EDA

In [ ]:

```
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
```

Transactions Data Set

In [ ]:

```
df = pd.read_csv('data/HI-Small_Trans_adjusted.csv')

def rename_columns(df):
    new_cols = {}
    for col in df.columns:
        new_col = col.lower().replace(' ', '_')
        new_cols[col] = new_col
    return df.rename(columns=new_cols)


df = rename_columns(df)
# Rename the 'account' column to 'from_account'
df = df.rename(columns={'account': 'from_account'})

# Rename the 'account.1' column to 'to_account'
df = df.rename(columns={'account.1': 'to_account'})
```

In [ ]:

```
df.head()
```

Out[ ]:

	timestamp	from_bank	from_account	to_bank	to_account	amount_received	receiving_
0	2022/09/01 00:20	10	8000EBD30	10	8000EBD30	3697.34	
1	2022/09/01 00:20	3208	8000F4580	1	8000F5340	0.01	
2	2022/09/01 00:00	3209	8000F4670	3209	8000F4670	14675.57	
3	2022/09/01 00:02	12	8000F5030	12	8000F5030	2806.97	
4	2022/09/01 00:06	10	8000F5200	10	8000F5200	36682.97	

In [ ]:

```
# save the dataframe to a new csv file overwriting the old one
# df.to_csv('data/HI-Small_Trans_adjusted.csv', index=False)
```

In [ ]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 4375554 entries, 0 to 4375553
Data columns (total 11 columns):
 #   Column              Dtype  
---  ------              -----  
 0   timestamp           object 
 1   from_bank           int64  
 2   from_account        object 
 3   to_bank             int64  
 4   to_account          object 
 5   amount_received     float64
 6   receiving_currency  object 
 7   amount_paid         float64
 8   payment_currency    object 
 9   payment_format      object 
 10  is_laundering       int64  
dtypes: float64(2), int64(3), object(6)
memory usage: 367.2+ MB
```

In [ ]:

```
df.describe()
```

Out[ ]:

	from_bank	to_bank	amount_received	amount_paid	is_laundering
count	4.375554e+06	4.375554e+06	4.375554e+06	4.375554e+06	4.375554e+06
mean	4.504443e+04	6.593507e+04	6.024675e+06	4.601136e+06	9.543934e-04
std	8.023166e+04	8.437782e+04	1.028182e+09	8.833349e+08	3.087852e-02
min	1.000000e+00	1.000000e+00	1.000000e-06	1.000000e-06	0.000000e+00
25%	1.210000e+02	4.403000e+03	1.791800e+02	1.804600e+02	0.000000e+00
50%	1.005700e+04	2.157500e+04	1.435670e+03	1.439415e+03	0.000000e+00
75%	2.831700e+04	1.223320e+05	1.277631e+04	1.272508e+04	0.000000e+00
max	3.563030e+05	3.562940e+05	1.046302e+12	1.046302e+12	1.000000e+00

In [ ]:

```
'''Checking for any null values'''

print('Null Values =',df.isnull().values.any())
```

```
Null Values = False
```

Payment_format deep dive

In [ ]:

```
# Get the count and percentage of each payment format
counts = df['payment_format'].value_counts().to_frame()
counts['percentage_of_transaction'] = counts['payment_format'] / len(df) * 1
print(counts)
```

```
              payment_format  percentage_of_transaction
Cheque               1578228                  36.069215
Credit Card          1125878                  25.731096
ACH                   502115                  11.475461
Reinvestment          481056                  10.994174
Cash                  415462                   9.495072
Wire                  146948                   3.358386
Bitcoin               125867                   2.876596
```

In [ ]:

```
# Calculate the average amount paid per transaction for each payment format,

# Group the DataFrame by payment_format and calculate the mean payment amour
avg_amount = df.groupby('payment_format')['amount_paid'].mean()
```

```
# Divide the mean payment amount by the number of transactions for each paym
num_transactions = df['payment_format'].value_counts()
avg_amount_per_transaction = avg_amount / num_transactions

# Convert the resulting Series into a DataFrame and sort it by the average a
result_df = avg_amount_per_transaction.to_frame()

# rename column name to 'average_amount_paid'
result_df = result_df.rename(columns={0: 'average_amount_paid'})

# sort the values in descending order
result_df = result_df.sort_values(by='average_amount_paid', ascending=False)
result_df
```

Out[ ]:

	average_amount_paid
Wire	34.004149
ACH	21.282938
Cash	17.546826
Reinvestment	5.394401
Cheque	3.876954
Credit Card	0.077772
Bitcoin	0.000260

Bank Deep Dive

In [ ]:

```
# Get the count and percentage of transactions grouped by from_bank
from_counts = df.groupby('from_bank').size().sort_values(ascending=False).he
from_pct = from_counts / len(df) * 100

# Get the count and percentage of transactions grouped by to_bank
to_counts = df.groupby('to_bank').size().sort_values(ascending=False).head(1
to_pct = to_counts / len(df) * 100

# Combine the count and percentage results into a single DataFrame
result_df = pd.concat([from_counts, from_pct, to_counts, to_pct], axis=1, ke

# Print the resulting DataFrame
print(result_df)
```

```
     from_count  from_pct  to_count    to_pct
70     449859.0  8.858378       NaN       NaN
10      81629.0  1.607394   42547.0  0.837812
12      79754.0  1.570472   41872.0  0.824521
1       62211.0  1.225025   30115.0  0.593008
15      52511.0  1.034018   38721.0  0.762473
220     52417.0  1.032167   30625.0  0.603051
20      41008.0  0.807507   22048.0  0.434157
3       38413.0  0.756408   25627.0  0.504633
7       31086.0  0.612129   23029.0  0.453475
211     30451.0  0.599624   20576.0  0.405171
28          NaN       NaN   21160.0  0.416671
```

Bank Account Analyis

In [ ]:

```
# Get the count of distinct 'from_account' and 'to_account' values
from_count = df['from_account'].nunique()
to_count = df['to_account'].nunique()

print("Distinct 'from_account' count:", from_count)
print("Distinct 'to_account' count:", to_count)
```

```
Distinct 'from_account' count: 496995
Distinct 'to_account' count: 420636
```

In [ ]:

```
# Get the count and percentage of accounts that overlap between 'from_accoun
from_set = set(df['from_account'].unique())
to_set = set(df['to_account'].unique())
overlap_count = len(from_set.intersection(to_set))

total_count = len(from_set.union(to_set))

overlap_pct = overlap_count / total_count * 100

print("Number of accounts in both 'from_account' and 'to_account':", overlap
print("Percentage of accounts in both 'from_account' and 'to_account': {:.2f
```

```
Number of accounts in both 'from_account' and 'to_account': 402551
Percentage of accounts in both 'from_account' and 'to_account': 78.15%
```

In [ ]:

```
# Get the count and percentage of accounts that don't overlap between 'from_
from_set = set(df['from_account'].unique())
to_set = set(df['to_account'].unique())
non_overlap_count = len(from_set.symmetric_difference(to_set))

total_count = len(from_set.union(to_set))

non_overlap_pct = non_overlap_count / total_count * 100

print("Number of accounts not in both 'from_account' and 'to_account':", non
print("Percentage of accounts not in both 'from_account' and 'to_account': {
```

