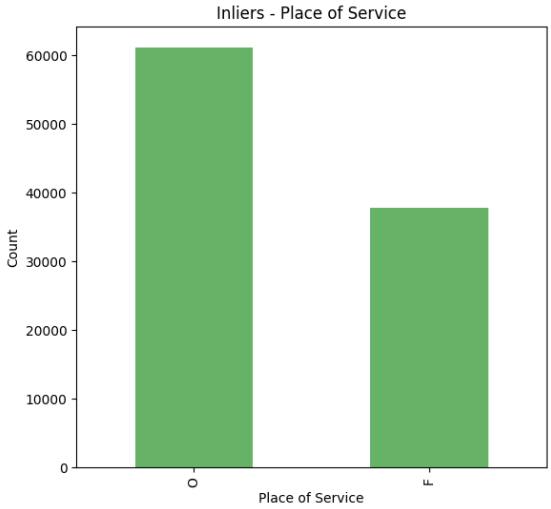
The above graph represents the distribution of anomalies on the basis of Money difference and Average Medicare Payment Amount columns

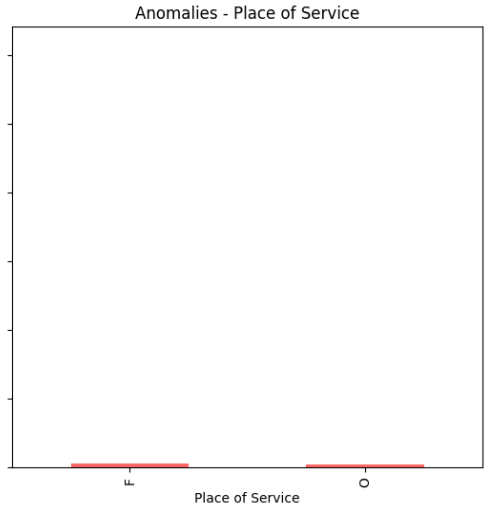
[395]:
```
inliers = df_org[df_org['Anomaly'] == 1]
anomalies = df_org[df_org['Anomaly'] == -1]

# Function to plot categorical feature distributions
def plot_categorical_feature(df_org, feature):
    fig, ax = plt.subplots(1, 2, figsize=(14, 6), sharey=True)

    # Plot for inliers
    inliers[feature].value_counts().plot(kind='bar', ax=ax[0], color='green',␣
 ↪alpha=0.6)
    ax[0].set_title(f'Inliers - {feature}')
    ax[0].set_ylabel('Count')

    # Plot for anomalies
```

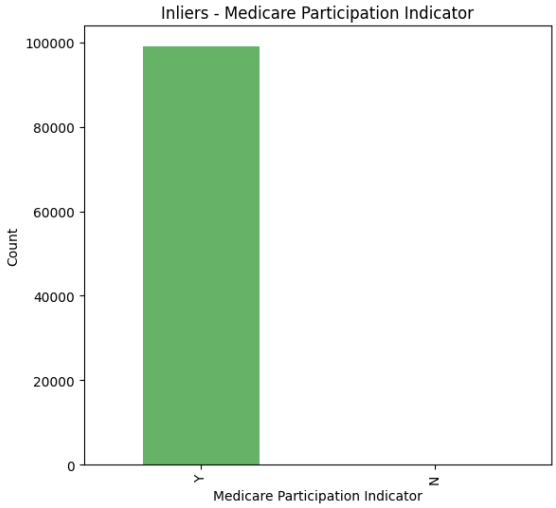
```
    anomalies[feature].value_counts().plot(kind='bar', ax=ax[1], color='red',␣
 ↪alpha=0.6)
    ax[1].set_title(f'Anomalies - {feature}')

    plt.show()

# Plot the categorical features
plot_categorical_feature(df_org, 'Gender of the Provider')
plot_categorical_feature(df_org, 'Entity Type of the Provider')
plot_categorical_feature(df_org, 'Place of Service')
plot_categorical_feature(df_org, 'Medicare Participation Indicator')
plot_categorical_feature(df_org, 'HCPCS Drug Indicator')
```

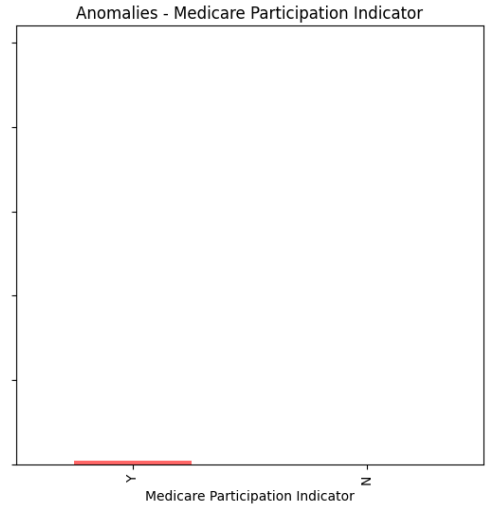


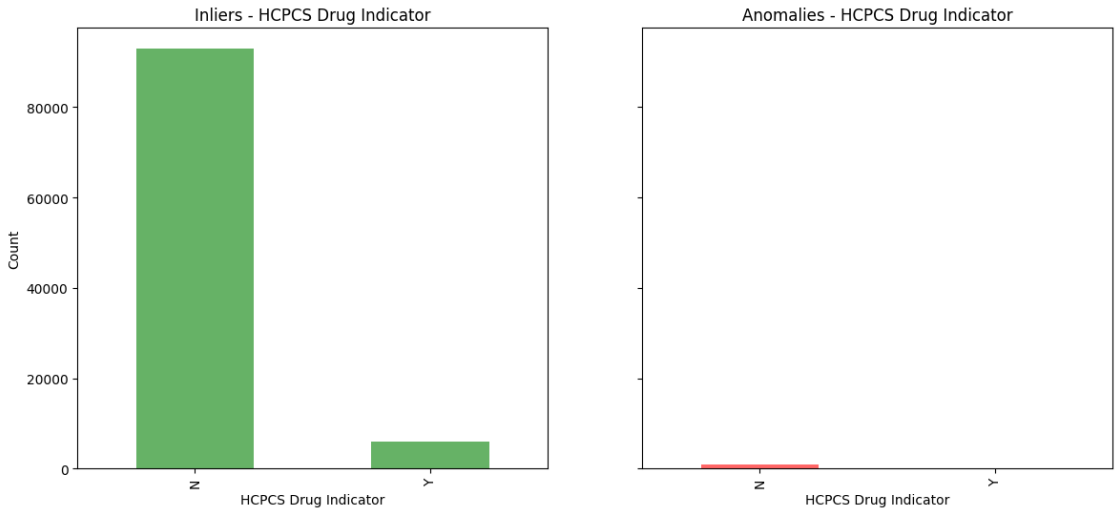



Inliers - Place of Service
Count
60000
50000
40000
30000
20000
10000
0
O
F
Place of Service


Anomalies - Place of Service
F
O
Place of Service


Inliers - Medicare Participation Indicator
Count
100000
80000
60000
40000
20000
0
Y
N
Medicare Participation Indicator


Anomalies - Medicare Participation Indicator
Y
N
Medicare Participation Indicator



The above bar graphs shows us the distribution of anomalies in the categorical columns

In the above the code we implemented three anomaly detection models: Isolation Forest, Elliptic Envelope and One Class SVM. The three models were fit to the dataset and they were used to predict and mark anomalies in the dataset. The Isolation Forest model marked 1000 anomalies, the Elliptic Envelope marked 1270 anomalies and the One Class SVM marked 1050. All the results are really similar to each so we can assume that the number of anomalies lie in the 1000 to 1200 range. The plots are also useful in us visualizing the distribution of anomalies in the dataset. The bar plots are also used to visualize the distribution of anomalies in the categorical columns. We can also infer from the models that the number of anomalies is really less which is roughly about 1% of the total dataset.