

```
%load_ext autoreload
%autoreload 2

import cv2
import matplotlib.pyplot as plt
import numpy as np
from sklearn.metrics import mean_squared_error, mean_absolute_error

from functions.utils import *
from functions.cart import *

norm_image = np.ones((500,500))
#testim[20:30,100:200] += 1
norm_image[200:400,50:200] = 1 - norm_image[200:400, 50:200]
norm_image[50:150,100:400] = 1 - norm_image[50:150,100:400]
for i in range(5):
    norm_image[200+i:400+i:15,50:200] = 1 - norm_image[200+i:400+i:15,50:200]
    norm_image[50+i:150+i:10,100:400] = 1 - norm_image[50+i:150+i:10,100:400]
plt.imshow(norm_image,cmap='gray')

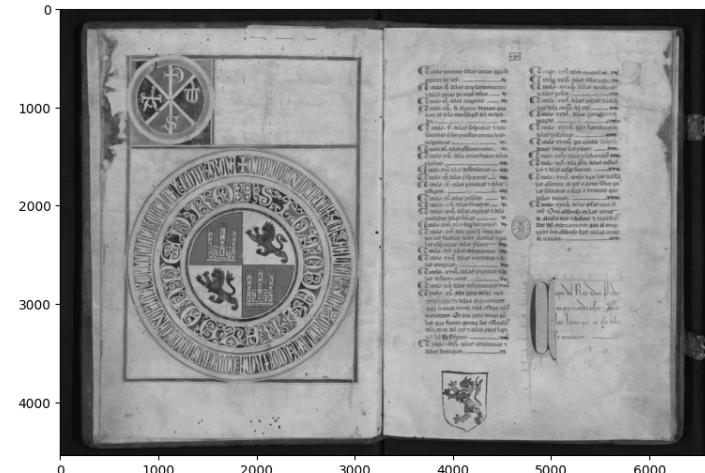
plt.plot(range(1,len(norm_image)),[ponderated_criterion(norm_image,mean_squared_error,t,'y') for t in range(1,len(norm_image))],color='blue')
plt.plot(range(1,len(norm_image[0])),[ponderated_criterion(norm_image,mean_squared_error,t,'x') for t in range(1,len(norm_image[0]))])
plt.axhline(mean_squared_error(norm_image,np.ones_like(norm_image)-1+np.mean(norm_image)),color='red')

image = cv2.imread("../ImagesCodicologie/Corpus de jeu/Foronda/FF-BNE15-7, fol. 1v-2.tif")

# Change color to RGB (from BGR)
image = cv2.cvtColor(image, cv2.COLOR_BGR2RGB)
# convert to grayscale
gray = cv2.cvtColor(image, cv2.COLOR_RGB2GRAY)
# normalize the image
norm_image = gray/255.0
```

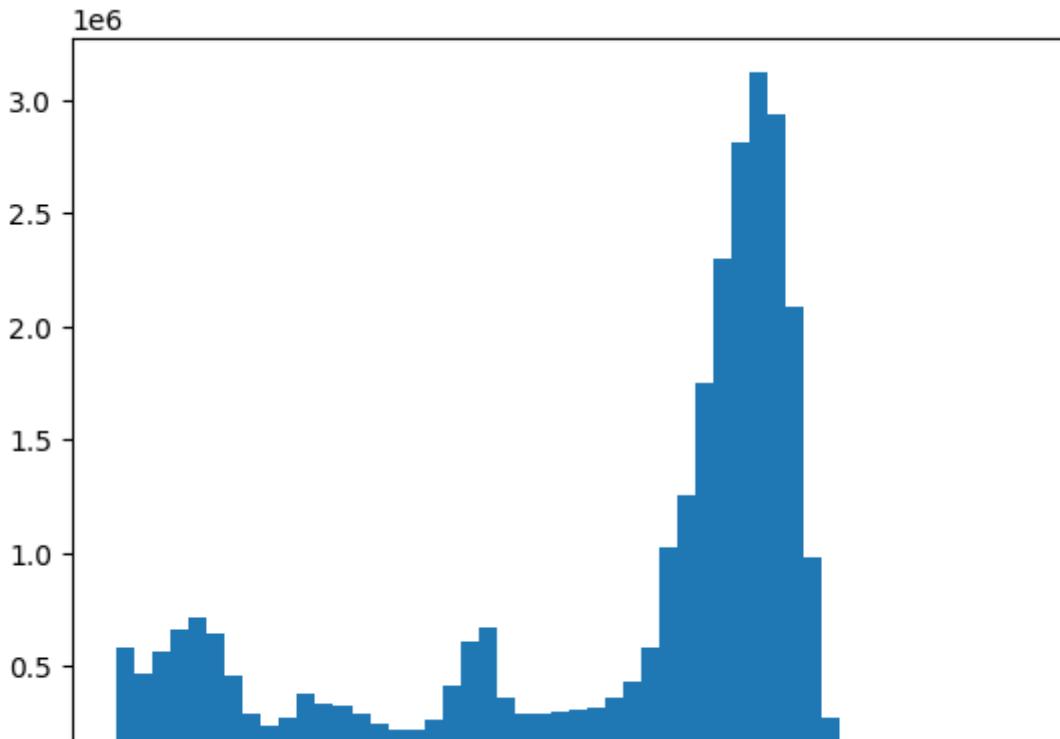
```
#f_image = ft_image(norm_image)
# Display the images
f, (ax1,ax2) = plt.subplots(1, 2, figsize=(20,10))
ax1.imshow(image)
ax2.imshow(norm_image, cmap="gray")
#ax2.imshow(f_image, cmap="gray")
```

<matplotlib.image.AxesImage at 0x2330b9c8950>



plt.hist(norm_image.flatten(),bins=50)

```
(array([5.789910e+05, 4.611000e+05, 5.617210e+05, 6.632750e+05,
       7.091720e+05, 6.403410e+05, 4.553310e+05, 2.838740e+05,
       2.361040e+05, 2.690880e+05, 3.737100e+05, 3.309230e+05,
       3.202350e+05, 2.887210e+05, 2.460830e+05, 2.170580e+05,
       2.133980e+05, 2.598490e+05, 4.060810e+05, 6.087760e+05,
       6.702070e+05, 3.608630e+05, 2.904940e+05, 2.849360e+05,
       2.968980e+05, 3.011600e+05, 3.126420e+05, 3.532360e+05,
       4.321880e+05, 5.779130e+05, 1.019159e+06, 1.257468e+06,
       1.751753e+06, 2.299391e+06, 2.815792e+06, 3.122416e+06,
       2.942270e+06, 2.084130e+06, 9.757710e+05, 2.713240e+05,
       4.528200e+04, 2.680000e+03, 4.090000e+02, 1.380000e+02,
       4.600000e+01, 3.800000e+01, 4.000000e+01, 2.800000e+01,
       1.700000e+01, 4.200000e+01]),
 array([0. , 0.02, 0.04, 0.06, 0.08, 0.1 , 0.12, 0.14, 0.16, 0.18, 0.2 ,
        0.22, 0.24, 0.26, 0.28, 0.3 , 0.32, 0.34, 0.36, 0.38, 0.4 , 0.42,
        0.44, 0.46, 0.48, 0.5 , 0.52, 0.54, 0.56, 0.58, 0.6 , 0.62, 0.64,
        0.66, 0.68, 0.7 , 0.72, 0.74, 0.76, 0.78, 0.8 , 0.82, 0.84, 0.86,
        0.88, 0.9 , 0.92, 0.94, 0.96, 0.98, 1. ]),
 <BarContainer object of 50 artists>)
```

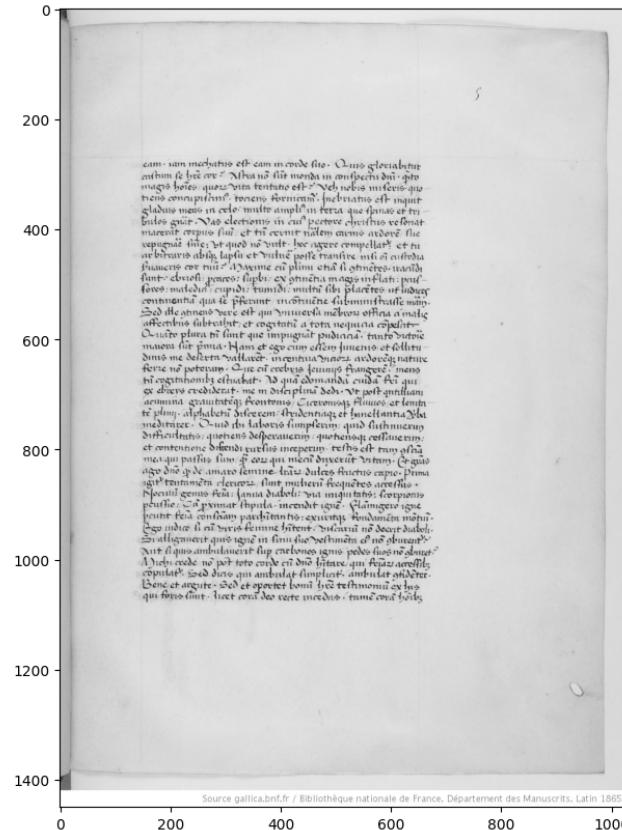
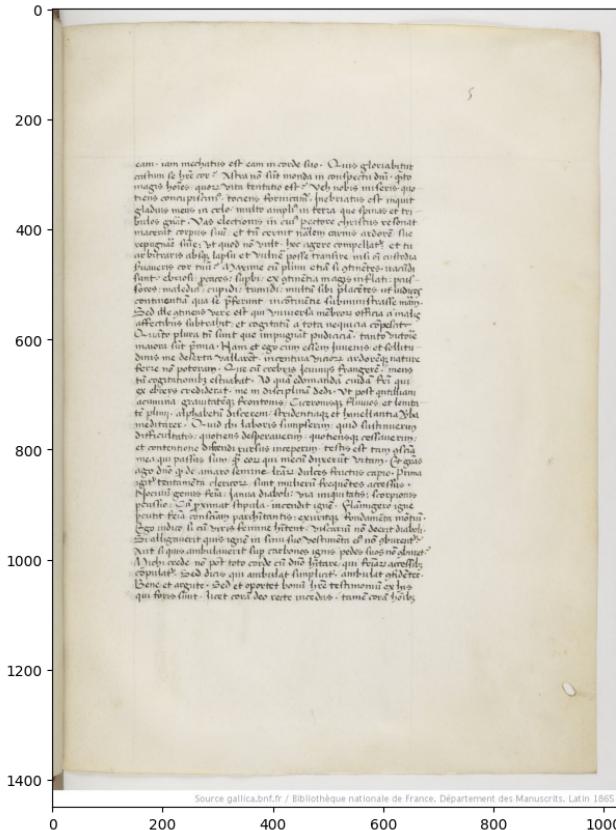




```
image = cv2.imread("../ImagesCodicologie/Corpus de jeu/Emilie Cottreau-Gabillet/BnF Lat 1865, f. 5r.jpeg")

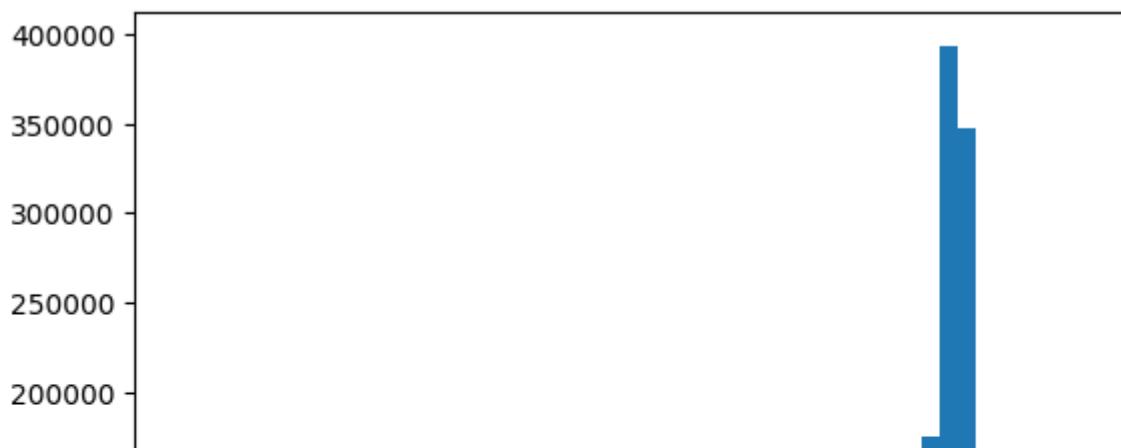
# Change color to RGB (from BGR)
image = cv2.cvtColor(image, cv2.COLOR_BGR2RGB)
# convert to grayscale
gray = cv2.cvtColor(image, cv2.COLOR_RGB2GRAY)
# normalize the image
norm_image = gray/255.0
#f_image = ft_image(norm_image)
# Display the images
f, (ax1,ax2) = plt.subplots(1, 2, figsize=(20,10))
ax1.imshow(image)
ax2.imshow(norm_image, cmap="gray")
#ax2.imshow(f_image, cmap="gray")
```

<matplotlib.image.AxesImage at 0x2331fb9bb10>



plt.hist(norm_image.flatten(), bins=50)

```
(array([3.00000e+00, 7.00000e+00, 1.30000e+01, 6.20000e+01, 1.03000e+02,
       3.29000e+02, 4.97000e+02, 1.08100e+03, 1.38400e+03, 2.59600e+03,
       2.83100e+03, 4.19400e+03, 5.04500e+03, 4.42600e+03, 5.52300e+03,
       4.35500e+03, 5.07000e+03, 3.71600e+03, 4.42600e+03, 3.35000e+03,
       4.05900e+03, 3.40900e+03, 4.18000e+03, 3.05100e+03, 3.58900e+03,
       3.62500e+03, 2.87800e+03, 3.66100e+03, 3.20700e+03, 4.26600e+03,
       4.02300e+03, 5.38500e+03, 4.70500e+03, 7.59600e+03, 9.42800e+03,
       1.78200e+04, 1.65460e+04, 1.60760e+04, 2.74140e+04, 4.44950e+04,
       1.14024e+05, 1.75474e+05, 3.92877e+05, 3.46922e+05, 1.65007e+05,
       1.95360e+04, 3.35200e+03, 9.23000e+02, 2.16600e+03, 2.60950e+04]),
 array([0.10980392, 0.12760784, 0.14541176, 0.16321569, 0.18101961,
        0.19882353, 0.21662745, 0.23443137, 0.25223529, 0.27003922,
        0.28784314, 0.30564706, 0.32345098, 0.3412549 , 0.35905882,
        0.37686275, 0.39466667, 0.41247059, 0.43027451, 0.44807843,
        0.46588235, 0.48368627, 0.5014902 , 0.51929412, 0.53709804,
        0.55490196, 0.57270588, 0.5905098 , 0.60831373, 0.62611765,
        0.64392157, 0.66172549, 0.67952941, 0.69733333, 0.71513725,
        0.73294118, 0.7507451 , 0.76854902, 0.78635294, 0.80415686,
        0.82196078, 0.83976471, 0.85756863, 0.87537255, 0.89317647,
        0.91098039, 0.92878431, 0.94658824, 0.96439216, 0.98219608,
        1.          ]),
<BarContainer object of 50 artists>)
```

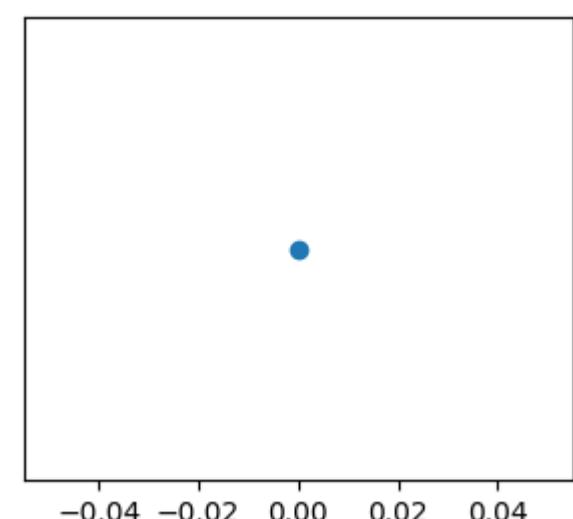
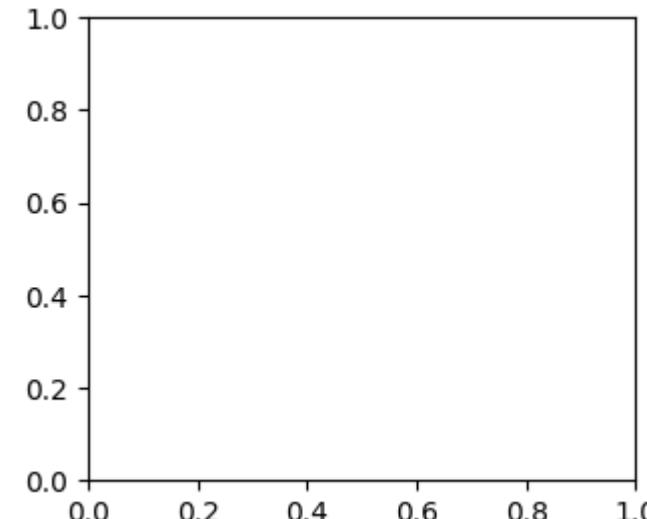
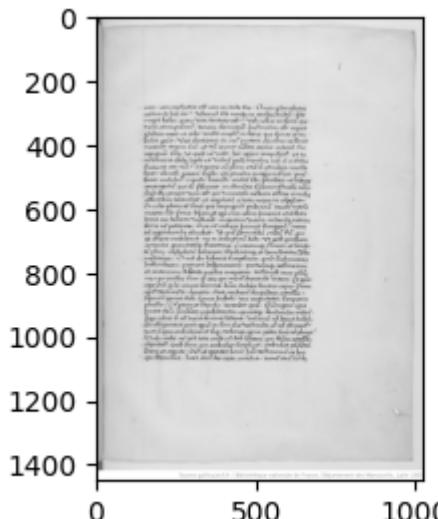


```
res = cart_regression_bi(norm_image,mean_squared_error,max_depth=10,rate=5)
print(res)
show_splits(image,res)
```



DEPTH = 10

done [(0, None), (1450, 0)] yet [None] chrono []



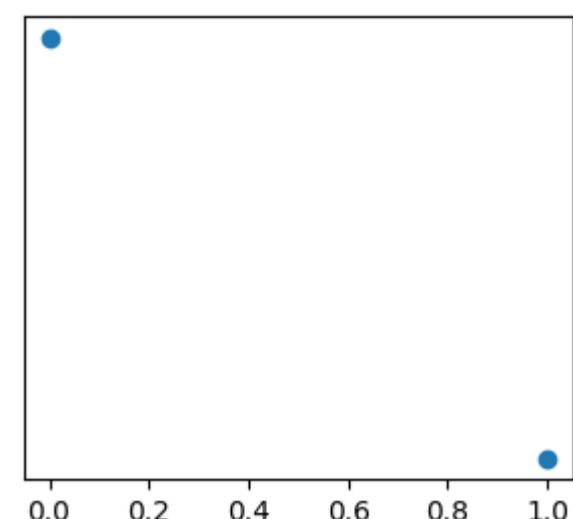
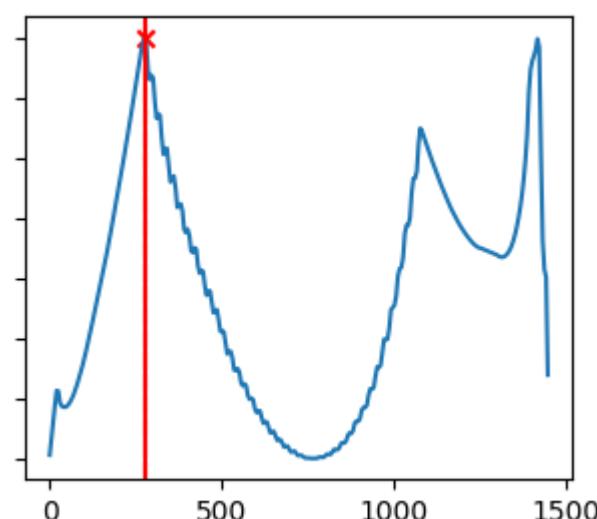
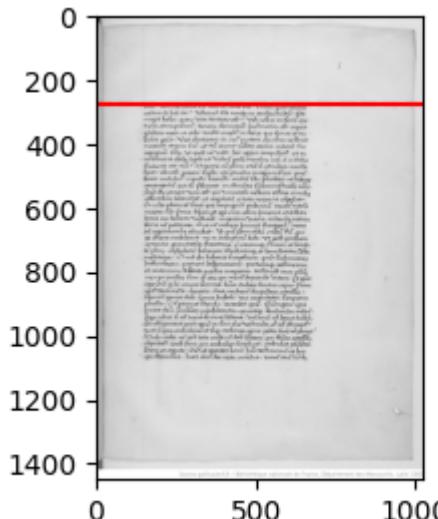
done with risk [(0, 17934.59063298759, 0.012078792182777203), (1450, 0)]

---> new split at 276

chrono final [[0, 17934.59063298759, None]]

DEPTH = 9

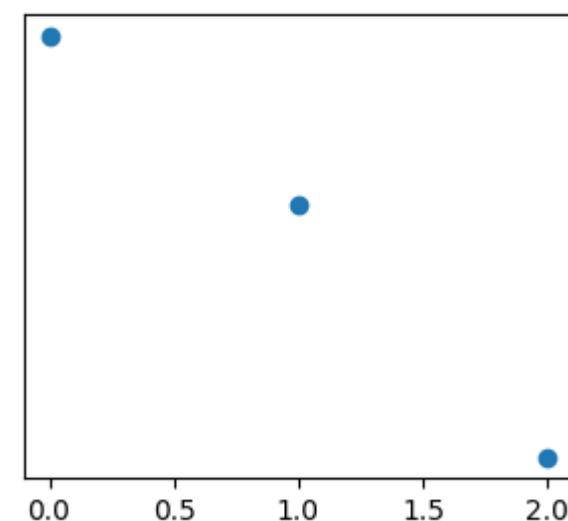
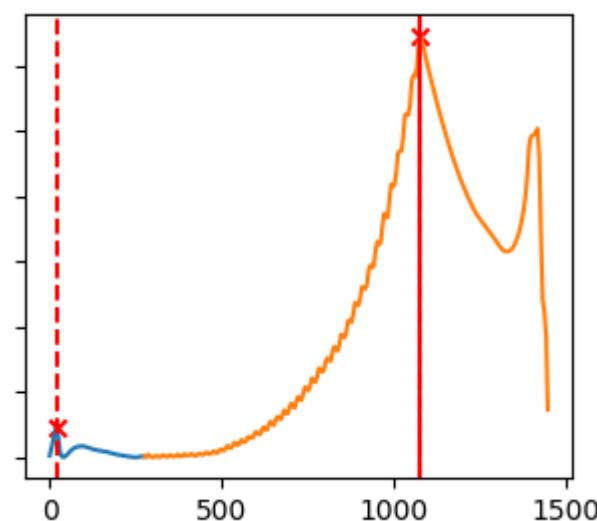
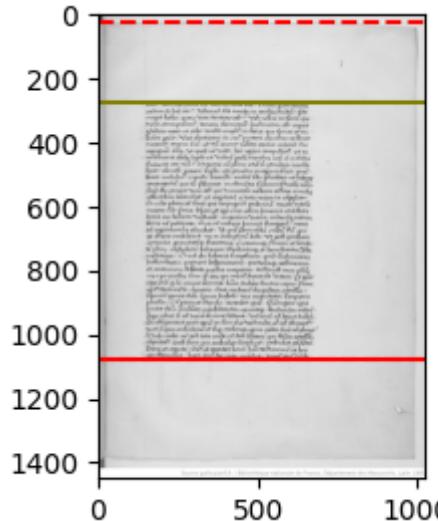
done [(0, None), (276, None), (1450, 0)] yet [None, None] chrono [[0, 17934.59063298759, None]]



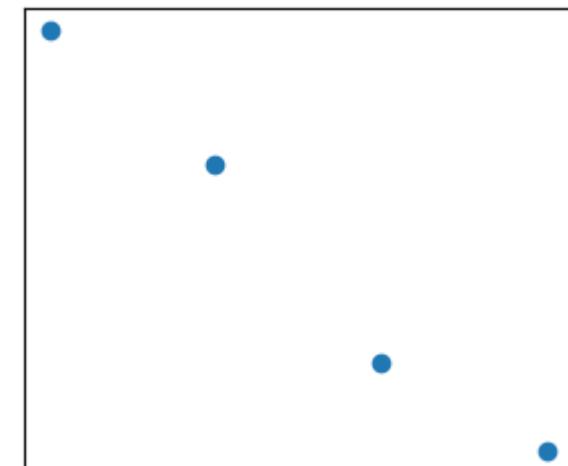
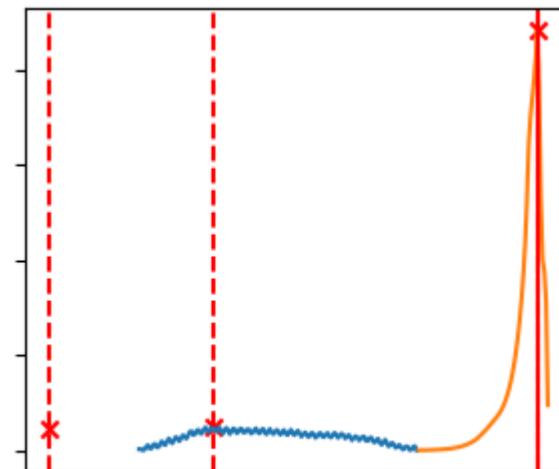
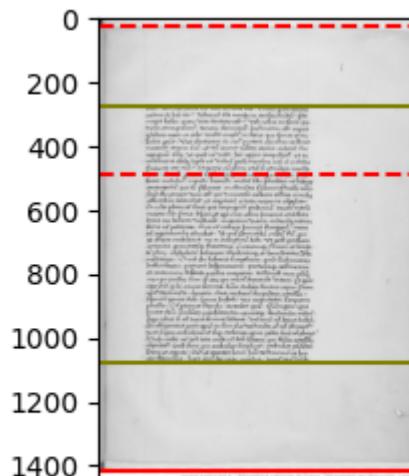
gain in empirical risk with splitting is 520.1504233183041

done with risk [(0, 110, 2556261711022, 0.015577122779012236), (276, 16971, 181572191881, 0.011119550259926101), (1450, 0)]

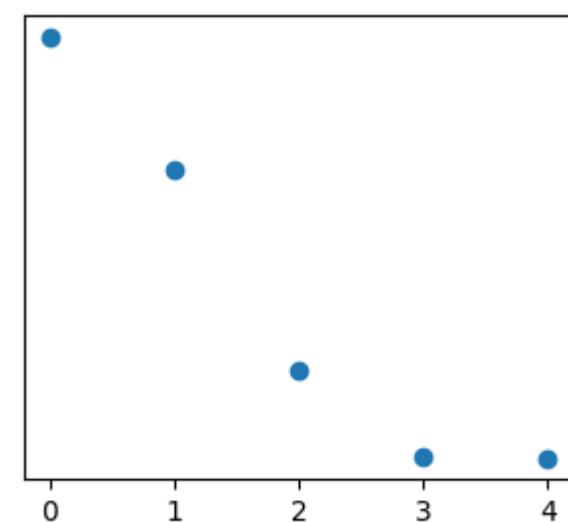
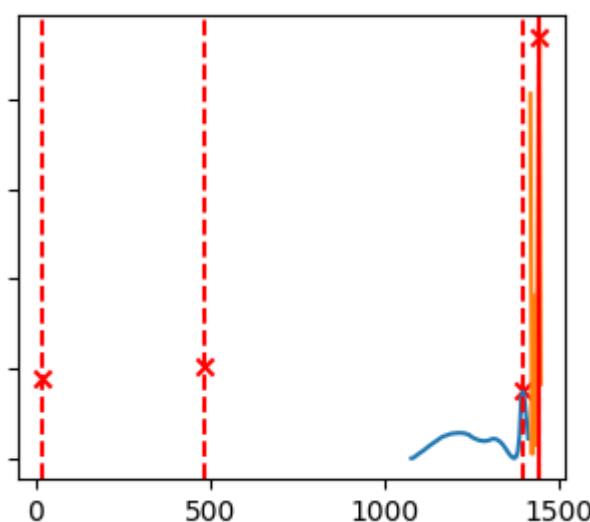
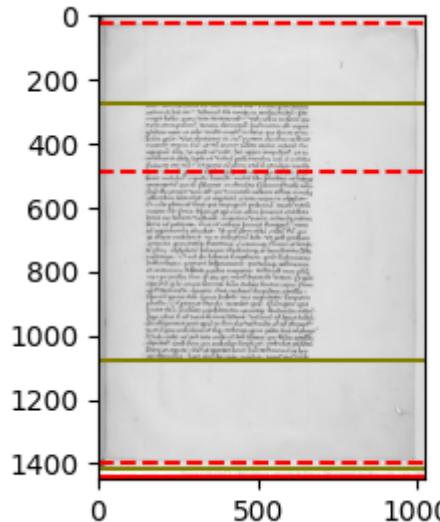
```
done with risk [(0, 440.2556361744033, 0.0015577432779042236), (276, 15019.113165457484, 0.01831098963875415), (1077, 1178.9886)
---> new split at 1077
chrono final [[0, 17934.59063298759, 276], [1, 17414.440209669287, None]]
DEPTH = 8
done [(0, 440.2556361744033, 0.0015577432779042236), (276, None), (1077, None), (1450, 0)] yet [(21, 0.0015126855035062857, 4.5
```



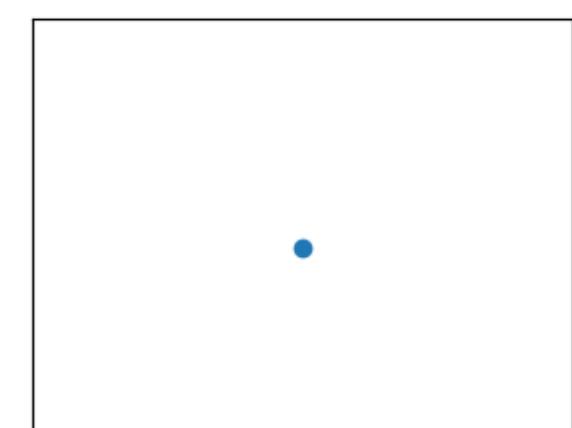
```
gain in empirical risk with splitting is 776.082738239631
done with risk [(0, 440.2556361744033, 0.0015577432779042236), (276, 15019.113165457484, 0.01831098963875415), (1077, 1178.9886)
---> new split at 1418
chrono final [[0, 17934.59063298759, 276], [1, 17414.440209669287, 1077], [2, 16638.357471429656, None]]
DEPTH = 7
done [(0, 440.2556361744033, 0.0015577432779042236), (276, 15019.113165457484, 0.01831098963875415), (1077, None), (1418, None)
```

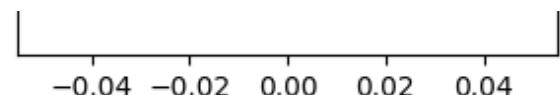
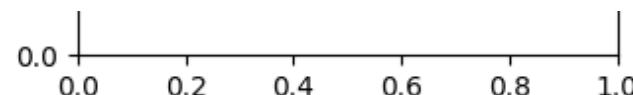


0 500 1000 0 500 1000 1500 0 1 2 3
gain in empirical risk with splitting is 337.7956724446358
done with risk [(0, 440.2556361744033, 0.0015577432779042236), (276, 15019.113165457484, 0.01831098963875415), (1077, 489.79469
---> new split at 1444
chrono final [[0, 17934.59063298759, 276], [1, 17414.440209669287, 1077], [2, 16638.357471429656, 1418], [3, 16300.56179898502,
DEPTH = 6
done [(0, 440.2556361744033, 0.0015577432779042236), (276, 15019.113165457484, 0.01831098963875415), (1077, 489.7946908954487,



gain in empirical risk with splitting is 7.703617721757837
chrono before break ----> [[0, 17934.59063298759, 276], [1, 17414.440209669287, 1077], [2, 16638.357471429656, 1418], [3, 1630
===== [(‘y’, 276), (‘y’, 1077), (‘y’, 1418)]
DEPTH = 10
done [(0, None), (1024, 0)] yet [None] chrono []





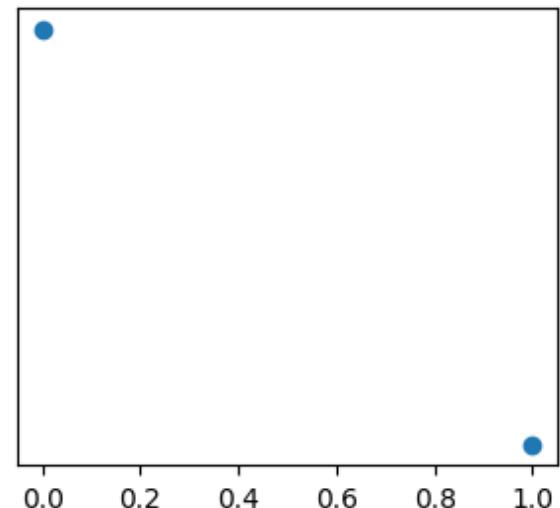
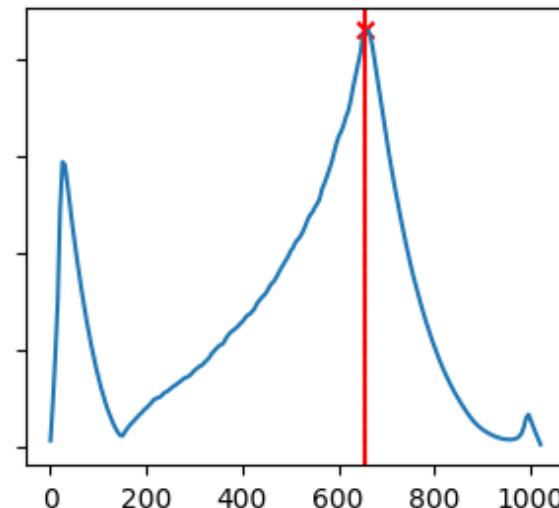
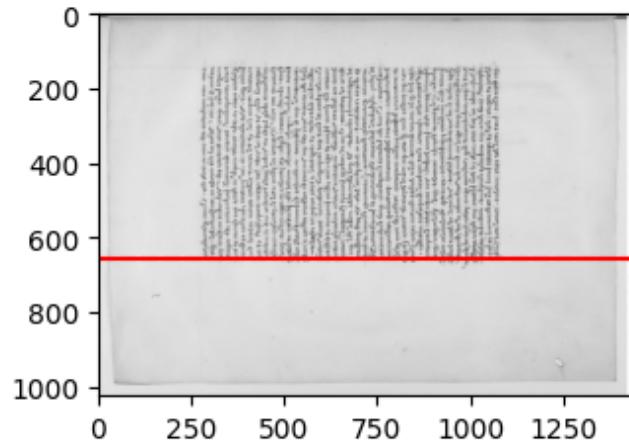
done with risk [(0, 17934.590632987587, 0.012078792182777201), (1024, 0)]

---> new split at 656

chrono final [[0, 17934.590632987587, None]]

DEPTH = 9

done [(0, None), (656, None), (1024, 0)] yet [None, None] chrono [[0, 17934.590632987587, None]]



gain in empirical risk with splitting is 641.5488252430223

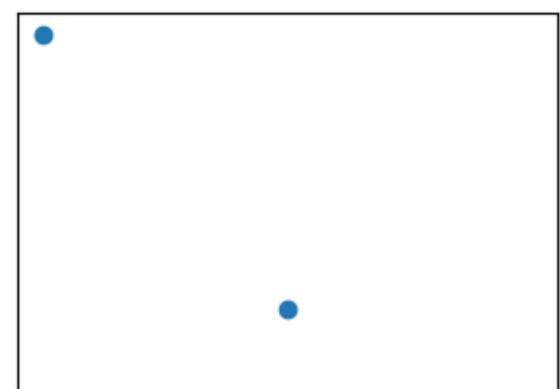
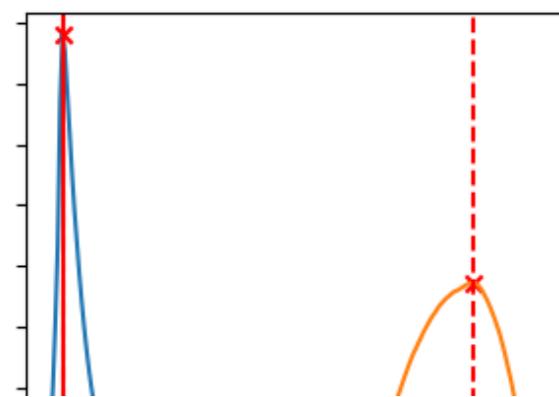
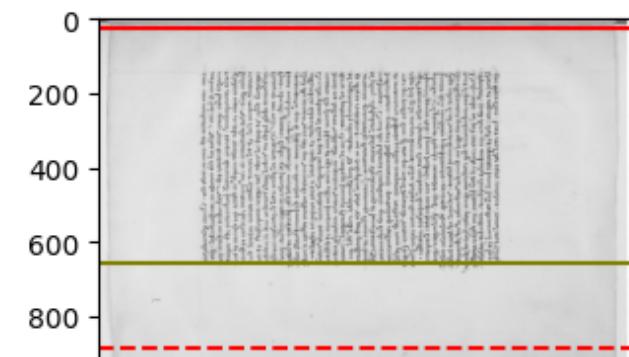
done with risk [(0, 16460.76746482018, 0.017305264365874873), (656, 832.2743429243849, 0.0015597345257203615), (1024, 0)]

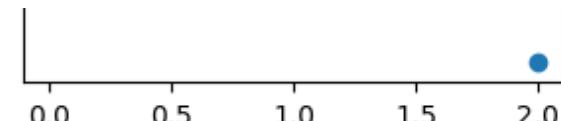
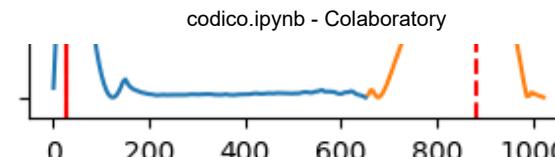
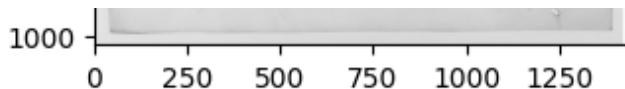
---> new split at 26

chrono final [[0, 17934.590632987587, 656], [1, 17293.041807744565, None]]

DEPTH = 8

done [(0, None), (26, None), (656, 832.2743429243849, 0.0015597345257203615), (1024, 0)] yet [None, None, (882, 0.0014232919461

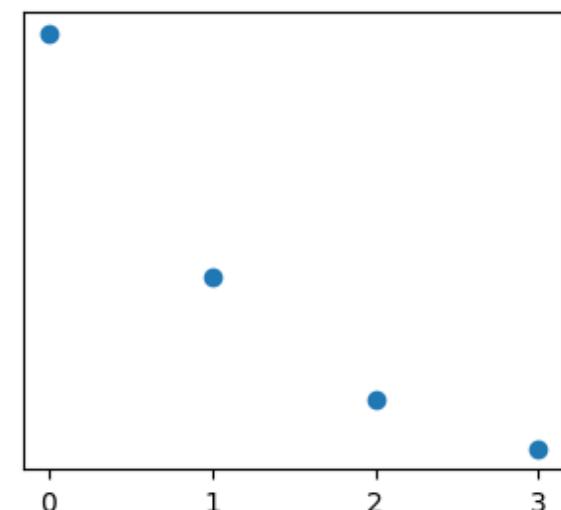
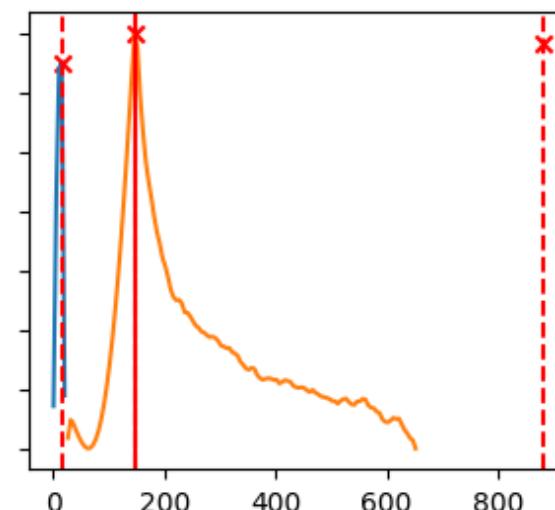
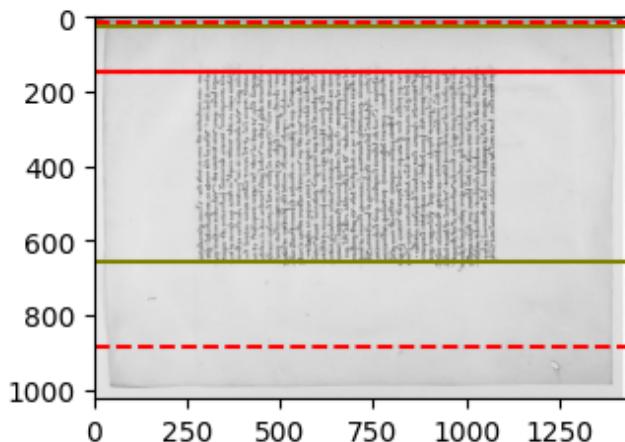




```

gain in empirical risk with splitting is 323.9797848509843
done with risk [(0, 169.67557937826405, 0.0045006784980971895), (26, 15967.11210059093, 0.01747904991854508), (656, 832.2743429243849, 0.0015597345257203615),
---> new split at 147
chrono final [[0, 17934.590632987587, 656], [1, 17293.041807744565, 26], [2, 16969.06202289358, None]]
DEPTH = 7
done [(0, 169.67557937826405, 0.0045006784980971895), (26, None), (147, None), (656, 832.2743429243849, 0.0015597345257203615),

```

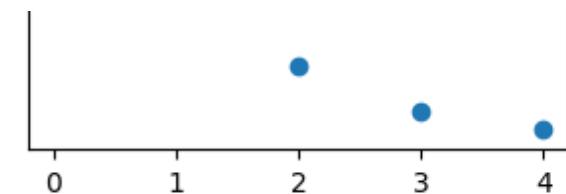
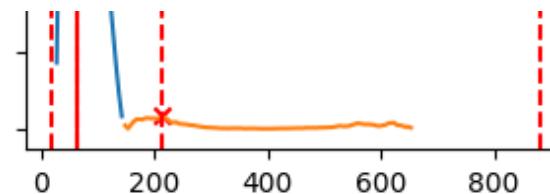
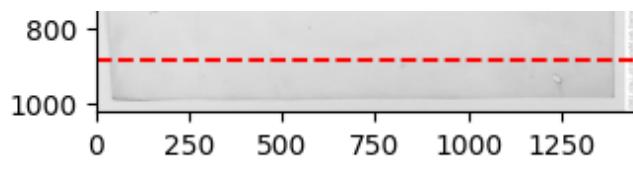


```

gain in empirical risk with splitting is 127.75081784211216
done with risk [(0, 169.67557937826405, 0.0045006784980971895), (26, 185.40551946592237, 0.0010567427726755336), (147, 15653.95
---> new split at 62
chrono final [[0, 17934.590632987587, 656], [1, 17293.041807744565, 26], [2, 16969.06202289358, 147], [3, 16841.31120505147, No
DEPTH = 6
done [(0, 169.67557937826405, 0.0045006784980971895), (26, None), (62, None), (147, 15653.955763282898, 0.0212098851883787), (6

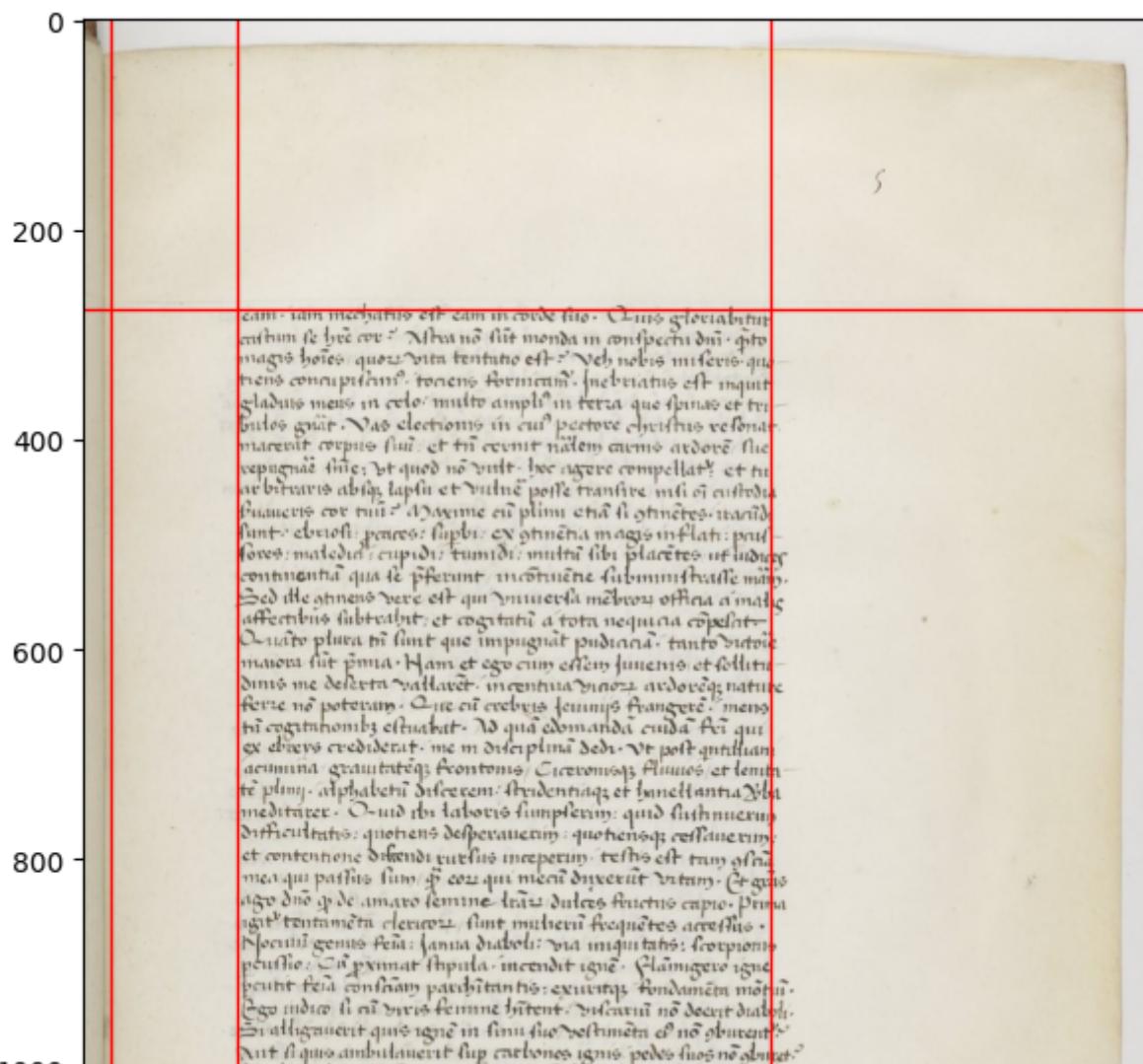
```

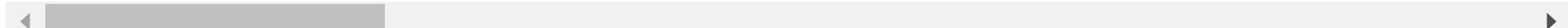
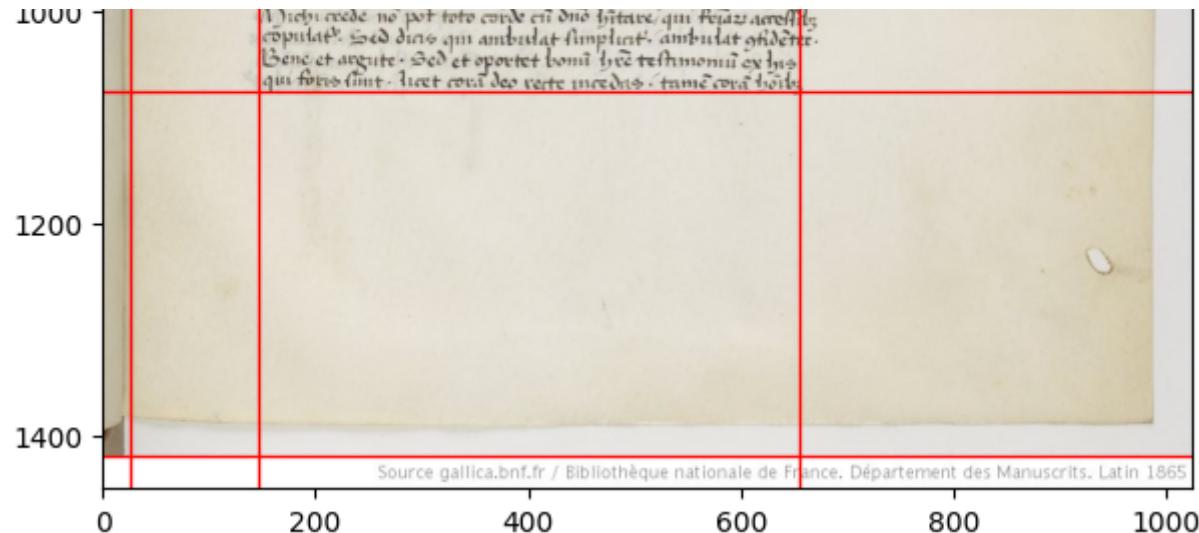




gain in empirical risk with splitting is 47.3542232773616

chrono before break ----> [[0, 17934.590632987587, 656], [1, 17293.041807744565, 26], [2, 16969.06202289358, 147], [3, 16841.3
====> [('y', 656), ('y', 26), ('y', 147)]
[('y', 276), ('y', 1077), ('y', 1418), ('x', 656), ('x', 26), ('x', 147)]



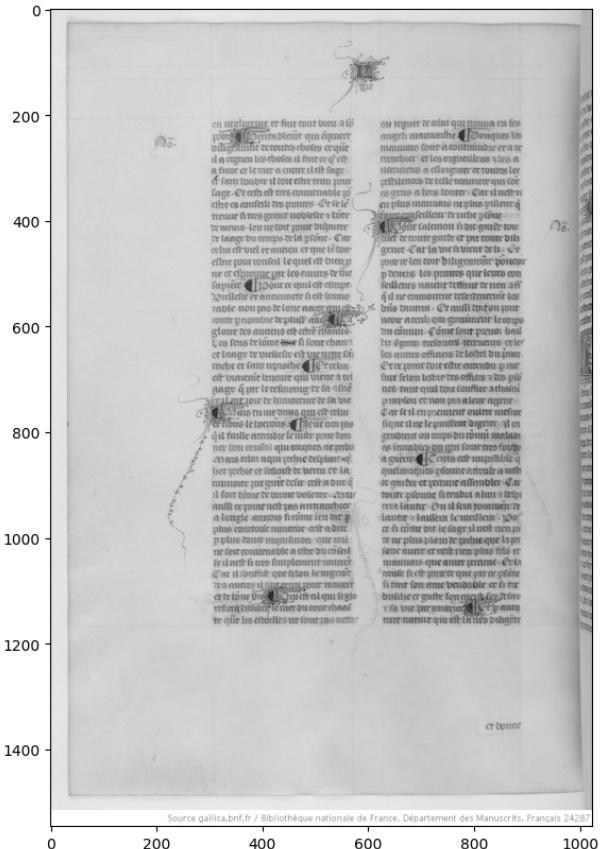
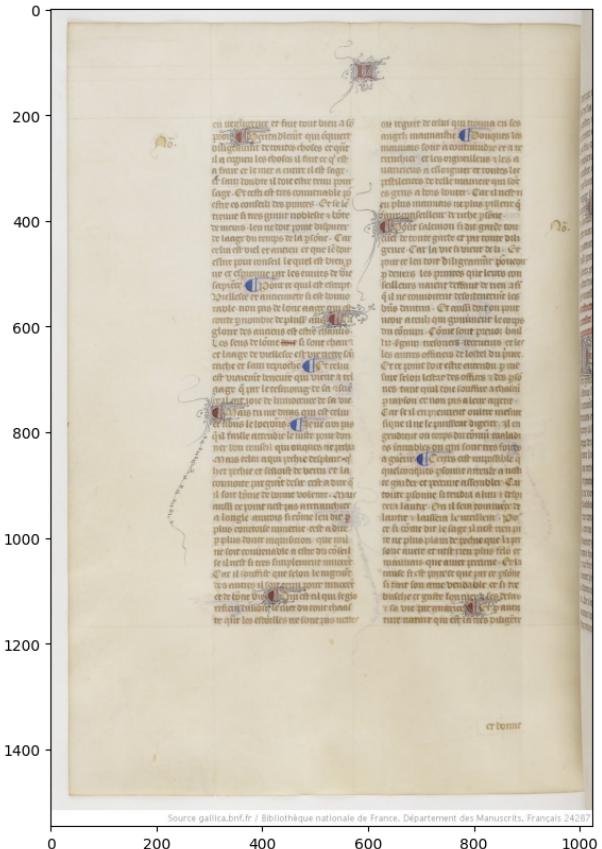


```
cart_regression_bi_simul(norm_image,mean_squared_error,max_depth=8,rate=5)
print(res)
show_splits(image,res)

image = cv2.imread("../ImagesCodicologie/Corpus de jeu/Emilie Cottreau-Gabillet/BnF Fr 24287, f. 130v.jpeg")

# Change color to RGB (from BGR)
image = cv2.cvtColor(image, cv2.COLOR_BGR2RGB)
# convert to grayscale
gray = cv2.cvtColor(image, cv2.COLOR_RGB2GRAY)
# normalize the image
norm_image = gray/255.0
#f_image = ft_image(norm_image)
# Display the images
f, (ax1,ax2) = plt.subplots(1, 2, figsize=(20,10))
ax1.imshow(image)
ax2.imshow(norm_image, cmap="gray")
#ax2.imshow(f_image, cmap="gray")
```

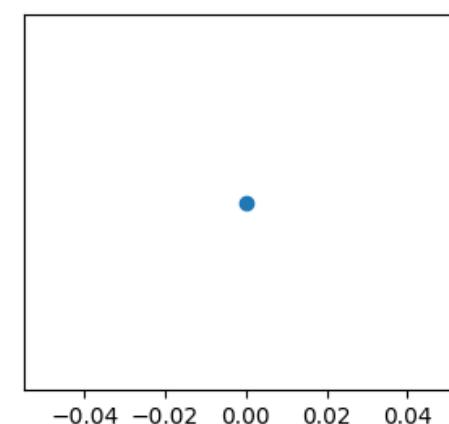
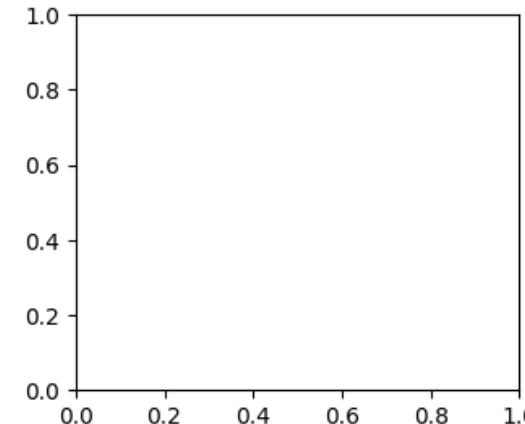
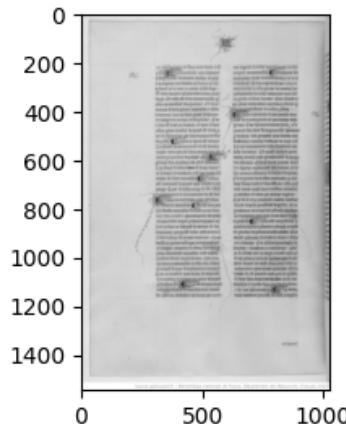
<matplotlib.image.AxesImage at 0x23312810450>



```
res = cart_regression_bi(norm_image,mean_squared_error,max_depth=10,rate=5)
print(res)
show_splits(image,res)
```

DEPTH = 10

done [(0, None), (1546, 0)] yet [None] chrono []



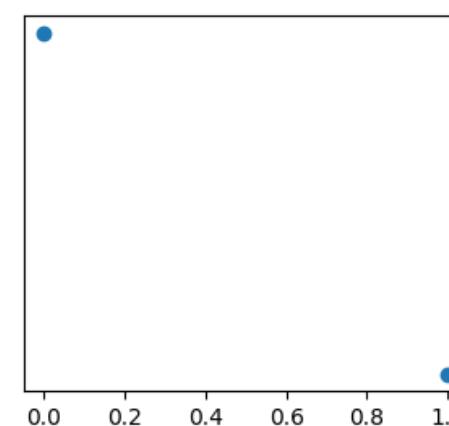
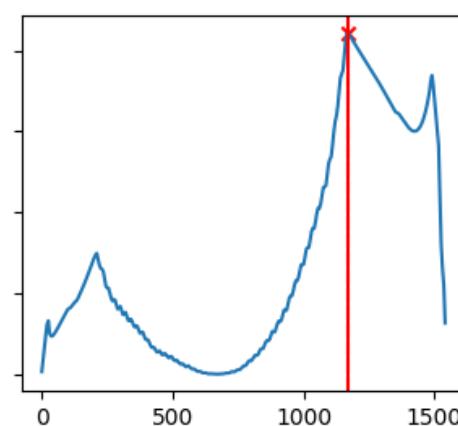
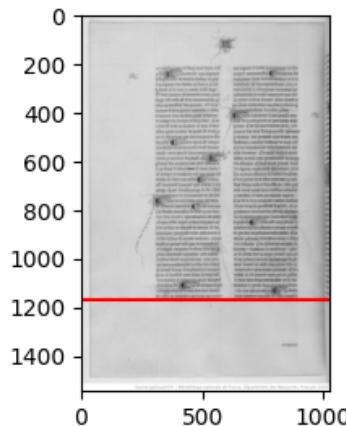
done with risk [(0, 16116.736596745295, 0.010180466094928252), (1546, 0)]

---> new split at 1171

chrono final [[0, 16116.736596745295, None]]

DEPTH = 9

done [(0, None), (1171, None), (1546, 0)] yet [None, None] chrono [[0, 16116.736596745295, None]]



gain in empirical risk with splitting is 1334.6265898505808

done with risk [(0, 13492.133562546427, 0.011251846013812336), (1171, 1289.9764443482873, 0.003359)]

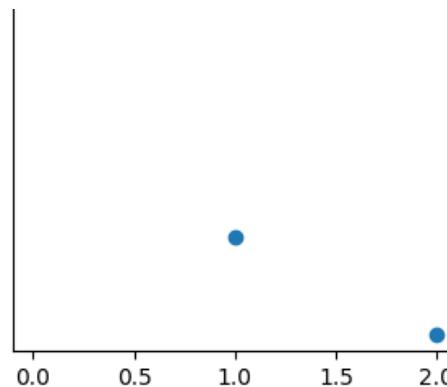
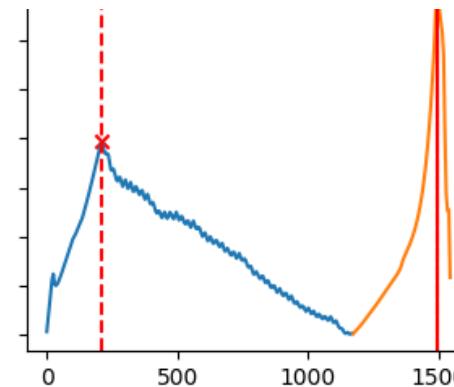
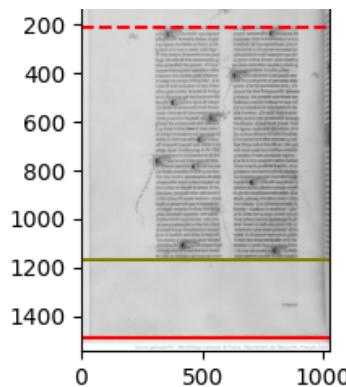
---> new split at 1492

chrono final [[0, 16116.736596745295, 1171], [1, 14782.110006894714, None]]

DEPTH = 8

done [(0, 13492.133562546427, 0.011251846013812336), (1171, None), (1492, None), (1546, 0)] yet [(

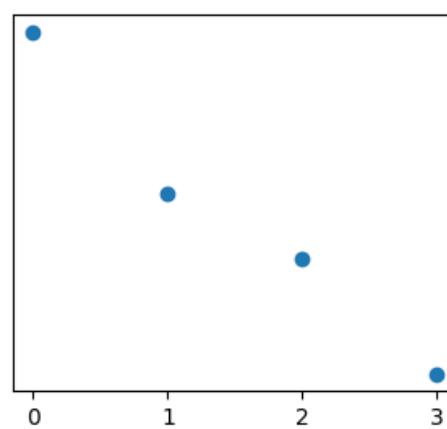
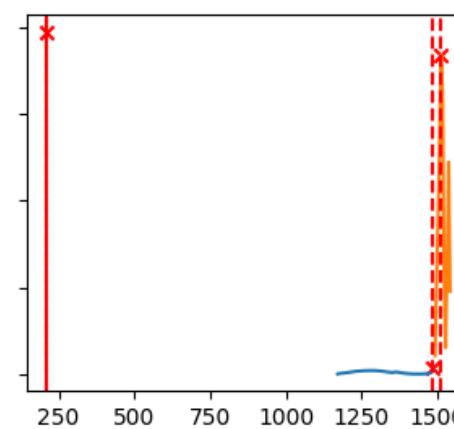
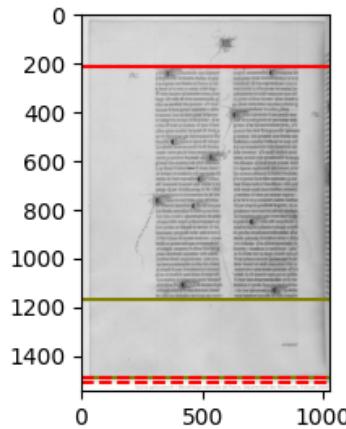




```

gain in empirical risk with splitting is 535.88621004639
done with risk [(0, 13492.133562546427, 0.011251846013812336), (1171, 347.4853403970536, 0.0010571:
---> new split at 211
chrono final [[0, 16116.736596745295, 1171], [1, 14782.110006894714, 1492], [2, 14246.223796890075,
DEPTH = 7
done [(0, None), (211, None), (1171, 347.4853403970536, 0.0010571375474501485), (1492, 406.60489394

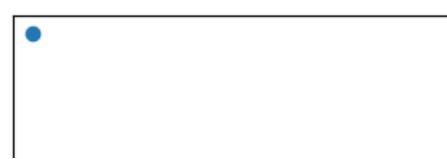
```

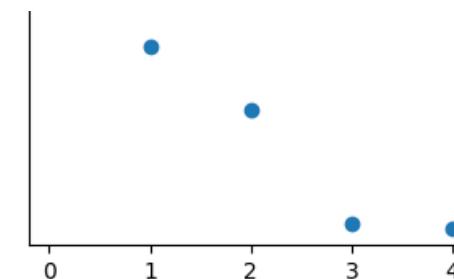
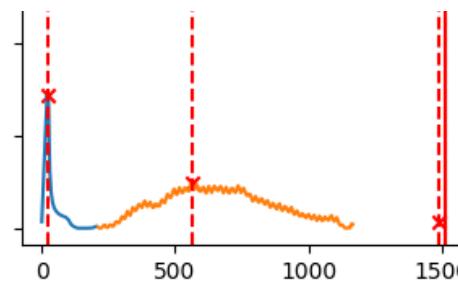
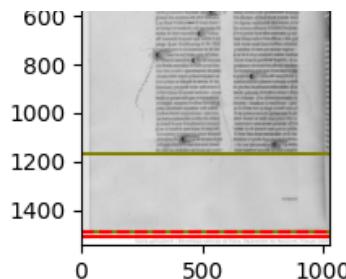


```

gain in empirical risk with splitting is 945.089921558394
done with risk [(0, 547.5741187379823, 0.002534314456540573), (211, 11999.46952225005, 0.0122064916
---> new split at 1513
chrono final [[0, 16116.736596745295, 1171], [1, 14782.110006894714, 1492], [2, 14246.223796890075,
DEPTH = 6
done [(0, 547.5741187379823, 0.002534314456540573), (211, 11999.46952225005, 0.012206491620127411),

```





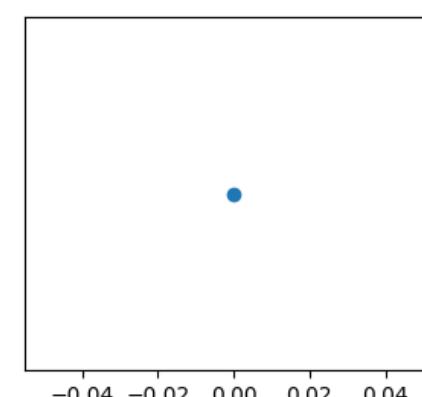
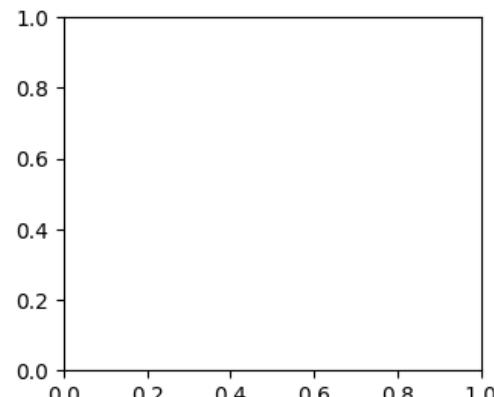
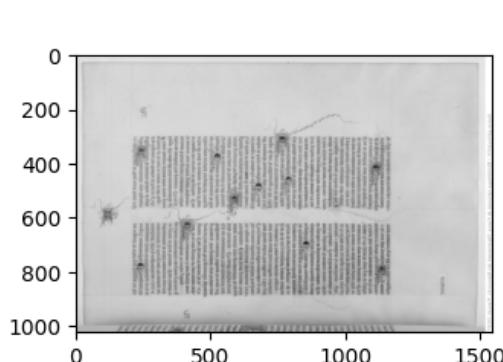
gain in empirical risk with splitting is 40.70121259487678

chrono before break ----> [[0, 16116.736596745295, 1171], [1, 14782.110006894714, 1492], [2, 14246.110006894714, 211]]

===== > [('y', 1171), ('y', 1492), ('y', 211)]

DEPTH = 10

done [(0, None), (1024, 0)] yet [None] chrono []



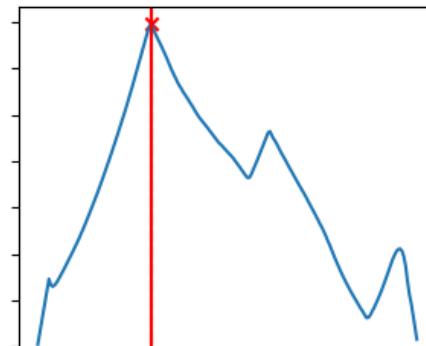
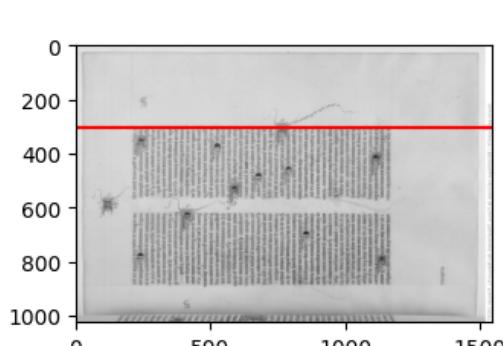
done with risk [(0, 16116.736596745326, 0.010180466094928271), (1024, 0)]

---> new split at 306

chrono final [[0, 16116.736596745326, None]]

DEPTH = 9

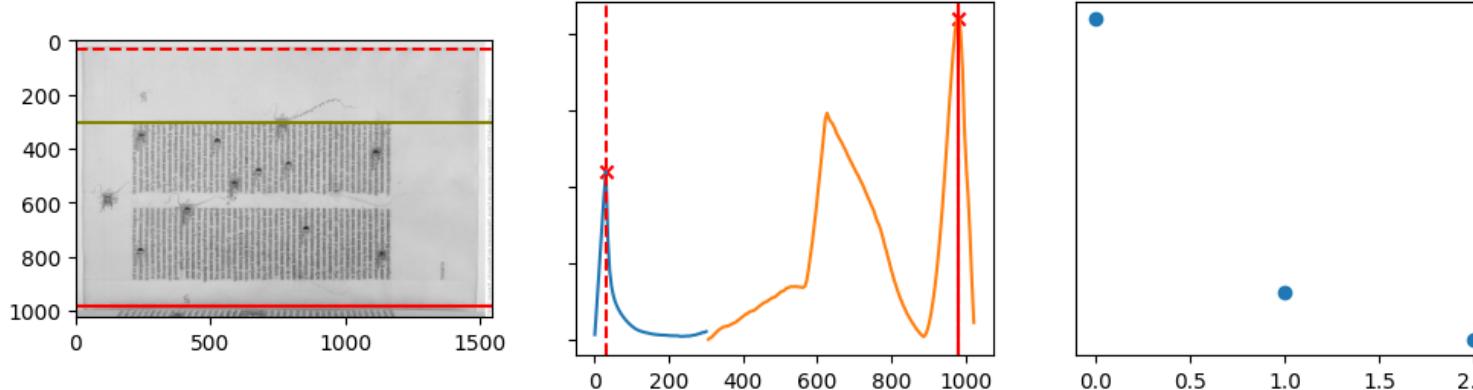
done [(0, None), (306, None), (1024, 0)] yet [None, None] chrono [[0, 16116.736596745326, None]]



```

gain in empirical risk with splitting is 2762.0045921875444
done with risk [(0, 562.3796127683416, 0.0011887722327244283), (306, 12792.35239178944, 0.011524351
---> new split at 982
chrono final [[0, 16116.736596745326, 306], [1, 13354.732004557782, None]]
DEPTH = 8
done [(0, 562.3796127683416, 0.0011887722327244283), (306, None), (982, None), (1024, 0)] yet [(31,

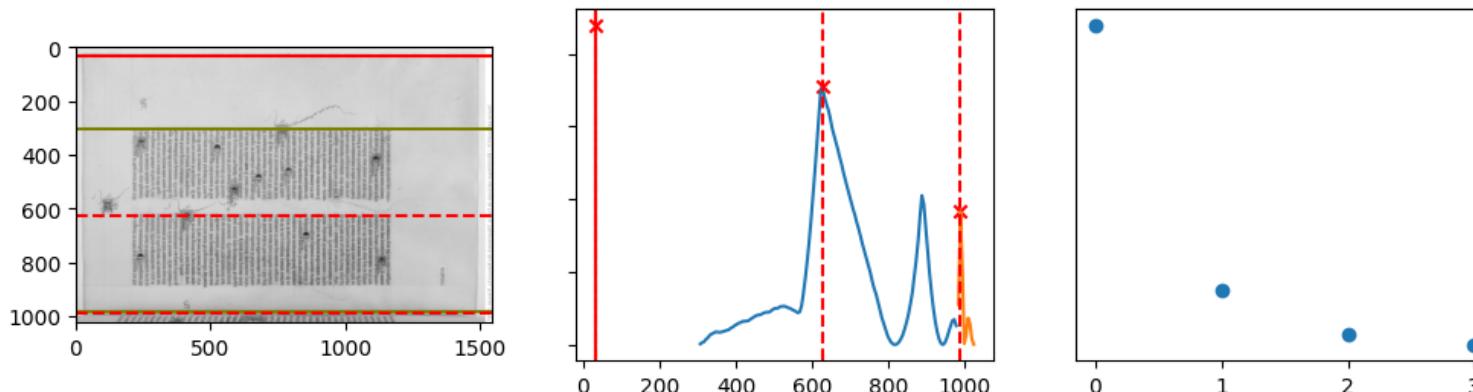
```



```

gain in empirical risk with splitting is 465.73647949195583
done with risk [(0, 562.3796127683416, 0.0011887722327244283), (306, 11749.604650952726, 0.011242608000559495
---> new split at 31
chrono final [[0, 16116.736596745326, 306], [1, 13354.732004557782, 982], [2, 12888.995525065826, 1
DEPTH = 7
done [(0, None), (31, None), (306, 11749.604650952726, 0.011242608000559495), (982, 577.01126134471

```



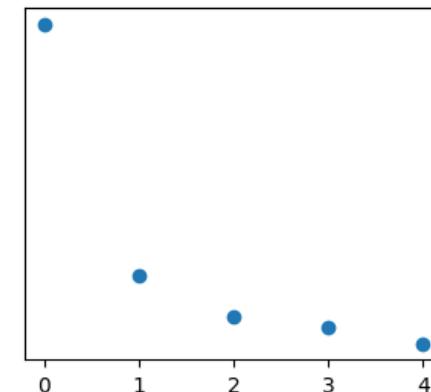
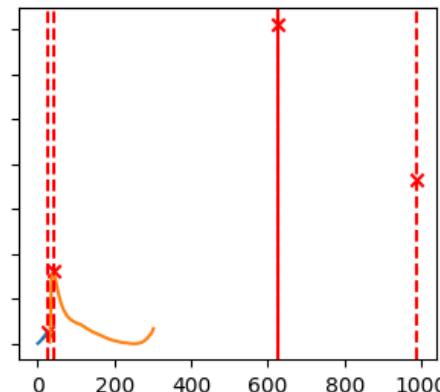
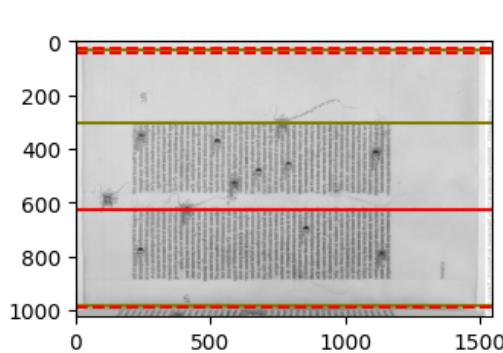
```

gain in empirical risk with splitting is 103.89322206030738
done with risk [(0, 9.71947450287924, 0.0002028017047715069), (31, 448.76691620515504, 0.0010555496
---> new split at 627
chrono final [[0, 16116.736596745326, 306], [1, 13354.732004557782, 982], [2, 12888.995525065826, 1

```

DEPTH = 6

done [(0, 9.71947450287924, 0.0002028017047715069), (31, 448.76691620515504, 0.0010555496088560626]



gain in empirical risk with splitting is 185.8066633802664

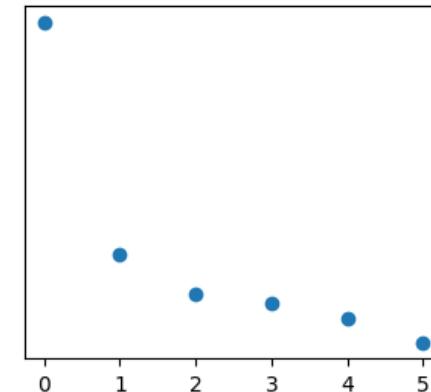
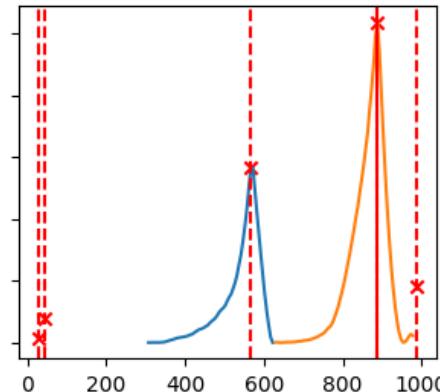
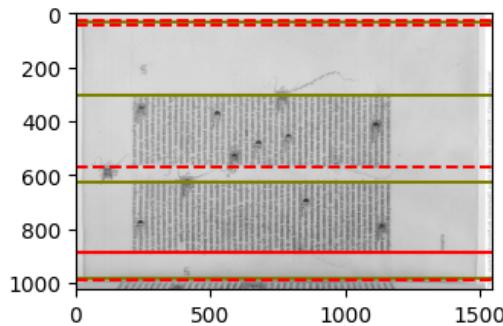
done with risk [(0, 9.71947450287924, 0.0002028017047715069), (31, 448.76691620515504, 0.0010555496088560626]

---> new split at 888

chrono final [[0, 16116.736596745326, 306], [1, 13354.732004557782, 982], [2, 12888.995525065826, 1]]

DEPTH = 5

done [(0, 9.71947450287924, 0.0002028017047715069), (31, 448.76691620515504, 0.0010555496088560626]



gain in empirical risk with splitting is 284.45285435723963

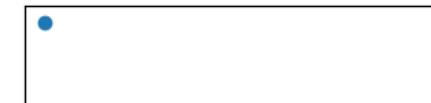
done with risk [(0, 9.71947450287924, 0.0002028017047715069), (31, 448.76691620515504, 0.0010555496088560626]

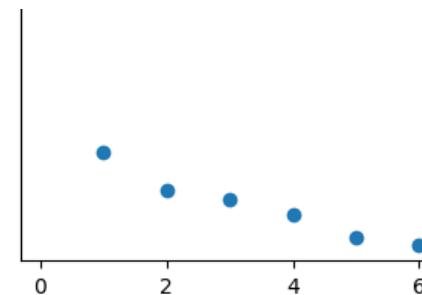
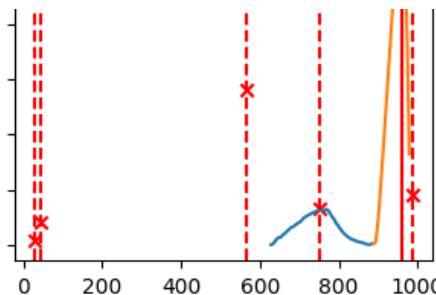
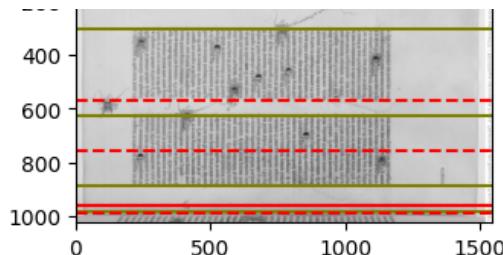
---> new split at 959

chrono final [[0, 16116.736596745326, 306], [1, 13354.732004557782, 982], [2, 12888.995525065826, 1]]

DEPTH = 4

done [(0, 9.71947450287924, 0.0002028017047715069), (31, 448.76691620515504, 0.0010555496088560626]





gain in empirical risk with splitting is 84.32015628512272

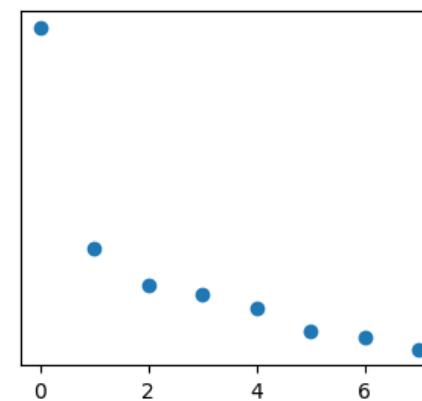
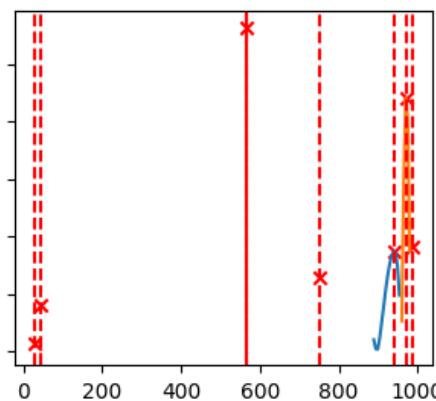
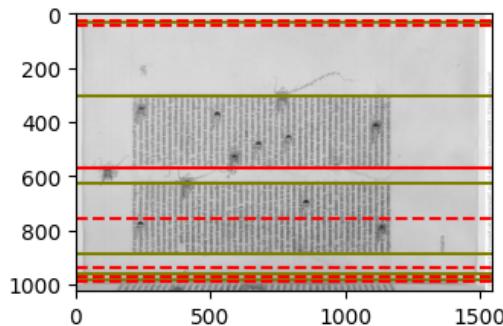
done with risk [(0, 9.71947450287924, 0.0002028017047715069), (31, 448.76691620515504, 0.0010555496088560626

---> new split at 567

chrono final [[0, 16116.736596745326, 306], [1, 13354.732004557782, 982], [2, 12888.995525065826, :]

DEPTH = 3

done [(0, 9.71947450287924, 0.0002028017047715069), (31, 448.76691620515504, 0.0010555496088560626



gain in empirical risk with splitting is 140.05475064272105

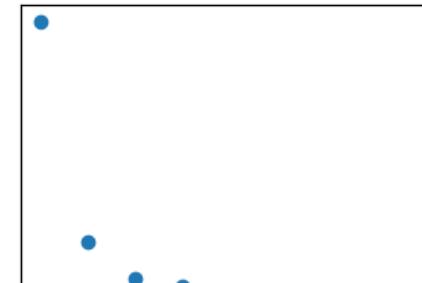
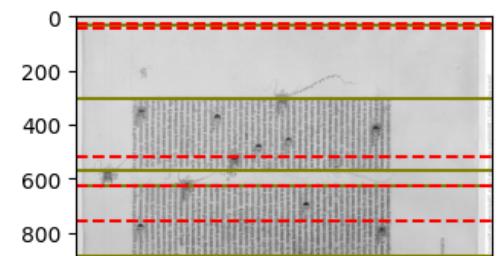
done with risk [(0, 9.71947450287924, 0.0002028017047715069), (31, 448.76691620515504, 0.0010555496088560626

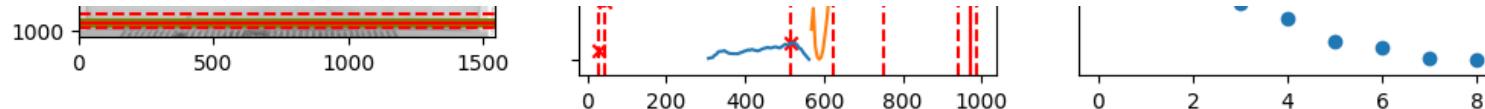
---> new split at 970

chrono final [[0, 16116.736596745326, 306], [1, 13354.732004557782, 982], [2, 12888.995525065826, :]

DEPTH = 2

done [(0, 9.71947450287924, 0.0002028017047715069), (31, 448.76691620515504, 0.0010555496088560626

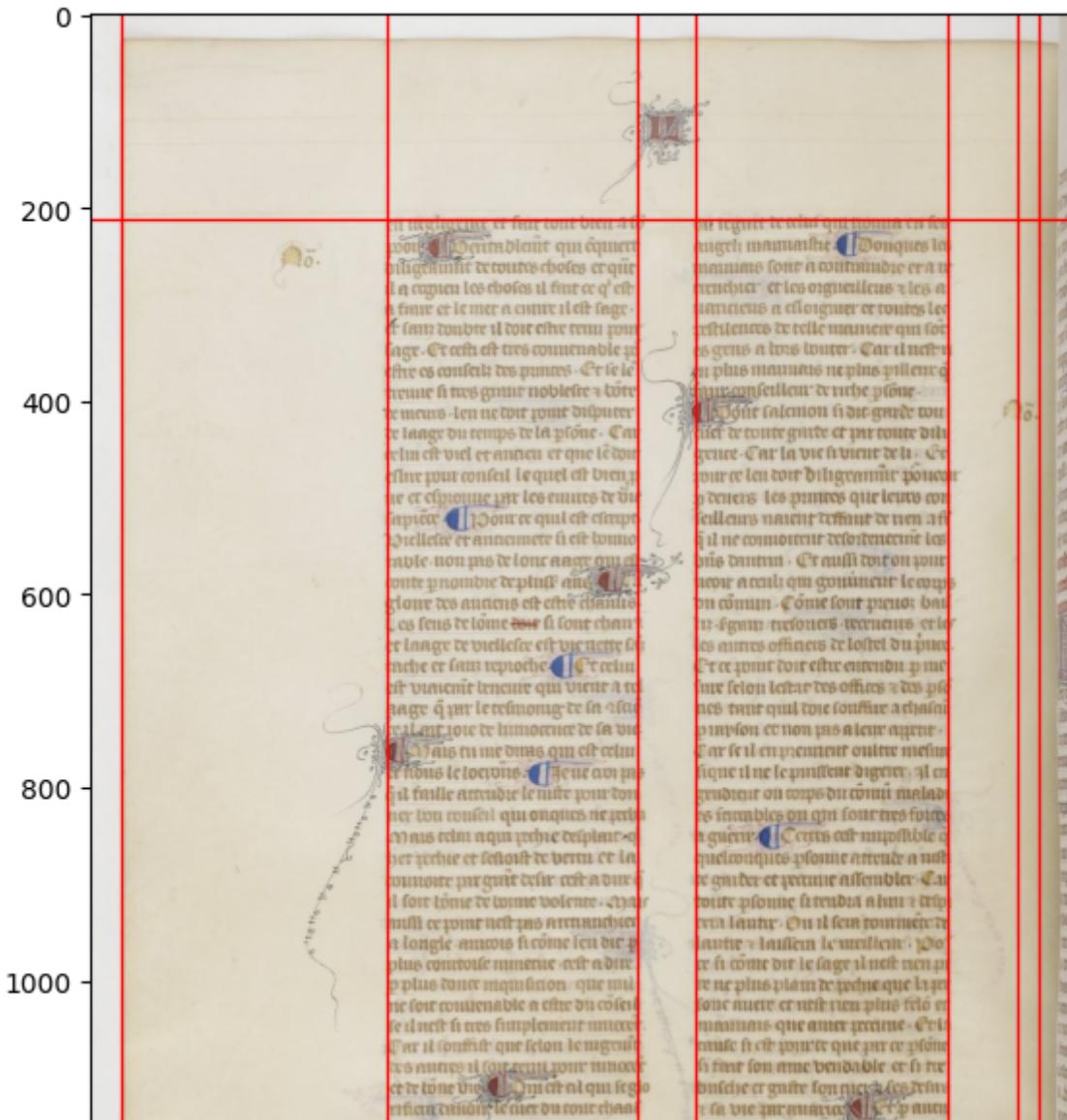


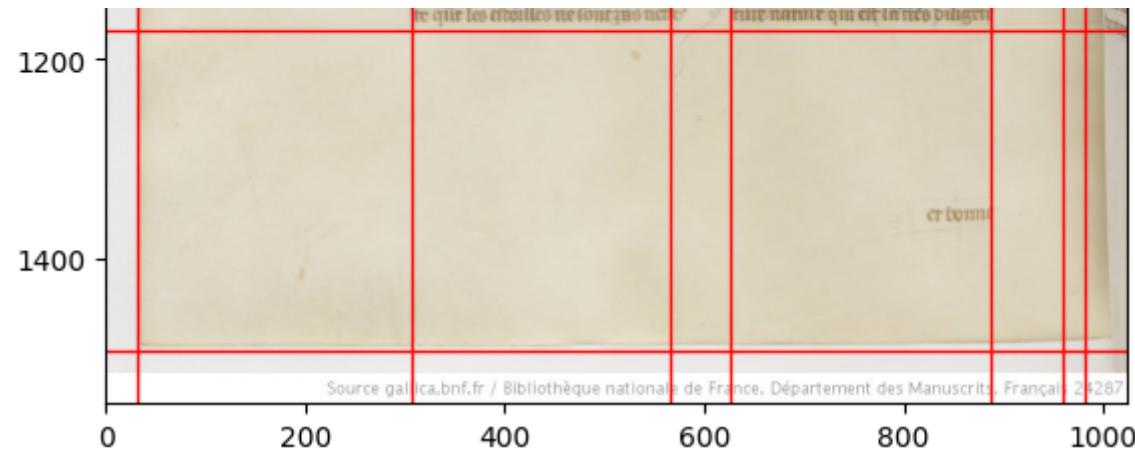


```

gain in empirical risk with splitting is 7.83921865846969
chrono before break ----> [[0, 16116.736596745326, 306], [1, 13354.732004557782, 982], [2, 12888.955111111111, 1171], [3, 12888.955111111111, 1492], [4, 12888.955111111111, 211], [5, 12888.955111111111, 306], [6, 12888.955111111111, 982], [7, 12888.955111111111, 31], [8, 12888.955111111111, 627], [9, 12888.955111111111, 888], [10, 12888.955111111111, 959], [11, 12888.955111111111, 567]]
=====> [('y', 306), ('y', 982), ('y', 31), ('y', 627), ('y', 888), ('y', 959), ('y', 567)]
[('y', 1171), ('y', 1492), ('y', 211), ('x', 306), ('x', 982), ('x', 31), ('x', 627), ('x', 888),
 ('x', 959), ('x', 567)]

```



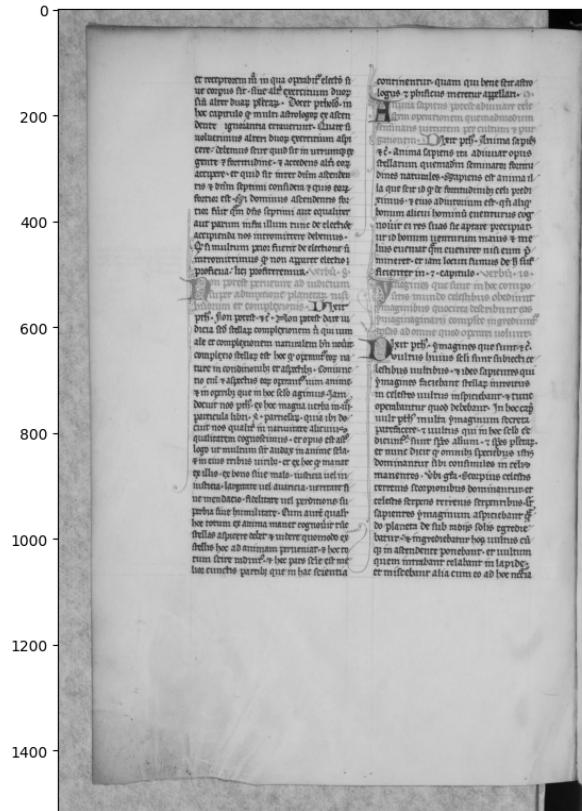
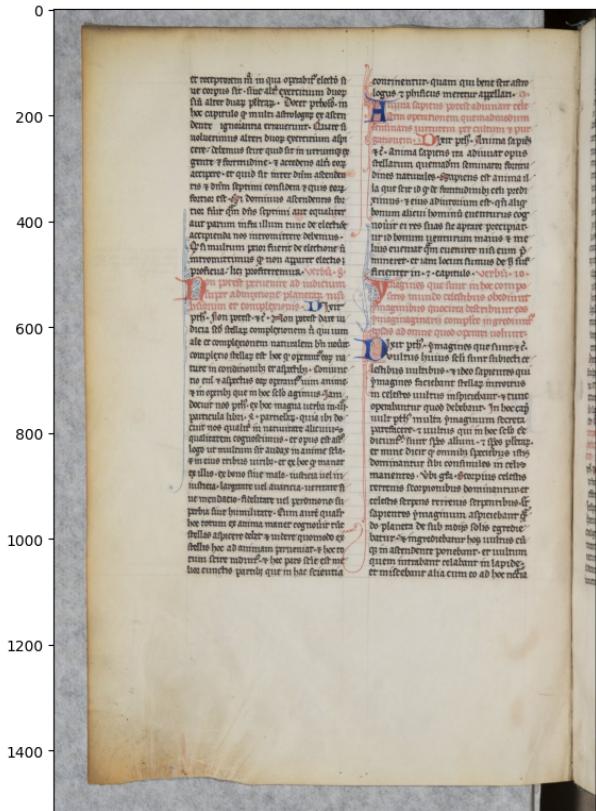


```
cart_regression_bi_simul(norm_image,mean_squared_error,max_depth=10,rate=5)
print(res)
show_splits(image,res)
```

```
image = cv2.imread("../ImagesCodicologie/Corpus de jeu/Lebec/Tractactus_diversi_super_scientias_phisicas-p556.jpeg")

# Change color to RGB (from BGR)
image = cv2.cvtColor(image, cv2.COLOR_BGR2RGB)
# convert to grayscale
gray = cv2.cvtColor(image, cv2.COLOR_RGB2GRAY)
# normalize the image
norm_image = gray/255.0
#f_image = ft_image(norm_image)
# Display the images
f, (ax1,ax2) = plt.subplots(1, 2, figsize=(20,10))
ax1.imshow(image)
ax2.imshow(norm_image, cmap="gray")
#ax2.imshow(f_image, cmap="gray")
```

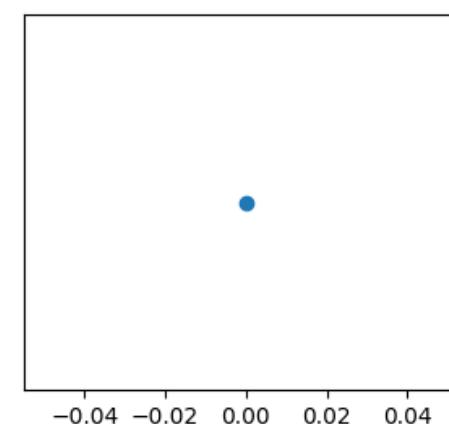
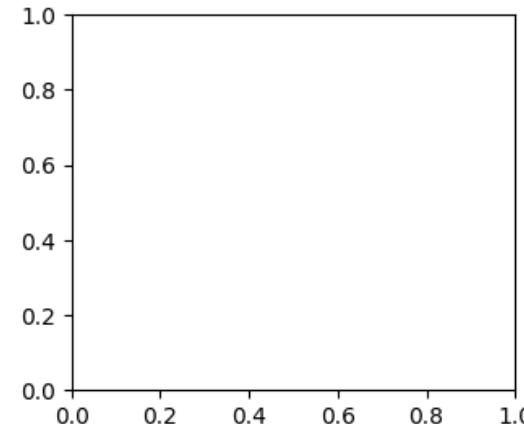
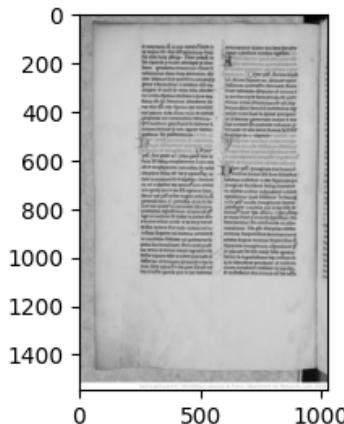
<matplotlib.image.AxesImage at 0x23312695590>



```
res = cart_regression_bi(norm_image, mean_squared_error, max_depth=10, rate=1)
print(res)
show_splits(image, res)
```

DEPTH = 10

done [(0, None), (1547, 0)] yet [None] chrono []



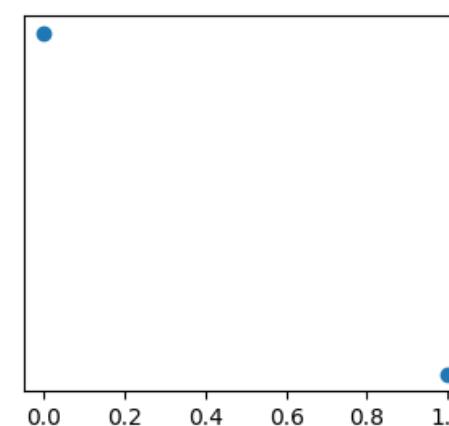
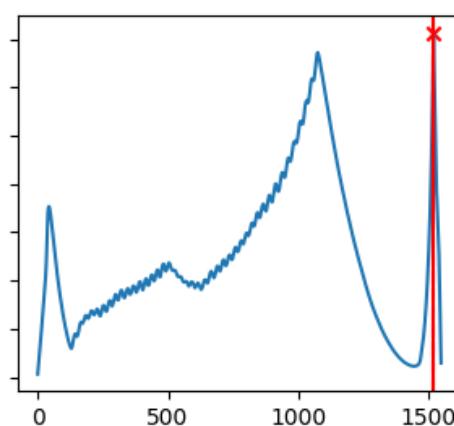
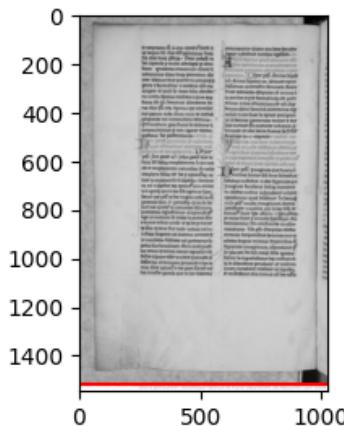
done with risk [(0, 38789.218062447515, 0.024486164036269492), (1547, 0)]

---> new split at 1517

chrono final [[0, 38789.218062447515, None]]

DEPTH = 9

done [(0, None), (1517, None), (1547, 0)] yet [None, None] chrono [[0, 38789.218062447515, None]]



gain in empirical risk with splitting is 2260.0972729118002

done with risk [(0, 36194.899333669884, 0.023300317324019115), (1517, 334.22145586583287, 0.010879604683132581)]

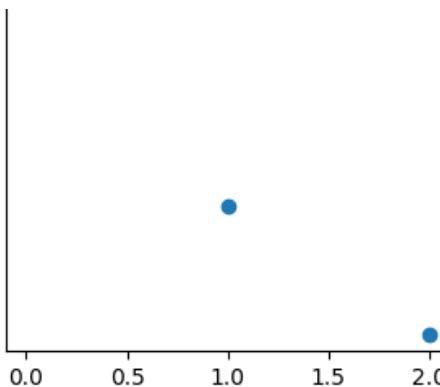
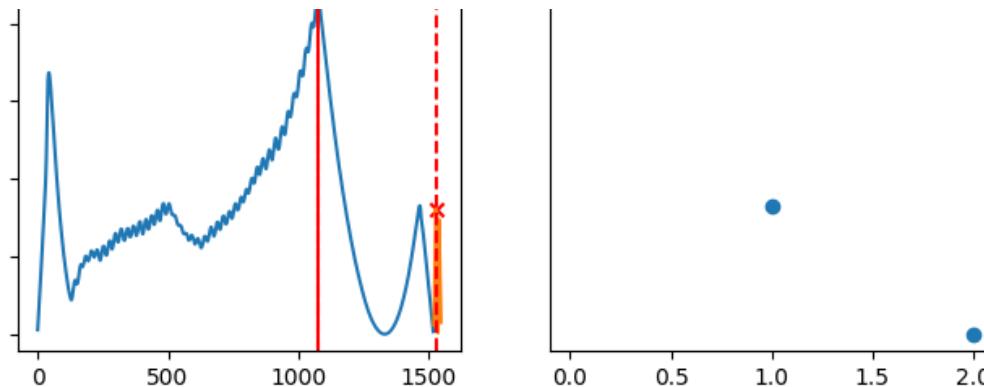
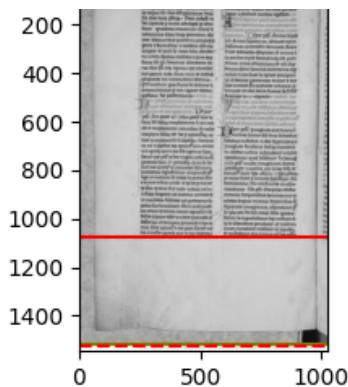
---> new split at 1073

chrono final [[0, 38789.218062447515, 1517], [1, 36529.120789535715, None]]

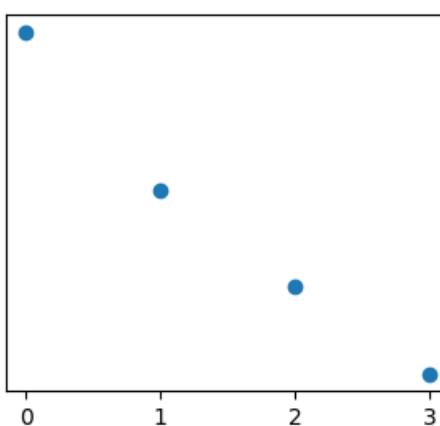
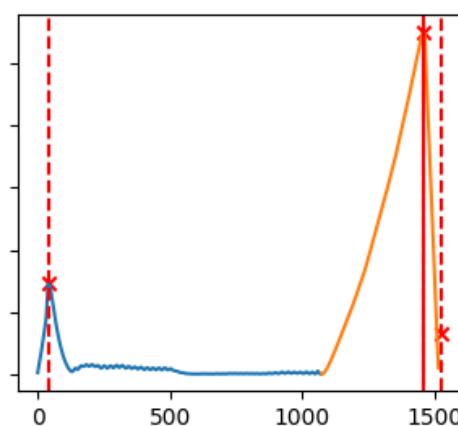
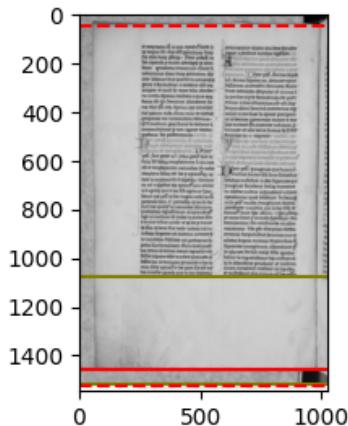
DEPTH = 8

done [(0, None), (1073, None), (1517, 334.22145586583287, 0.010879604683132581), (1547, 0)] yet [None]



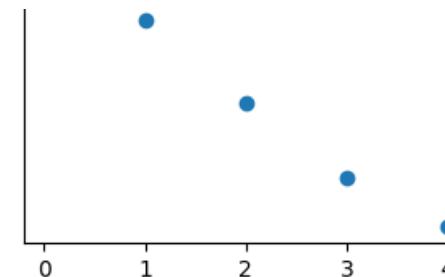
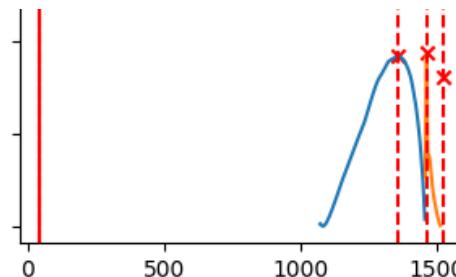
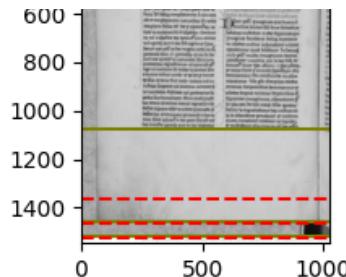


```
gain in empirical risk with splitting is 1364.4728078666158
done with risk [(0, 30708.31862984719, 0.027948361986915325), (1073, 4122.107895956077, 0.009066432
---> new split at 1460
chrono final [[0, 38789.218062447515, 1517], [1, 36529.120789535715, 1073], [2, 35164.6479816691, 1
DEPTH = 7
done [(0, 30708.31862984719, 0.027948361986915325), (1073, None), (1460, None), (1517, 334.22145586
```



```
gain in empirical risk with splitting is 1251.876829688139
done with risk [(0, 30708.31862984719, 0.027948361986915325), (1073, 1411.8018379726495, 0.003562565199987508
---> new split at 43
chrono final [[0, 38789.218062447515, 1517], [1, 36529.120789535715, 1073], [2, 35164.6479816691, 1
DEPTH = 6
done [(0, None), (43, None), (1073, 1411.8018379726495, 0.003562565199987508), (1460, 1458.42922825
```

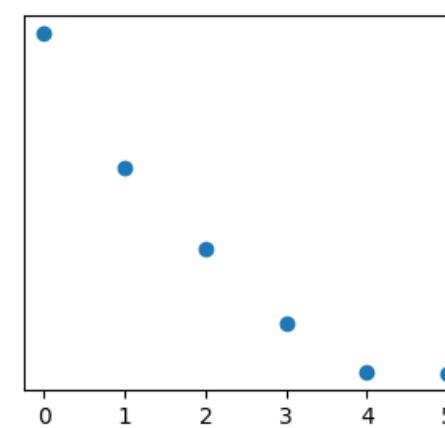
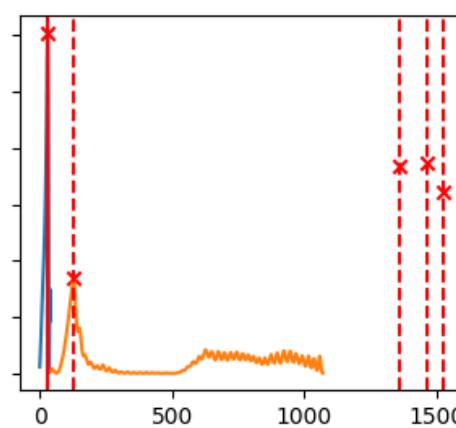
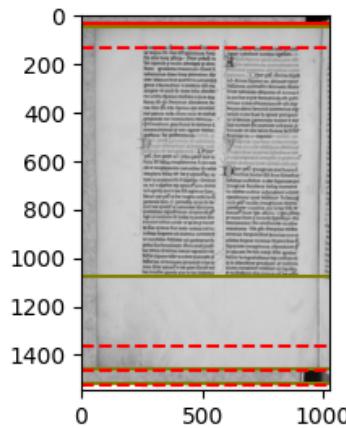




```

gain in empirical risk with splitting is 808.227487186814
done with risk [(0, 1129.5074314664305, 0.02565196746607991), (43, 28770.583711193947, 0.027277935102391106),
---> new split at 32
chrono final [[0, 38789.218062447515, 1517], [1, 36529.120789535715, 1073], [2, 35164.6479816691, 1460]
DEPTH = 5
done [(0, None), (32, None), (43, 28770.583711193947, 0.027277935102391106), (1073, 1411.8018379726), (1517, 38789.218062447515, 0.02565196746607991), (43, 28770.583711193947, 0.027277935102391106)]

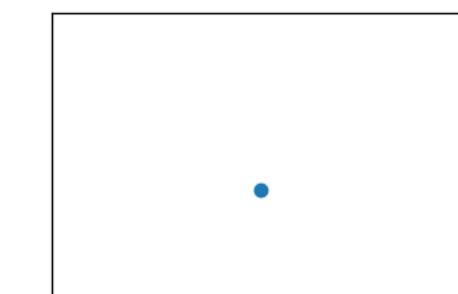
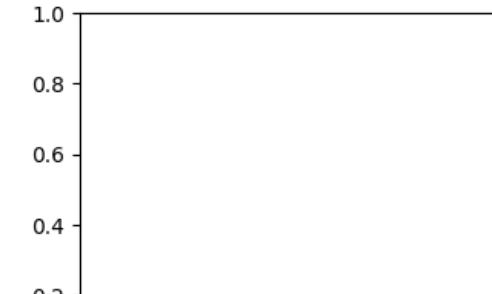
```

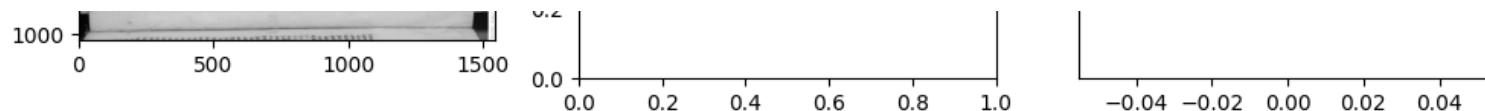


```

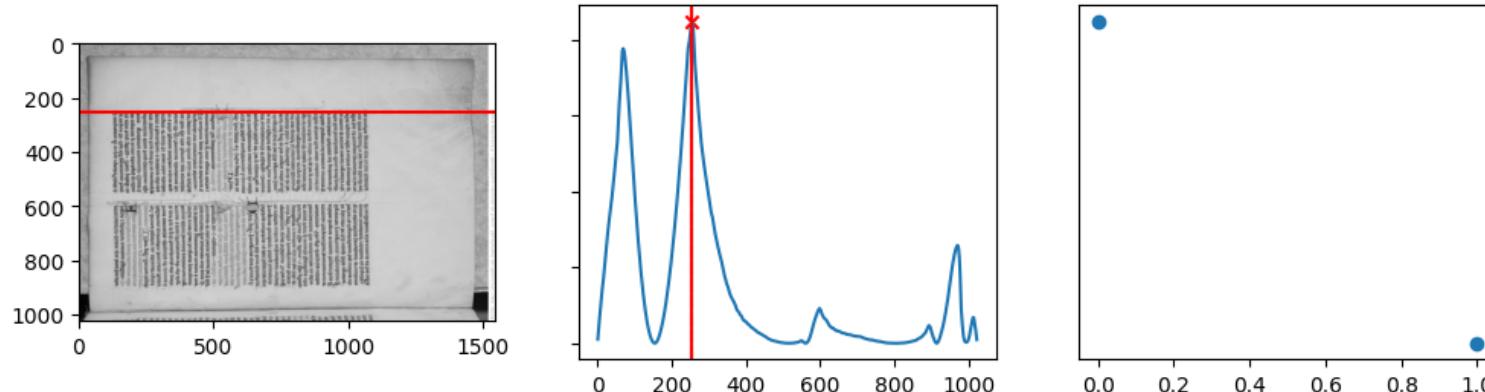
gain in empirical risk with splitting is 26.61740981879848
chrono before break -----> [[0, 38789.218062447515, 1517], [1, 36529.120789535715, 1073], [2, 35164.6479816691, 1460]
=====> [('y', 1517), ('y', 1073), ('y', 1460), ('y', 43)]
DEPTH = 10
done [(0, None), (1024, 0)] yet [None] chrono []

```

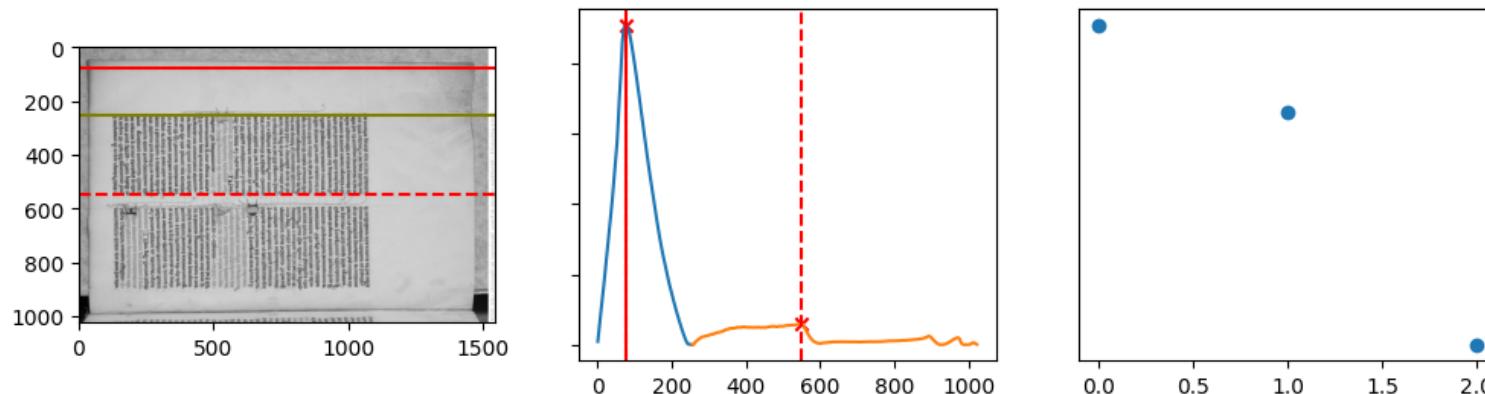




```
done with risk [(0, 38789.21806244721, 0.024486164036269298), (1024, 0)]
---> new split at 255
chrono final [[0, 38789.21806244721, None]]
DEPTH = 9
done [(0, None), (255, None), (1024, 0)] yet [None, None] chrono [[0, 38789.21806244721, None]]
```

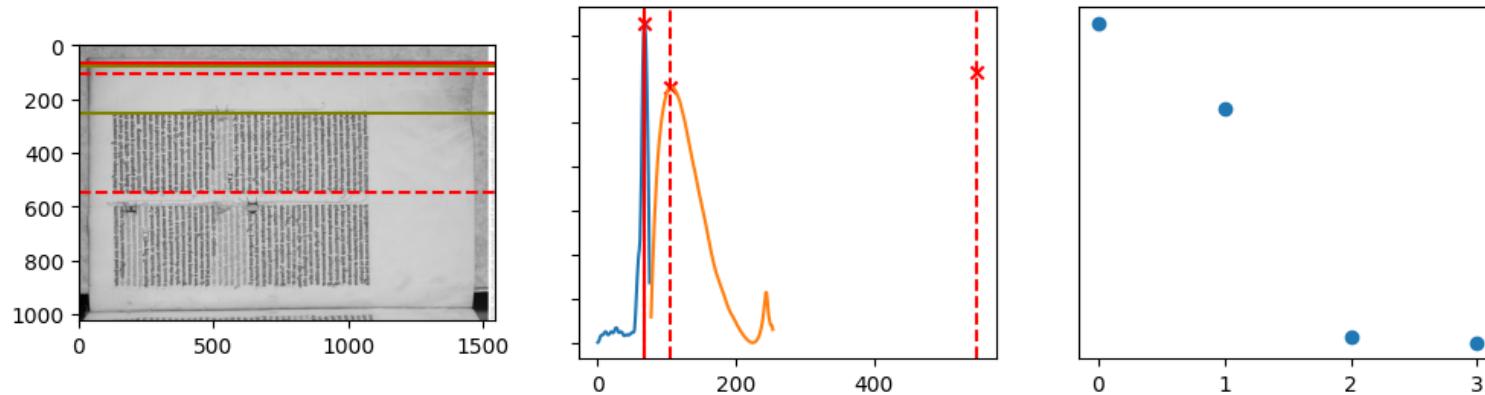


```
gain in empirical risk with splitting is 335.64875717437826
done with risk [(0, 3075.5645136218336, 0.0077964042070594155), (255, 35378.004791650994, 0.0297383372924911),
---> new split at 77
chrono final [[0, 38789.21806244721, 255], [1, 38453.56930527283, None]]
DEPTH = 8
done [(0, None), (77, None), (255, 35378.004791650994, 0.0297383372924911), (1024, 0)] yet [None, None]
```



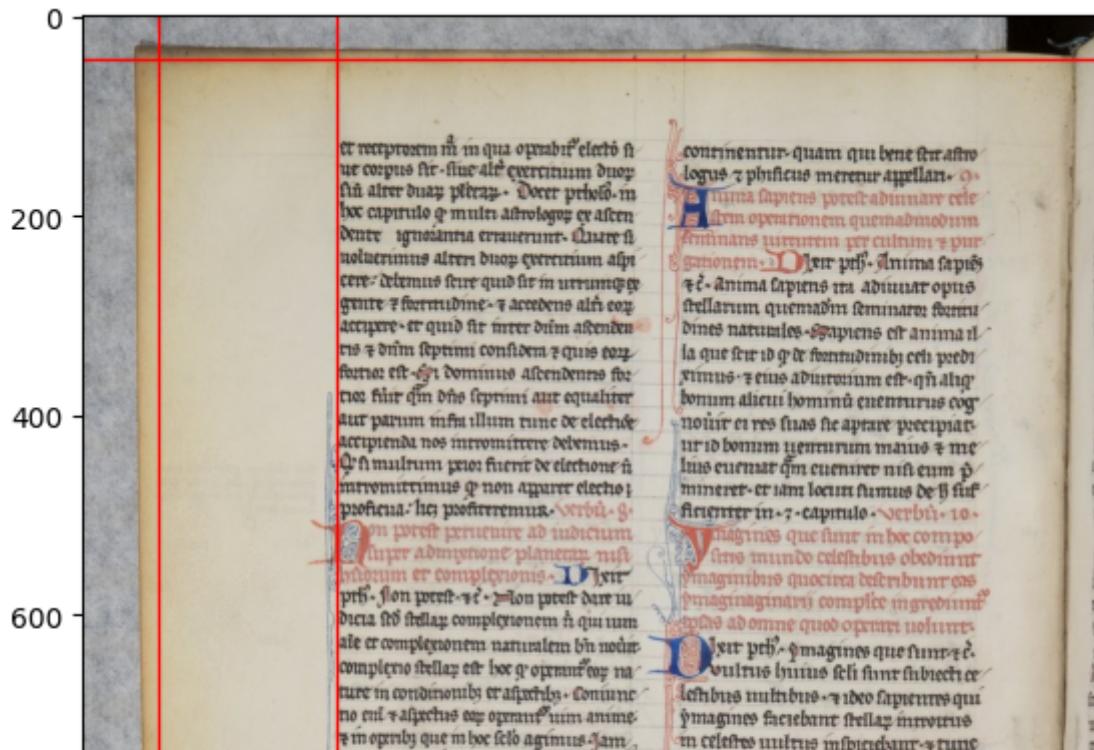
```
gain in empirical risk with splitting is 896.9620413240191
done with risk [(0, 652.851141025659, 0.005480663378853575), (77, 1525.7513312721599, 0.00554081234),
---> new split at 68
```

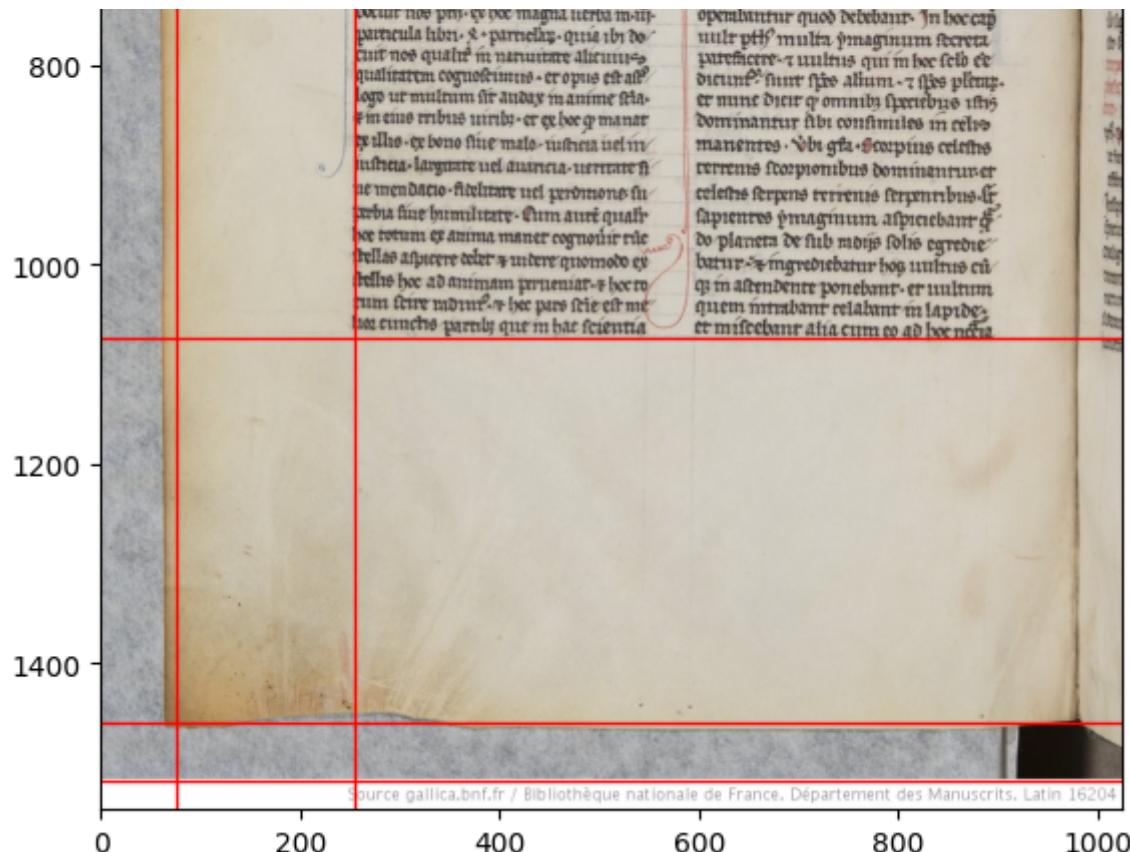
```
chrono final [[0, 38789.21806244721, 255], [1, 38453.56930527283, 77], [2, 37556.60726394881, None]
DEPTH = 7
done [(0, None), (68, None), (77, 1525.7513312721599, 0.00554081234165496), (255, 35378.0047916509)]
```



gain in empirical risk with splitting is 21.64449729561602

```
chrono before break -----> [[0, 38789.21806244721, 255], [1, 38453.56930527283, 77], [2, 37556.60726394881, None]
=====> [('y', 255), ('y', 77)]
[('y', 1517), ('y', 1073), ('y', 1460), ('y', 43), ('x', 255), ('x', 77)]
```

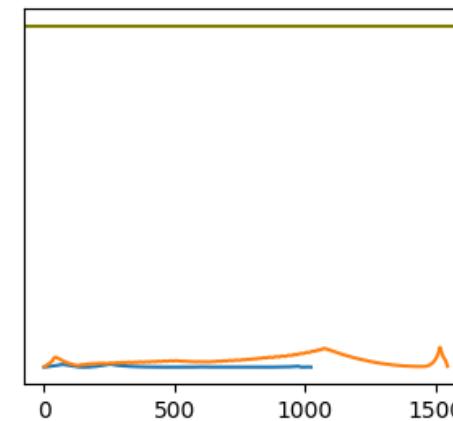
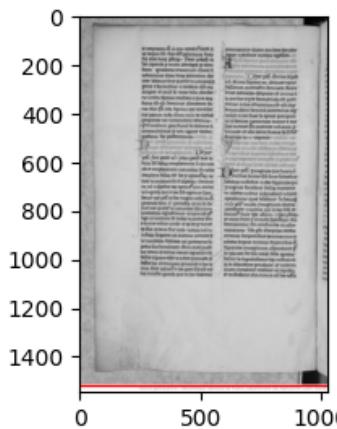
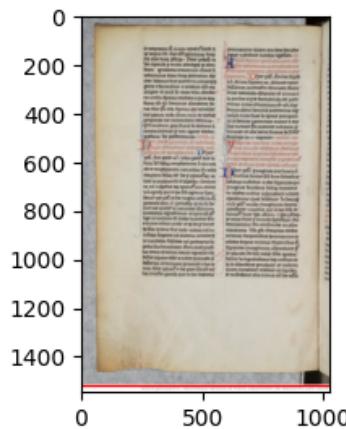




```
res = cart_regression_1(norm_image,mean_squared_error,max_depth=10,rate=1,whole_image=image)
print(res)
show_splits(image,res)
```

DEPTH = 10

1547 1024



homogeneity of each child [0.023300317324019115, 0.010879604683132581]

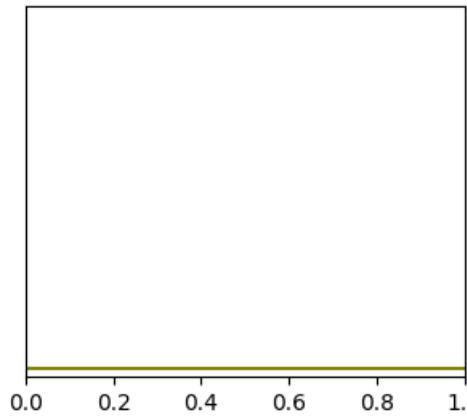
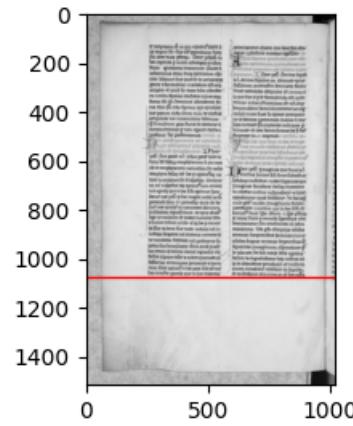
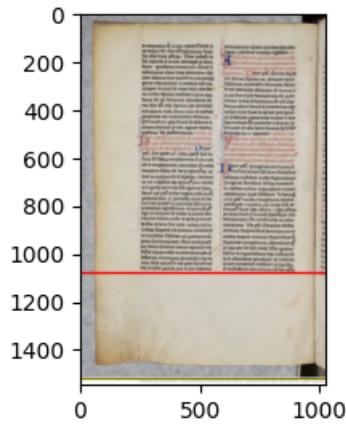
ponderated homogeneity of children if split original 0.023059450239839026 risk no split 0.0244861646
y 1073 0.02242194357554697

y 1526 0.010556853185999287

gain of splitting each child 0.0008783737484721436 0.0003227514971332942

DEPTH = 9

1517 1024



homogeneity of each child [0.027948361986915325, 0.009066432414740106]

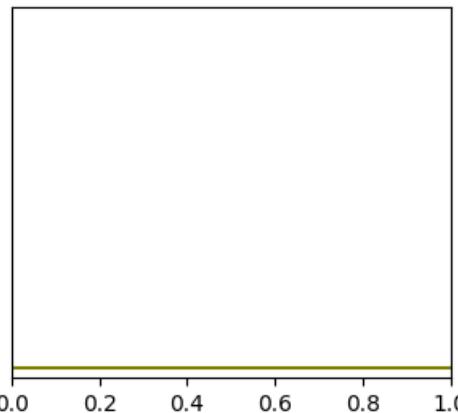
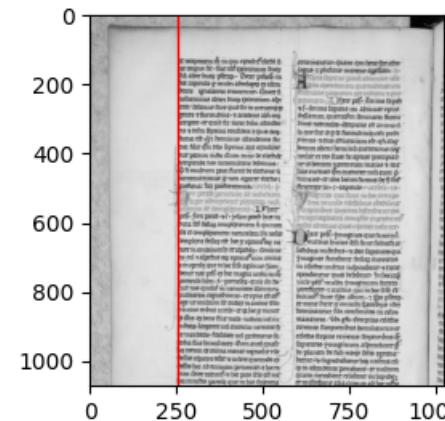
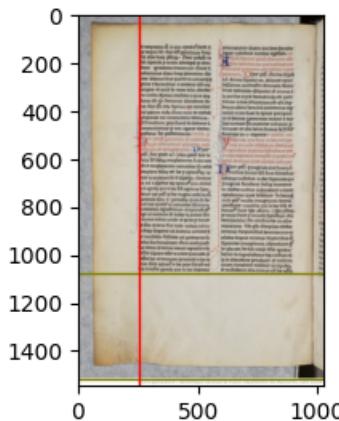
ponderated homogeneity of children if split original 0.02242194357554697 risk no split 0.02330031731
x 255 0.02692769904804237

y 1460 0.006312973030748392

gain of splitting each child 0.0010206629388729536 0.002753459383991714

DEPTH = 8

1073 1024



homogeneity of each child [0.006761045644611217, 0.033614950826813435]

ponderated homogeneity of children if split original 0.02692769904804237 risk no split 0.02794836198

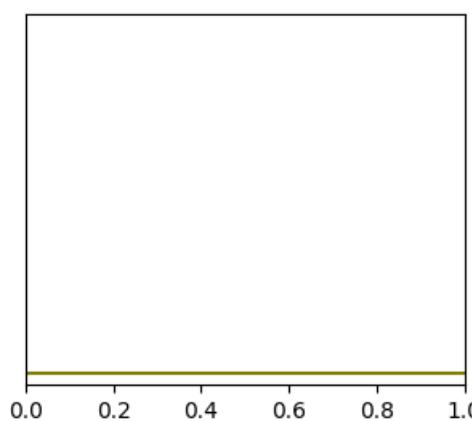
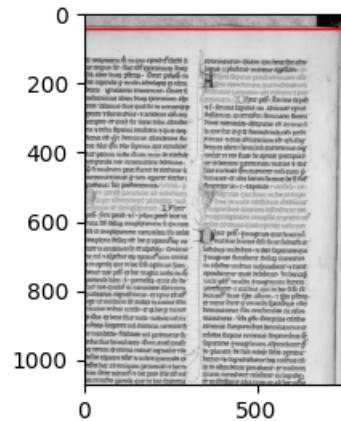
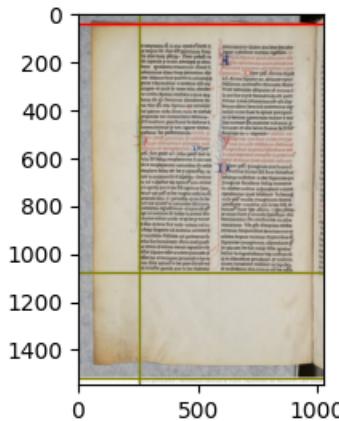
x 72 0.003578414441922082

y 296 0.03301335378950981

gain of splitting each child 0.003182631202689135 0.0006015970373036278

DEPTH = 7

1073 769



homogeneity of each child [0.03238334775258221, 0.03303838309911643]

ponderated homogeneity of children if split original 0.03301335378950981 risk no split 0.03361495088

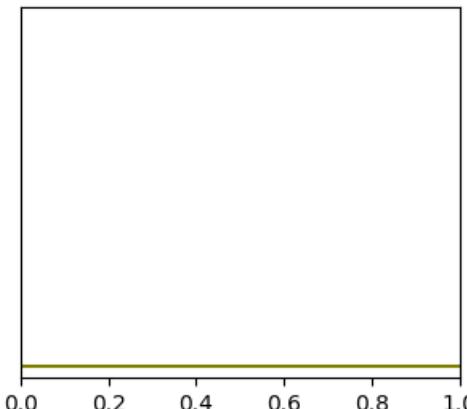
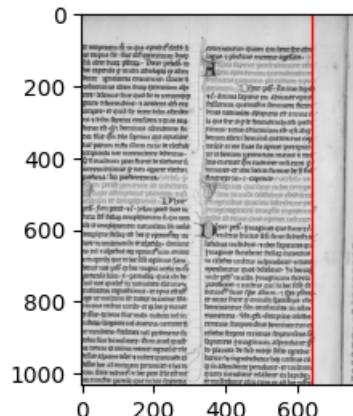
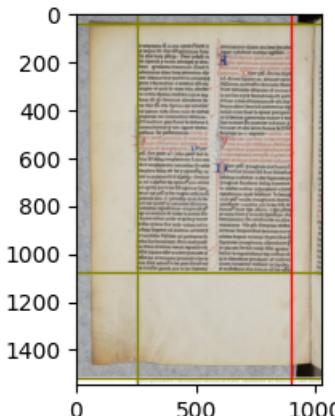
x 671 0.009245670356988867

x 681 0.032127211535374525

gain of splitting each child 0.023137677395593345 0.0009111715637419027

DEPTH = 6

1032 769



homogeneity of each child [0.036817578467086796, 0.008857174044708987]

ponderated homogeneity of children if split original 0.032127211535374525 risk no split 0.0330383836

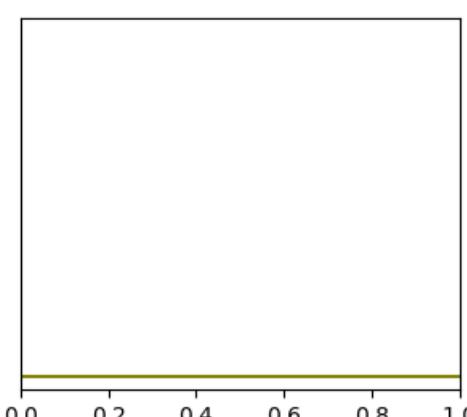
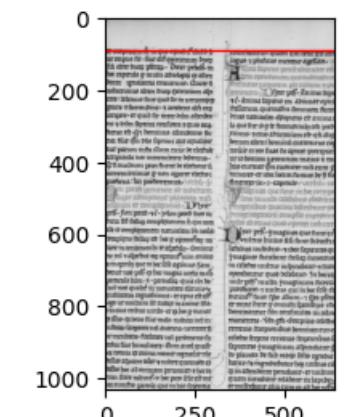
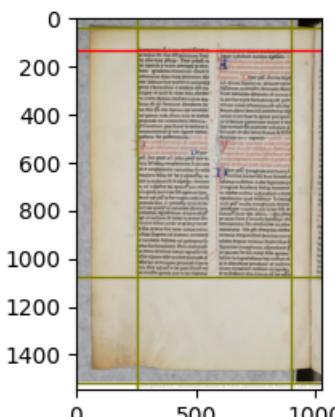
y 88 0.035939551229461165

x 716 0.006583689440953666

gain of splitting each child 0.000878027237625631 0.002273484603755321

DEPTH = 5

1032 640



homogeneity of each child [0.002177187392513925, 0.03908689023121048]

ponderated homogeneity of children if split original 0.035939551229461165 risk no split 0.0368175784

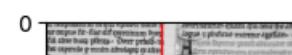
y 15 0.0013683347729918035

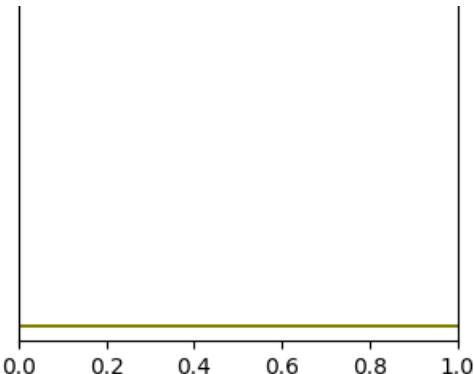
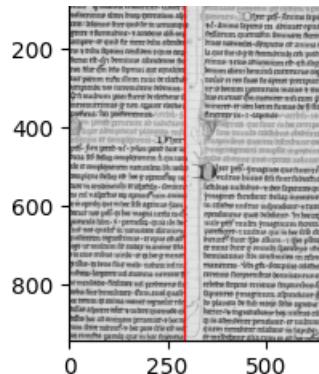
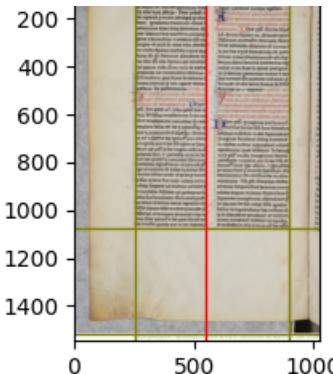
x 382 0.03888567812668827

gain of splitting each child 0.0008088526195221216 0.00020121210452220956

DEPTH = 4

944 640





homogeneity of each child [0.04222170261968389, 0.03605102147657062]

ponderated homogeneity of children if split original 0.03888567812668827 risk no split 0.0390868902:

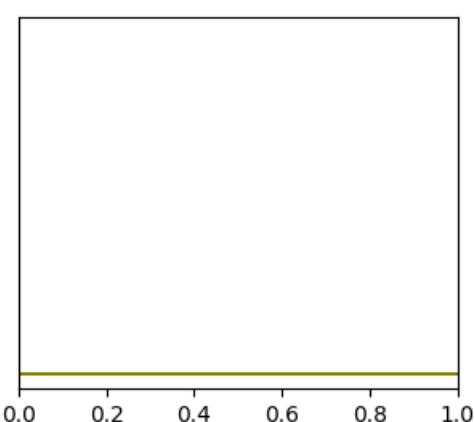
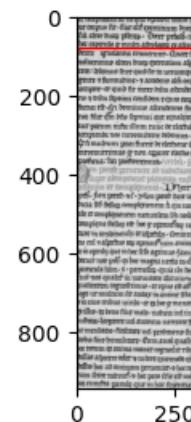
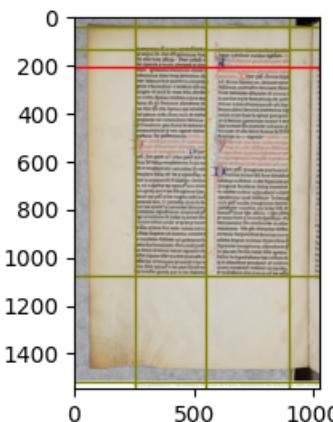
y 76 0.0419571848760249

x 342 0.03420394376004797

gain of splitting each child 0.0002645177436589874 0.0018470777165226493

DEPTH = 3

944 294



homogeneity of each child [0.04804902800165442, 0.04142379768990987]

ponderated homogeneity of children if split original 0.0419571848760249 risk no split 0.042221702619

y 66 0.04646664272007321

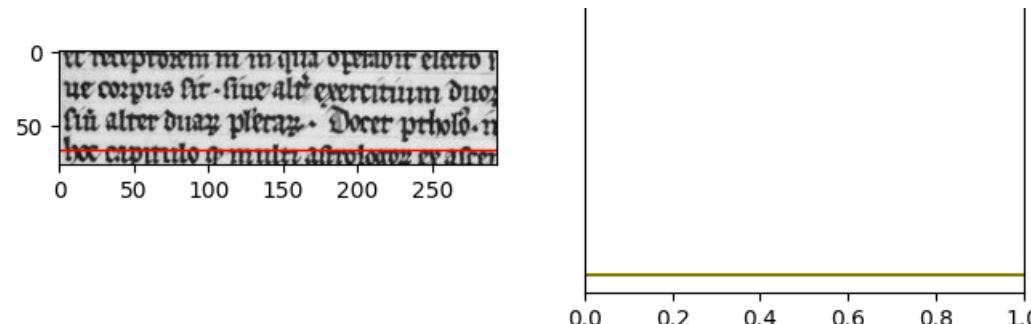
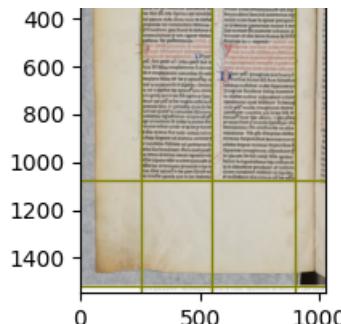
y 87 0.04132700958483934

gain of splitting each child 0.0015823852815812084 9.67881050705291e-05

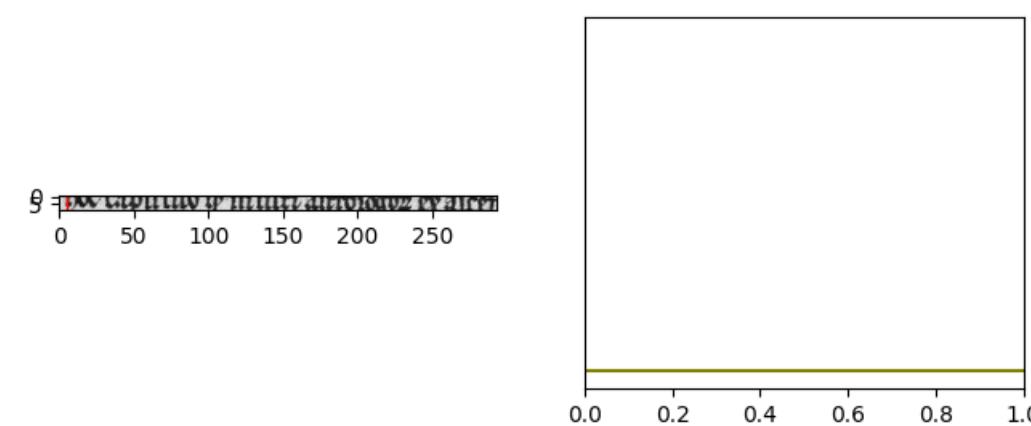
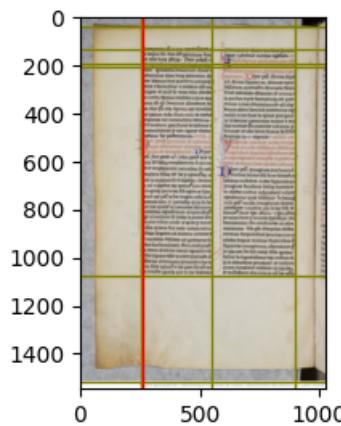
DEPTH = 2

76 294



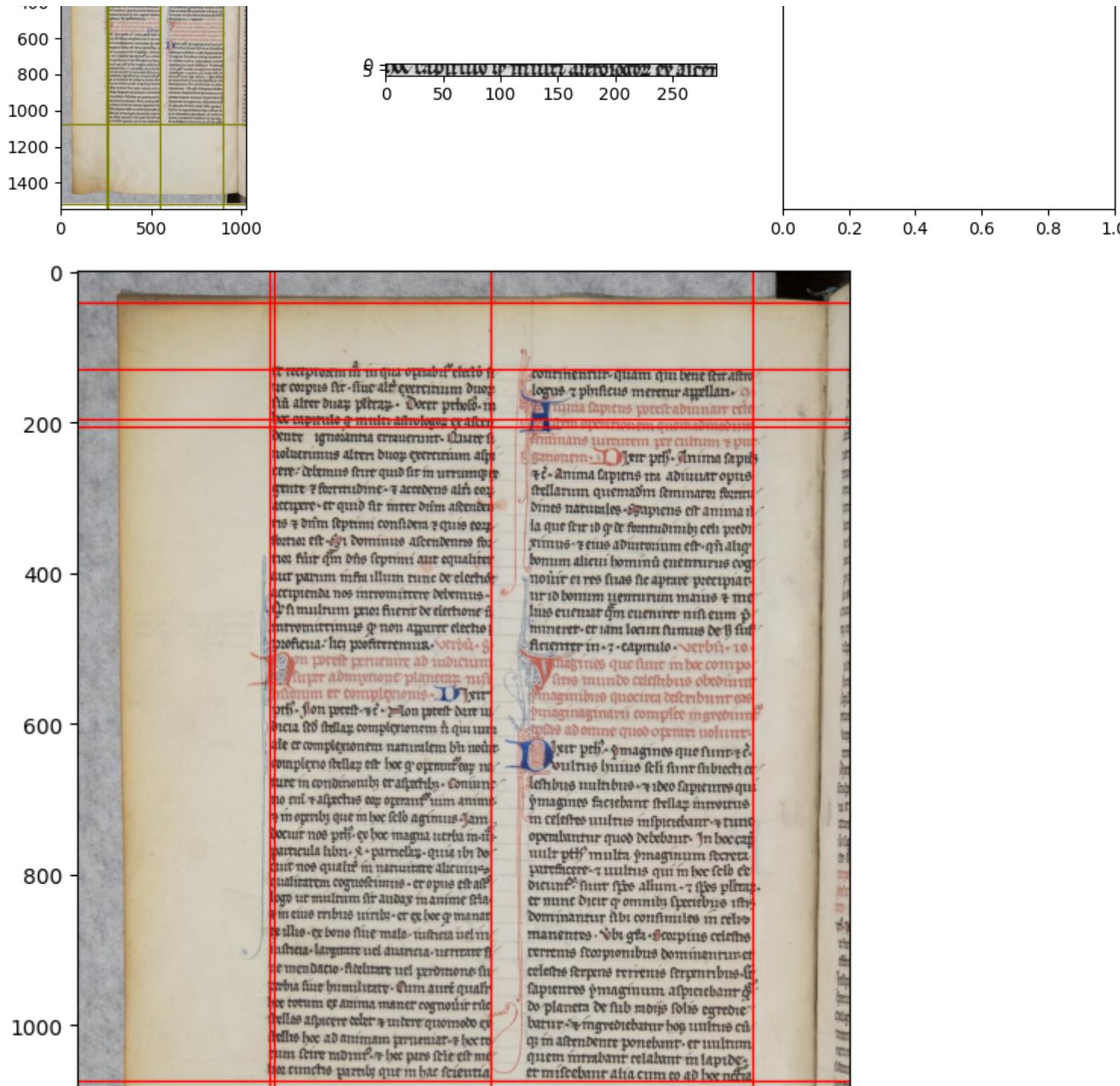


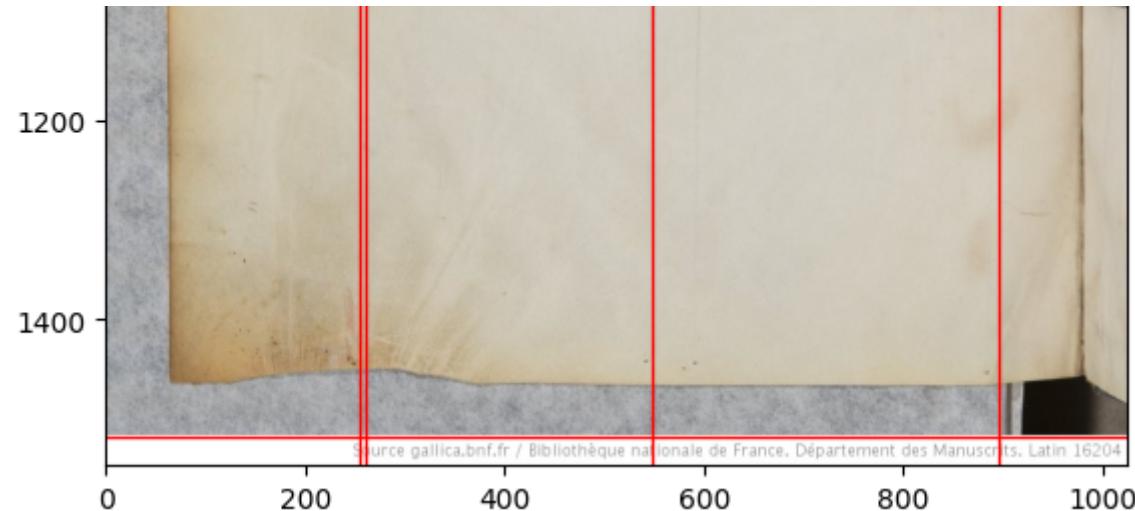
homogeneity of each child [0.04612105607947277, 0.0487475145480361]
ponderated homogeneity of children if split original 0.04646664272007321 risk no split 0.04804902806
y 55 0.043648694589768645
x 71 0.04761287248056153
gain of splitting each child 0.0024723614897041238 0.0011346420674745727
DEPTH = 1
10 294



homogeneity of each child [0.0034103806228373695, 0.0483776214746398]
ponderated homogeneity of children if split original 0.04761287248056153 risk no split 0.0487475145480361
x 3 0.0019948993976675634
y 14 0.047992994305083324
gain of splitting each child 0.001415481225169806 0.00038462716955647847
DEPTH = 0
10 289
[('y', 1517), ('y', 1073), ('x', 255), ('y', 41), ('x', 895), ('y', 129), ('x', 549), ('y', 205),







```
res = cart_regression_bi_simul(norm_image,mean_squared_error,max_depth=10,rate=10)
print(res)
show_splits(image,res)
```

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