```
Number of accounts not in both 'from_account' and 'to_account': 112529
Percentage of accounts not in both 'from_account' and 'to_account': 21.85%
```

Check multicolinearity between variables

Check if we need to remove features based on the high colinearity.

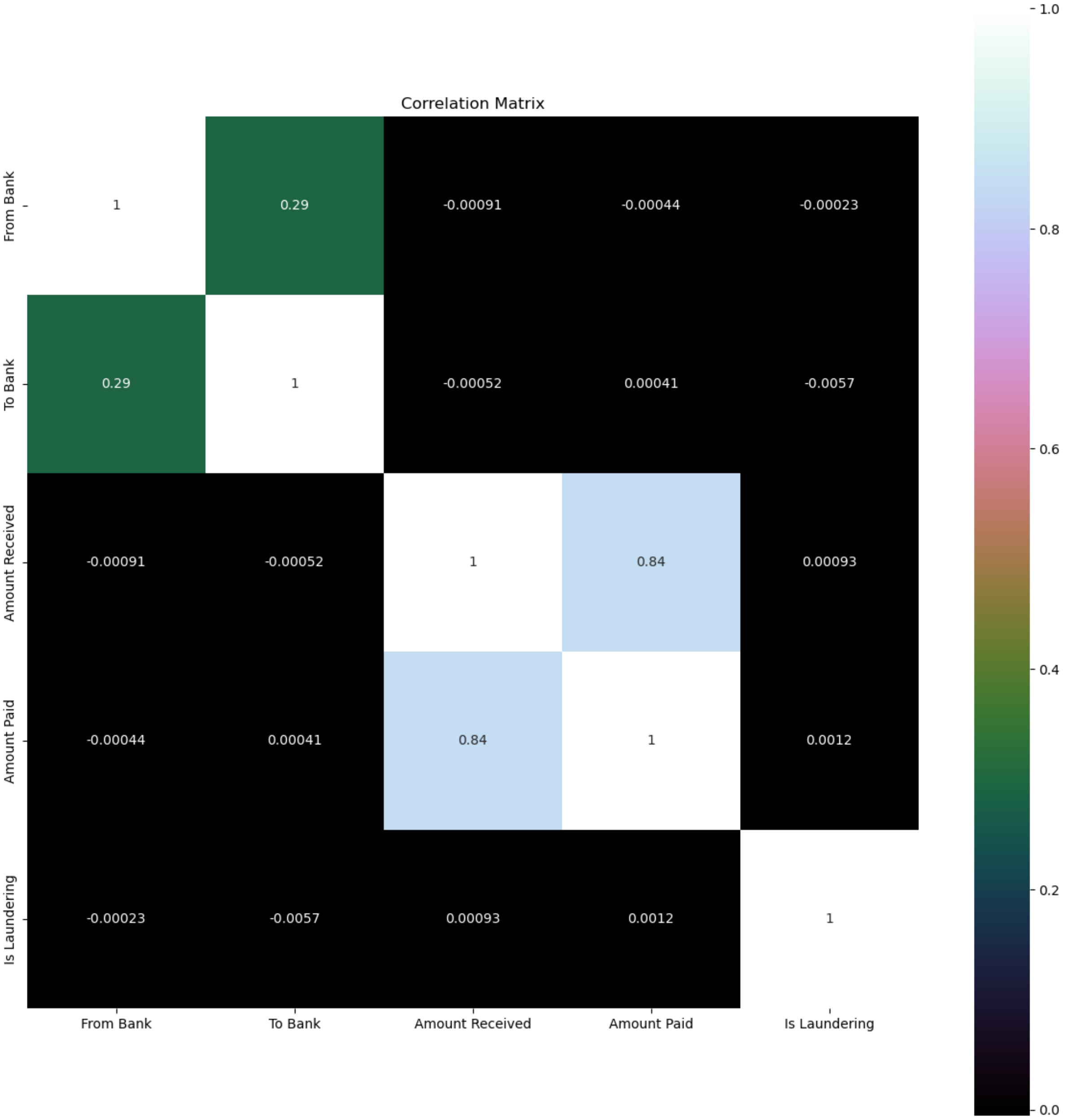
In [ ]:

```
''' correlation matrix to check multicolinearity between variables '''

correlation = df.corr()
plt.figure(figsize=(15,15))
plt.title('Correlation Matrix')
sns.heatmap(correlation, vmax=1, square=True,annot=True,cmap='cubehelix')
```

Out[ ]:

```
<AxesSubplot:title={'center':'Correlation Matrix'}>
```



Is_laudering = 1 Analysis

In [ ]:

```
# get rows where is_laudering is 1
df_laundering = df[df['is_laundering'] == 1]

# Get the count and percentage of each payment format
counts = df_laundering['payment_format'].value_counts().to_frame()
counts['percentage_of_transaction'] = counts['payment_format'] / len(df_laun
print(len(df_laundering) / len(df) * 100)
print(counts)
```

```
0.09543934322373807
                 payment_format  percentage_of_transaction
ACH                        3583                  85.799808
Cheque                      275                   6.585249
Credit Card                 178                   4.262452
Cash                         93                   2.227011
Bitcoin                      47                   1.125479
```

In [ ]:

```
# get rows where is_laudering is 0
df_isNotlaundering = df[df['is_laundering'] == 0]

# Get the count and percentage of each payment format
```

```
counts = df_isNotlaundering['payment_format'].value_counts().to_frame()
counts['percentage_of_transaction'] = counts['payment_format'] / len(df_isNo
print(counts)
```

```
              payment_format  percentage_of_transaction
Cheque               1577953                  36.097382
Credit Card          1125700                  25.751605
ACH                   498532                  11.404459
Reinvestment          481056                  11.004676
Cash                  415369                   9.502015
Wire                  146948                   3.361594
Bitcoin               125820                   2.878269
```

Money Laudering Patterns Data Set

Pre Processing

In [ ]:

```
# read the file
with open("data/HI-Small_Patterns.txt", "r") as f:
    lines = f.readlines()

patterns_data = []
current_laundering_id = 0
current_pattern_name = ""

# loop over the lines
for line in lines:
    line = line.strip()
    if not line:
        continue
    if line.startswith("BEGIN LAUNDERING ATTEMPT"):
        current_laundering_id += 1
        laundering_type = line.split(" - ")[1]
        current_pattern_name = laundering_type.split(":")[0].strip()
    elif line.startswith("END LAUNDERING ATTEMPT"):
        continue
    else:
        cols = line.split(",")
        cols = [col.strip() for col in cols]
        cols.append(laundering_type)
        cols.append(current_laundering_id)
        cols.append(current_pattern_name)
        patterns_data.append(cols)

# convert to dataframe
patterns = pd.DataFrame(patterns_data, columns=['timestamp', 'from_bank', 'f
                                 'receiving_currency', 'amount_paid', 'payme

# convert columns to appropriate data types
patterns['amount_received'] = patterns['amount_received'].astype(float)
patterns['amount_paid'] = patterns['amount_paid'].astype(float)
```

In [ ]:

```
#patterns.to_csv("data/patterns_dataframe.csv", index=False)
```

In [ ]:

```
patterns = pd.read_csv("data/patterns_dataframe.csv")
```

In [ ]:

```
# display the first few rows of the DataFrame
patterns[20:30]
```

Out[ ]:

	timestamp	from_bank	from_account	to_bank	to_account	amount_received	receivin
20	2022/09/03 10:20	24856	8090E8EB0	71	804ABCE90	637140.60	
21	2022/09/03 12:08	71	804ABCE90	213737	805494C30	621578.18	
22	2022/09/03 13:24	213737	805494C30	14290	801B949C0	7222.58	
23	2022/09/04 03:24	14290	801B949C0	10057	803DE1580	892031.21	
24	2022/09/04 09:44	10057	803DE1580	28628	80ACEE280	11364.12	Aust
25	2022/09/04 15:51	28628	80ACEE280	1467	8013C4030	7945.55	
26	2022/09/01 00:04	119	811C597B0	48309	811C599A0	34254.65	
27	2022/09/01 19:27	150240	812D22980	48309	811C599A0	5971.98	
28	2022/09/04 05:06	222	811B83280	48309	811C599A0	50445.58	
29	2022/09/04 05:03	48309	811C599A0	48309	811C599A0	48649.42	

In [ ]:

```
patterns.columns
```

Out[ ]:

```
Index(['timestamp', 'from_bank', 'from_account', 'to_bank', 'to_account',
       'amount_received', 'receiving_currency', 'amount_paid',
       'payment_currency', 'payment_format', 'is_laundering',
       'laundering_type', 'pattern_id', 'pattern_name'],
      dtype='object')
```

Payment Format Deep Dive

In [ ]:

```
# Get the count and percentage of each payment format
counts = patterns['payment_format'].value_counts().to_frame()
counts['percentage_of_transaction'] = counts['payment_format'] / len(pattern
print(counts)
```

```
         payment_format  percentage_of_transaction
ACH                3208                  99.968838
Bitcoin               1                   0.031162
```

Pattern Analysis

In [ ]:

```
# count the number of unique patterns
pattern_count = patterns['pattern_name'].nunique()
print("Number of unique patterns:", pattern_count)
```

```
Number of unique patterns: 8
```

In [ ]:

```
# count the number of unique patterns_id for each pattern_name and sort the
pattern_id_count = patterns.groupby('pattern_name')['pattern_id'].nunique().
print(pattern_id_count)
```

```
pattern_name
CYCLE              54
GATHER-SCATTER     51
BIPARTITE          49
FAN-OUT            48
SCATTER-GATHER     44
STACK              43
RANDOM             41
FAN-IN             40
Name: pattern_id, dtype: int64
```

In [ ]:

```
# count the number of unique from_account for each pattern_name and sort the
from_account_count = patterns.groupby('pattern_name')['from_account'].nuniqu
print(from_account_count)
```

```
pattern_name
STACK              446
GATHER-SCATTER     380
SCATTER-GATHER     339
FAN-IN             307
CYCLE              271
BIPARTITE          250
RANDOM             181
FAN-OUT             43
Name: from_account, dtype: int64
```

In [ ]: