UBS - Code Assessment

Exercise 1 - Longest run of heads in a sequence of coin tosses

In [4]:

```python
import numpy as np
import random
import matplotlib.pyplot as plt
from matplotlib.ticker import MaxNLocator
from matplotlib import pyplot as plt
```

1.A) Write an effcient function which generates random sequences of heads and tails for any value of n

In [4]:

```python
def coinToss (n):
    sequence=[]
    for i in range (n):
        toss=random.randint(0,1)  # We generate random numbers between 0 and 1
        if toss==0:
            sequence.append("T")  # If number is 0, we call it Tails and add it to the
        if toss==1:
            sequence.append("H")  # If number is 1, we call it Heads and add it to the
    return sequence

random_toss = coinToss (10)
print (random_toss)
```

```
['T', 'T', 'H', 'H', 'T', 'T', 'T', 'T', 'H', 'T']
```

1.B) Write an efficient function which computes the length of the longest run of heads in an arbitrary sequence of heads and tails.

In [8]:

```python
def headRun (random_toss):
    current_headRun=0
    max_headRun=0
    for i in random_toss: # We iterate through every element of the random toss seque
        if i=='H':
            current_headRun+=1  # Every H found is added to counter of current headRun
            if current_headRun>max_headRun:   # If the current head run larger than ma
                max_headRun=current_headRun   # we set a new max
        else:
            current_headRun=0 # If no H is found, current head run resets back to 0
    return max_headRun

random_toss = coinToss (1000)
max_headRun = headRun (random_toss)
#print (random_toss)
print (max_headRun)
```

```
9
```

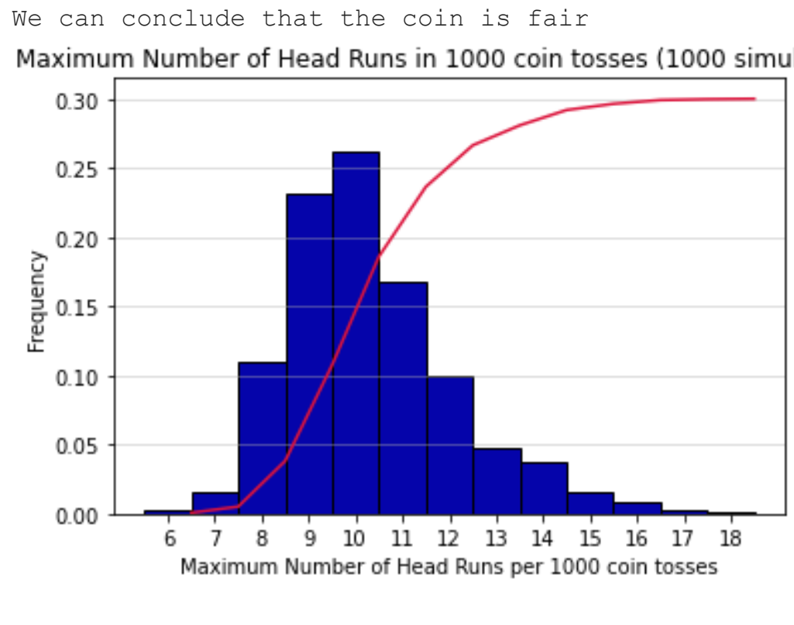
1.C) For a sequence of length n = 1000, we have observed a longest run of heads equal to M = 6.

Basing your decision on this piece of information, do you believe that the coin is fair or not? Please elaborate on your analysis and results.

In [33]:

```python
# Monte-Carlo Simulation
n_simulations=1000
max_headRun_list = []
for i in range(n_simulations):
    random_toss = coinToss (1000) # We generate 1000 random coin tosses
    max_headRun = headRun (random_toss) # We count the maximum number of run-heads
    max_headRun_list.append(max_headRun) # We add the max_headRun to a list

# Histogram - We create a histogram with all the head-runs saved in the previous list
n_bins=13
x, y, patches = plt.hist(max_headRun_list, density=True,
                         bins=n_bins,color='#0504aa',edgecolor="black")
plt.xticks([(patch._x0 + patch._x1)/2 for patch in patches],[i for i in range(6,19)])
plt.grid(axis='y', alpha=0.5)
plt.ylabel('Frequency')
plt.xlabel('Maximum Number of Head Runs per 1000 coin tosses')
plt.title('Maximum Number of Head Runs in 1000 coin tosses (1000 simulations)\n')

# Cumulative Distribution Function
dx = y[1] - y[0]
F1 = np.cumsum(x)*dx*0.3
plt.plot(y[1:], F1,color='#DC143C')

# Hypothesis Testing I - Monte-Carlo Approach
confidenceInterval = 0.99
alpha=round(1-confidenceInterval,3)
p_value=0

# WIn this loop, we calculate the cumulative frequency of 6 (sum of all the frequenci
for i in range (min(max_headRun_list),7):
    p_value += round(max_headRun_list.count(i)/n_simulations,3)   # For a lower-tailed

print ("Hypothesis: \n H0: mu = 6 \n H1: mu < 6")
print ("Significance Level: ",alpha," (99% Confidence Interval)")
print ("p-value (Cumulative Frequency of 6): ",p_value)
if p_value < alpha:
    print ("H0 can be rejected: ",p_value," < ",alpha)
    print ("We can conclude that the coin IS NOT fair")
else:
    print ("H0 CANNOT be rejected: ",p_value," > ",alpha)
    print ("")
    print ("We can conclude that the coin is fair")
```

```
Hypothesis:
 H0: mu = 6
 H1: mu < 6
Significance Level:  0.01  (99% Confidence Interval)
p-value (Cumulative Frequency of 6):  0.017
H0 CANNOT be rejected:  0.017  >  0.01

We can conclude that the coin is fair
```



Exercise 2 - Outlier detection and statistics

2.A) Load the data of the csv file into a data format of your choice

In [5]:

```python
import pandas as pd

df=pd.read_csv('/Users/alvarosanchezfernandez/Documents/Programming/Raw Data/data.csv
df_list = df.values.tolist()

GDP=df_list[0]
GDP=GDP[1:len(GDP)]
GDP = [x for x in GDP if pd.isnull(x) == False]
GDP_vect=[]
GDP_dx=(max(GDP)-min(GDP))/(len(GDP))
for i in range(len(GDP)):
    GDP_vect.append([GDP[i],i*GDP_dx])
print (GDP_vect)

LIBOR=df_list[1]
LIBOR=LIBOR[1:len(LIBOR)]
LIBOR_vect=[]
LIBOR_dx=(max(LIBOR)-min(LIBOR))/(len(LIBOR))
for i in range(len(LIBOR)):
    LIBOR_vect.append([LIBOR[i],i*LIBOR_dx])
print (LIBOR_vect)

Eq1=df_list[2]
Eq1=Eq1[1:len(Eq1)]
Eq1_vect=[]
Eq1_dx=(max(Eq1)-min(Eq1))/(len(Eq1))
for i in range(len(Eq1)):
    Eq1_vect.append([Eq1[i],i*Eq1_dx])
print (Eq1_vect)

Eq2=df_list[3]
Eq2=Eq2[1:len(Eq2)]
Eq2 = [x for x in Eq2 if pd.isnull(x) == False]
Eq2_vect=[]
Eq2_dx=(max(Eq2)-min(Eq2))/(len(Eq2))
for i in range(len(Eq2)):
    Eq2_vect.append([Eq2[i],i*Eq2_dx])
print (Eq2_vect)

Eq3=df_list[4]
Eq3=Eq3[1:len(Eq3)]
Eq3 = [x for x in Eq3 if pd.isnull(x) == False]
Eq3_vect=[]
Eq3_dx=(max(Eq3)-min(Eq3))/(len(Eq3))
for i in range(len(Eq3)):
    Eq3_vect.append([Eq3[i],i*Eq3_dx])
print (Eq3_vect)
```

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8.4604395604395], [664.46, 928.7802197802197]]
```

In [ ]:

2.B) Detect potential outliers for each time series based on a simple methodology

In [32]:

```python
from sklearn.metrics.pairwise import euclidean_distances
from sklearn.cluster import DBSCAN
import pandas as pd

def DBSCAN_alg (eps, M, dataset_vector):
    print("Outlier Detection Algorithm:")

    mDistance = euclidean_distances(dataset_vector)
    clustering = density_clustering_DBSCAN(mDistance,eps,M)

    return clustering


def density_clustering_DBSCAN(mDistance, eps, M):
    labels = np.zeros(mDistance.shape[0])
    #print(labels)
    C = 0

    for i in np.arange(mDistance.shape[0]):

        if labels[i] != 0:
            continue

        vecindario = find_vecindario(mDistance, i, eps)
        #print('Vecindario:', vecindario)  # Uncomment to see output

        if len(vecindario)<M:
            # If it is NOT a nuclear point
            labels[i] = -1
        else:
            # If it is a nuclear point, a new C is assigned and we try to expand it
            C += 1
            labels[i] = C
            expand_cluster(mDistance, labels, vecindario, C, eps, M)
            #print(labels)

    return labels

def expand_cluster(mDistance, labels, vecindario, C, eps, M):
    it = 0
    while it < vecindario.size:
        j = vecindario[it]

        if labels[j] == -1:
            # If element has been labelled as no-nuclear
            labels[j] = C
        elif labels[j] == 0:
            # If element has not been labelled yet
            labels[j] = C
            # Calculation of vecindario
            vecindario_j = find_vecindario(mDistance, j, eps)
            if vecindario_j.size >= M:
                # If "j" is a nuclear point, it is mingledd with its neighbours
                # with the neighbourhood that we are analyzing
                vecindario = np.append(vecindario, vecindario_j)
        it += 1

def find_vecindario(mDistance, i, eps):
    vecinos = np.where(mDistance[i,:] < eps)[0]

    vecinos = vecinos[vecinos != i]

    return vecinos


# IMPORTANT! Dataset must have constant volatility
def outlier_detection (dataset, name):
    # I) Configuration of x-axis scale: x=range(y)
    #    between consecutive elements of the dataset
    dx =(max(dataset)-min(dataset))/(len(dataset))

    # II) Calculation of difference (delta)
    #    between consecutive elements of the dataset
    dataset_delta=[]
    for i in range(0,len(dataset)-1):
        dataset_delta.append(abs(dataset[i]-dataset[i+1]))

    # III) Calculation of the mean and standard deviation
    #     of the dataset differences
    dataset_delta_mean=np.mean(dataset_delta)
    dataset_delta_std=np.std(dataset_delta)**(1/2)

    # IV) Calculation of Chebyshev k: nº of std that
    #      contain at least 95% of observations
    k=(1/0.05)**(1/2)

    # V) Calculation of the epsilon: min distance
    #    between 2 points to be considered same cluster:
    #        Eps = 2*(dx^2 + 95% CI of daily variability)^(1/2)
    eps=2*(dx**2+(dataset_delta_mean+dataset_delta_std*k)**2)**(1/2)

    # VI) Determination of M: min 3 points within Eps. distance
    M=3

    # VII) Clustering process
    # Creation of the Dataset vector: [y,i*dx]
    dataset_vect=[]
    for i in range(len(dataset)):
        dataset_vect.append([dataset[i],i*dx])
    #clustering = DBSCAN (eps=eps, min_samples=M).fit(dataset_vect)
    clustering = DBSCAN_alg (eps,M,dataset_vect)

    # VIII) Printing Results
    print (name+" Outliers:")
    print (" - Delta mean:",dataset_delta_mean)
    print (" - Delta std:",dataset_delta_std)
    print (" - k: ",k)
    print (" - Epsilon: ",eps)
    print (" - M: ",M)
    #print (clustering.labels_)
    print(clustering)
    print ()

    return clustering

cluster_GDP   = outlier_detection (GDP, "GDP")
cluster_LIBOR = outlier_detection (LIBOR, "LIBOR")
cluster_Eq1   = outlier_detection (Eq1, "Equities I")
cluster_Eq2   = outlier_detection (Eq2, "Equities II")
cluster_Eq3   = outlier_detection (Eq3, "Equities III")
```

```
Outlier Detection Algorithm:
GDP Outliers:
 - Delta mean: 3080.262931818182
 - Delta std: 56.41750591131117
 - k:  4.47213595499958
 - Epsilon:  7348.799001038649
 - M:  3
[ 1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1. -1.  1.  1.  1.  1.  1.  1.
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  2.  2.  2.  2.  2.  2.  2.  2.  2.  2.  3.  3.  3.  3.  3.  3.  3.]

Outlier Detection Algorithm:
LIBOR Outliers:
 - Delta mean: 0.12706601503759402
 - Delta std: 0.44290452184477486
 - k:  4.47213595499958
 - Epsilon:  4.215738544315322
 - M:  3
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Outlier Detection Algorithm:
Equities I Outliers:
 - Delta mean: 170.56627819548874
 - Delta std: 11.987532911705578
 - k:  4.47213595499958
 - Epsilon:  449.54327669403915
 - M:  3
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 1. 1. 1.]

Outlier Detection Algorithm:
Equities II Outliers:
 - Delta mean: 77.20996138996139
 - Delta std: 10.03284466137934
 - k:  4.47213595499958
 - Epsilon:  244.8601224491558
 - M:  3
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  1.  1.  1.  1.  1.  1.  1.  1.]

Outlier Detection Algorithm:
Equities III Outliers:
 - Delta mean: 23.071444444444444
 - Delta std: 9.398752236818474
 - k:  4.47213595499958
 - Epsilon:  131.83354900643172
 - M:  3
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```

In [ ]: