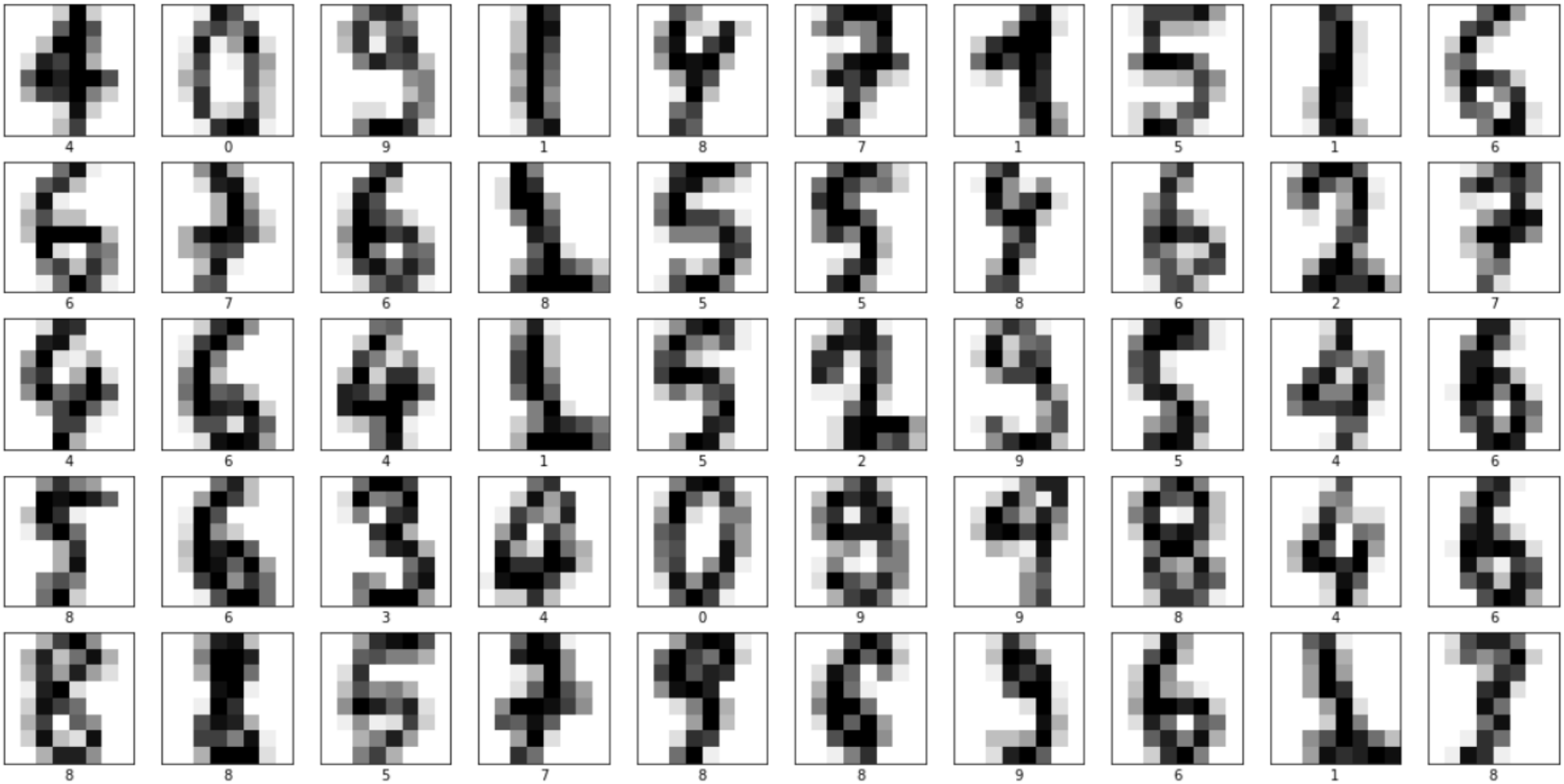


In [1]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from sklearn import model_selection
from sklearn import cluster
from sklearn import metrics
import seaborn as sns
import warnings
warnings.filterwarnings('ignore')
```

In [2]:
```
from sklearn.datasets import load_digits
data, labels = load_digits(return_X_y=True)
```

In [3]:
```
data[0]
```

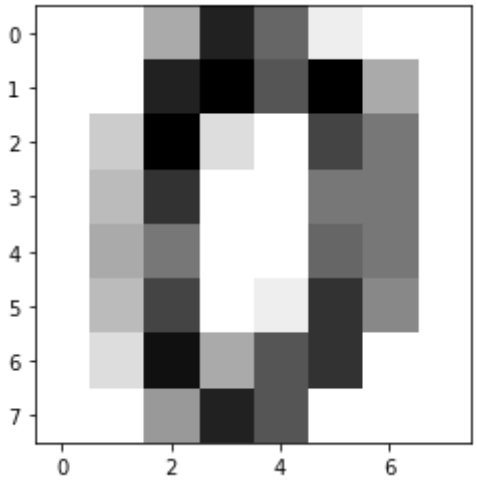
Out[3]:
```
array([ 0.,  0.,  5., 13.,  9.,  1.,  0.,  0.,  0.,  0., 13., 15., 10.,
       15.,  5.,  0.,  0.,  3., 15.,  2.,  0., 11.,  8.,  0.,  0.,  4.,
       12.,  0.,  0.,  8.,  8.,  0.,  0.,  5.,  8.,  0.,  0.,  9.,  8.,
        0.,  0.,  4., 11.,  0.,  1., 12.,  7.,  0.,  0.,  2., 14.,  5.,
       10., 12.,  0.,  0.,  0.,  0.,  6., 13., 10.,  0.,  0.,  0.])
```

In [4]:
```
labels[0]
```

Out[4]:
```
0
```

In [5]:
```
b=data[0]
a= b.reshape(8,8)
plt.imshow(a, cmap="binary")
```

Out[5]:
```
<matplotlib.image.AxesImage at 0x19e7ea7d570>
```



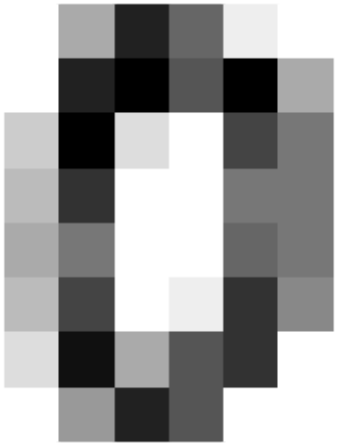
In [3]:
```
digits=np.unique(labels)
digits
```

Out[3]:
```
array([0, 1, 2, 3, 4, 5, 6, 7, 8, 9])
```

In [4]:
```
n_samples, n_features = data.shape
n_samples, n_features
```

Out[4]:
```
(1797, 64)
```

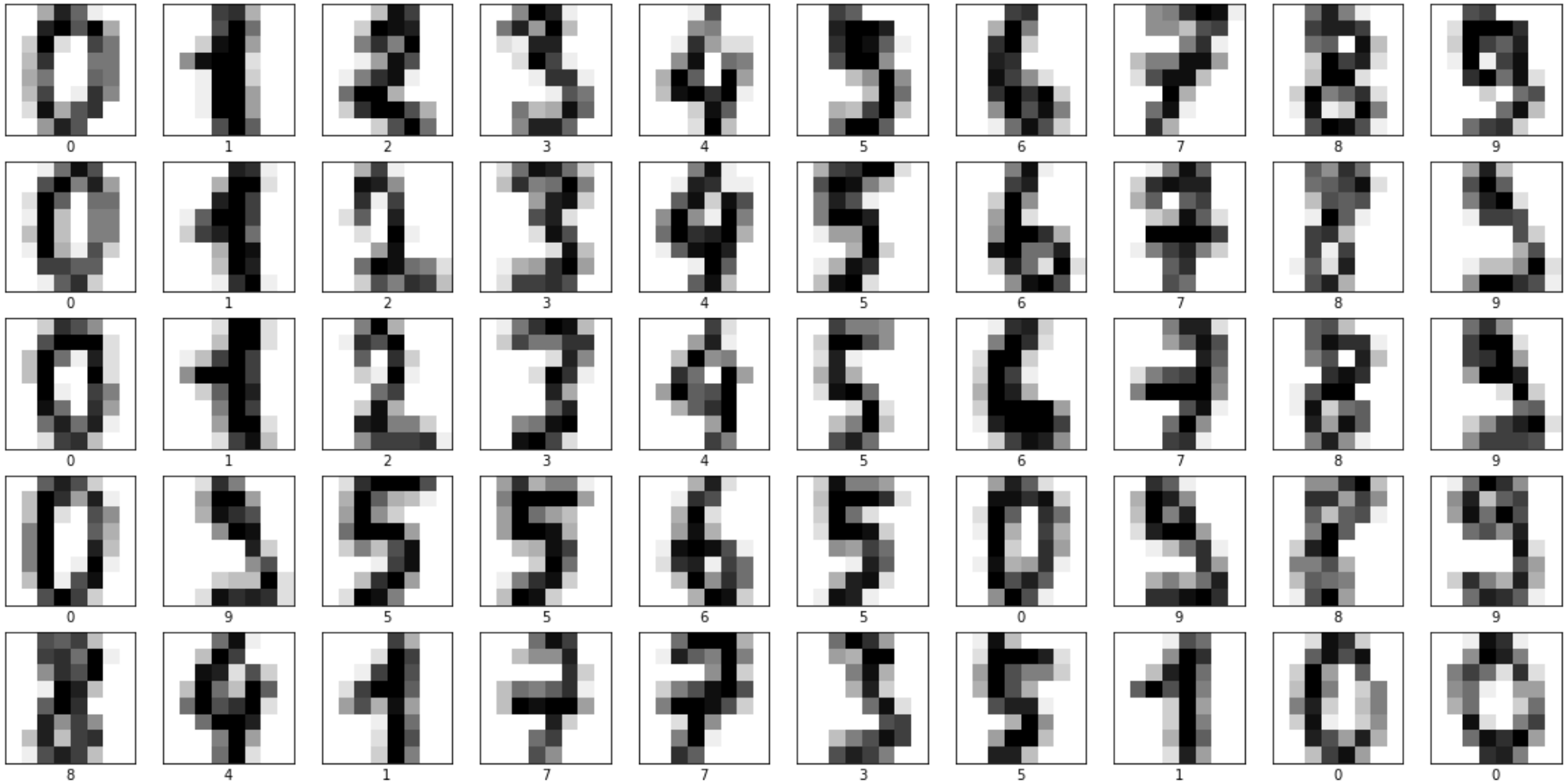
In [5]:
```
first_digit=data[0]
first_digit_image= first_digit.reshape(8,8)
plt.imshow(first_digit_image, cmap="binary")
plt.axis("off")
plt.show()
```



In [6]:
```
labels[0]
```

Out[6]:
```
0
```

In [7]:
```
plt.figure(figsize=(20,10))
for i in range(50):
    plt.subplot(5,10,i+1)
    plt.xticks([])
    plt.yticks([])
    plt.grid(True)
    x=data[i].reshape(8,8)
    plt.imshow(x, cmap=plt.cm.binary)
    plt.xlabel(labels[i])
plt.show()
```



In [8]:
```
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(data, labels, train_size=0.8, random_state=2)
```

In [9]:
```
X_train.shape, X_test.shape, y_train.shape, y_test.shape
```

Out[9]:
```
((1437, 64), (360, 64), (1437,), (360,))
```

In [10]:
```
unique,count = np.unique(y_train,return_counts=True)
unique,count/y_train.shape
```

Out[10]:
```
(array([0, 1, 2, 3, 4, 5, 6, 7, 8, 9]),
 array([0.10160056, 0.0960334 , 0.10160056, 0.10229645, 0.10160056,
        0.0967293 , 0.10160056, 0.0967293 , 0.0960334 , 0.10577592]))
```

In [11]:
```
unique,count=np.unique(y_test,return_counts=True)
unique,count/y_test.shape
```

Out[11]:
```
(array([0, 1, 2, 3, 4, 5, 6, 7, 8, 9]),
 array([0.08888889, 0.12222222, 0.08611111, 0.1       , 0.09722222,
        0.11944444, 0.09722222, 0.11111111, 0.1       , 0.07777778]))
```

In [12]:
```
from imblearn.over_sampling import SMOTE
smote = SMOTE()
```

In [13]:
```
#x_train, y_train = smote.fit_resample(X_train.astype('float'),y_train)
```

In [14]:
```
#unique,count = np.unique(y_train,return_counts=True)
#unique,count/y_train.shape
```

In [15]:
```
from sklearn.linear_model import LogisticRegression
log_reg = LogisticRegression()
```

In [16]:
```
log_reg.fit(X_train, y_train)
```

Out[16]:
```
▾ LogisticRegression

LogisticRegression()
```

In [17]:
```
log_reg.intercept_
```

Out[17]:
```
array([ 0.00032198, -0.07937238, -0.00385451,  0.01053846,  0.00497534,
       -0.00169985, -0.00646291,  0.0135647 ,  0.09386533, -0.03187616])
```

In [18]:
```
log_reg.coef_[:1]
```

Out[18]:
```
array([[ 0.00000000e+00, -8.15705766e-03, -2.32205836e-02,
         4.61992144e-02,  2.20580221e-02, -9.17586844e-02,
        -1.35182879e-01, -1.25730676e-02, -1.33547647e-04,
        -2.76676448e-02,  1.32057172e-02,  8.80933587e-02,
         4.58700949e-02,  1.25854630e-01, -5.14246170e-02,
        -1.36075029e-02, -3.68904186e-04,  1.51055813e-02,
         1.68600194e-01,  3.08444242e-03, -2.76660795e-01,
         1.34407265e-01,  8.32086378e-02, -4.42461295e-03,
        -1.77917038e-04,  9.16759492e-02,  1.50048819e-01,
        -1.39245474e-01, -4.38755662e-01, -2.01798036e-02,
         1.85175261e-01, -9.23918256e-05,  0.00000000e+00,
         1.81283421e-01,  1.06883578e-01, -2.44530303e-01,
        -3.99549904e-01,  3.30743059e-02,  1.29451516e-01,
         0.00000000e+00, -3.41447798e-04,  2.35667731e-02,
         1.77988133e-01, -6.96931855e-02, -1.35088531e-01,
         1.38911449e-01,  3.90999609e-02, -4.18488588e-04,
        -6.90084203e-04, -5.73505700e-02,  9.71085744e-02,
         1.16909493e-02,  1.40547033e-01,  7.68943581e-02,
        -4.26785128e-02, -9.11547234e-03, -1.43540636e-05,
        -1.36853632e-02, -6.09164000e-02,  9.76872006e-02,
        -2.79778888e-02, -3.99407490e-02, -4.30172735e-02,
        -1.57015176e-02]])
```

In [19]:
```
y_predict=log_reg.predict(X_test)
y_predict[:1]
```

Out[19]:
```
array([4])
```

In [20]:
```
log_reg.score(X_test, y_test)
```

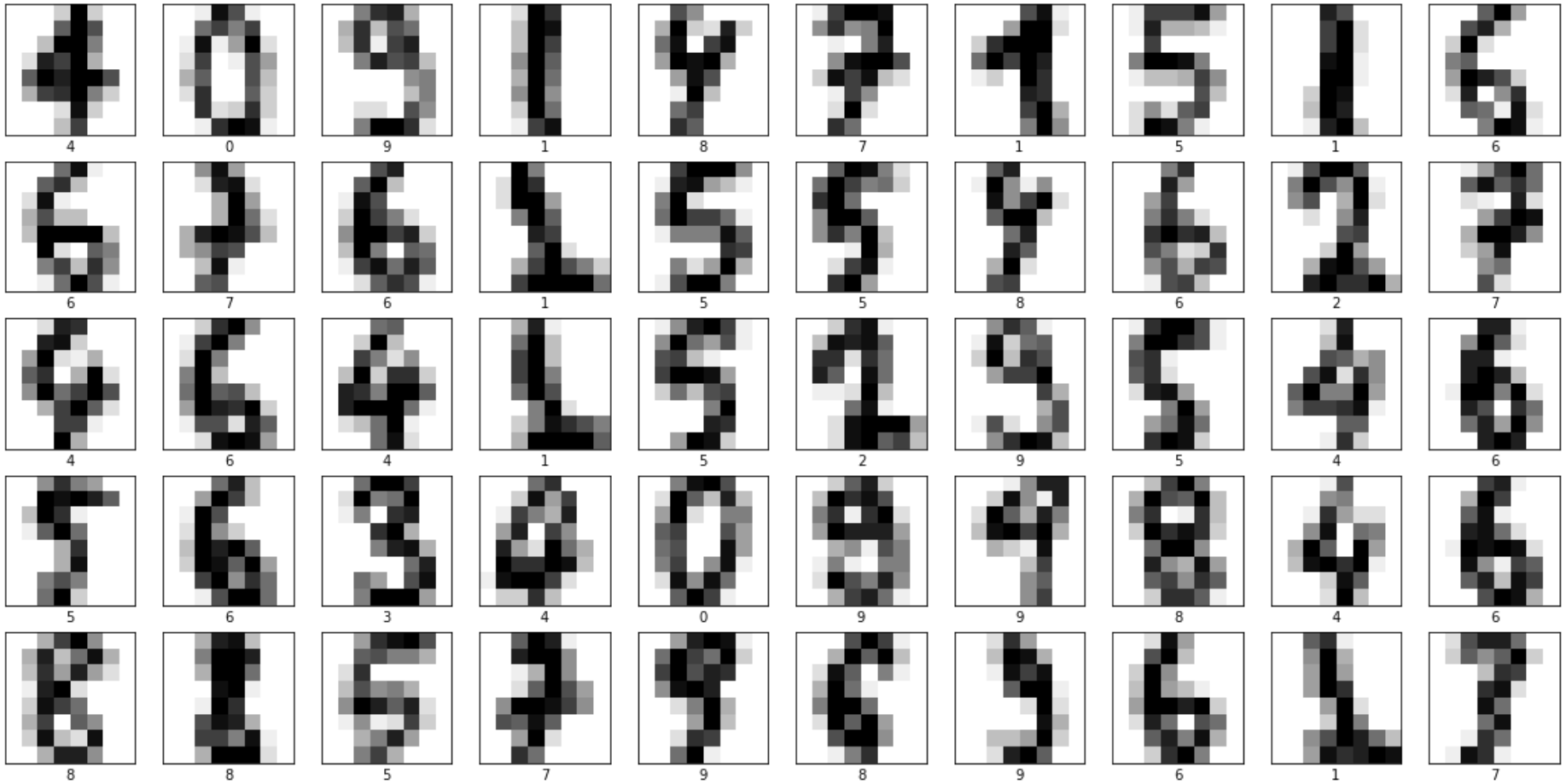
Out[20]:
```
0.9444444444444444
```

In [21]:
```
from sklearn.metrics import accuracy_score
accuracy_score(y_test,y_predict)
```

Out[21]:
```
0.9444444444444444
```

In [22]:
```
plt.figure(figsize=(20,10))
for i in range(50):
    plt.subplot(5,10,i+1)
    plt.xticks([])
    plt.yticks([])
```

```
    plt.grid(True)
    x=X_test[i].reshape(8,8)
    plt.imshow(x, cmap=plt.cm.binary)
    plt.xlabel(y_predict[i])
plt.show()
```



In [23]:
```
from sklearn.metrics import classification_report
print(classification_report(y_test, y_predict))
```

	precision	recall	f1-score	support
0	1.00	0.97	0.98	32
1	0.95	0.93	0.94	44
2	1.00	1.00	1.00	31
3	0.94	0.92	0.93	36
4	0.94	0.89	0.91	35
5	0.98	0.95	0.96	43
6	1.00	0.94	0.97	35
7	0.97	0.97	0.97	40
8	0.81	0.97	0.89	36
9	0.86	0.89	0.88	28
accuracy			0.94	360
macro avg	0.95	0.94	0.94	360
weighted avg	0.95	0.94	0.95	360

In [24]:
```
from sklearn.preprocessing import QuantileTransformer
quantile_transformer = QuantileTransformer(output_distribution='normal', random_state=2)
```

In [25]:
```
X_train_trans = quantile_transformer.fit_transform(X_train)
```

In [26]:
```
X_test_trans = quantile_transformer.transform(X_test)
```

In [27]:
```
lreg = LogisticRegression()
```

In [28]:
```
lreg.fit(X_train_trans,y_train)
```

Out[28]:
```
LogisticRegression
LogisticRegression()
```

In [29]:
```
lreg.score(X_test, y_test)
```

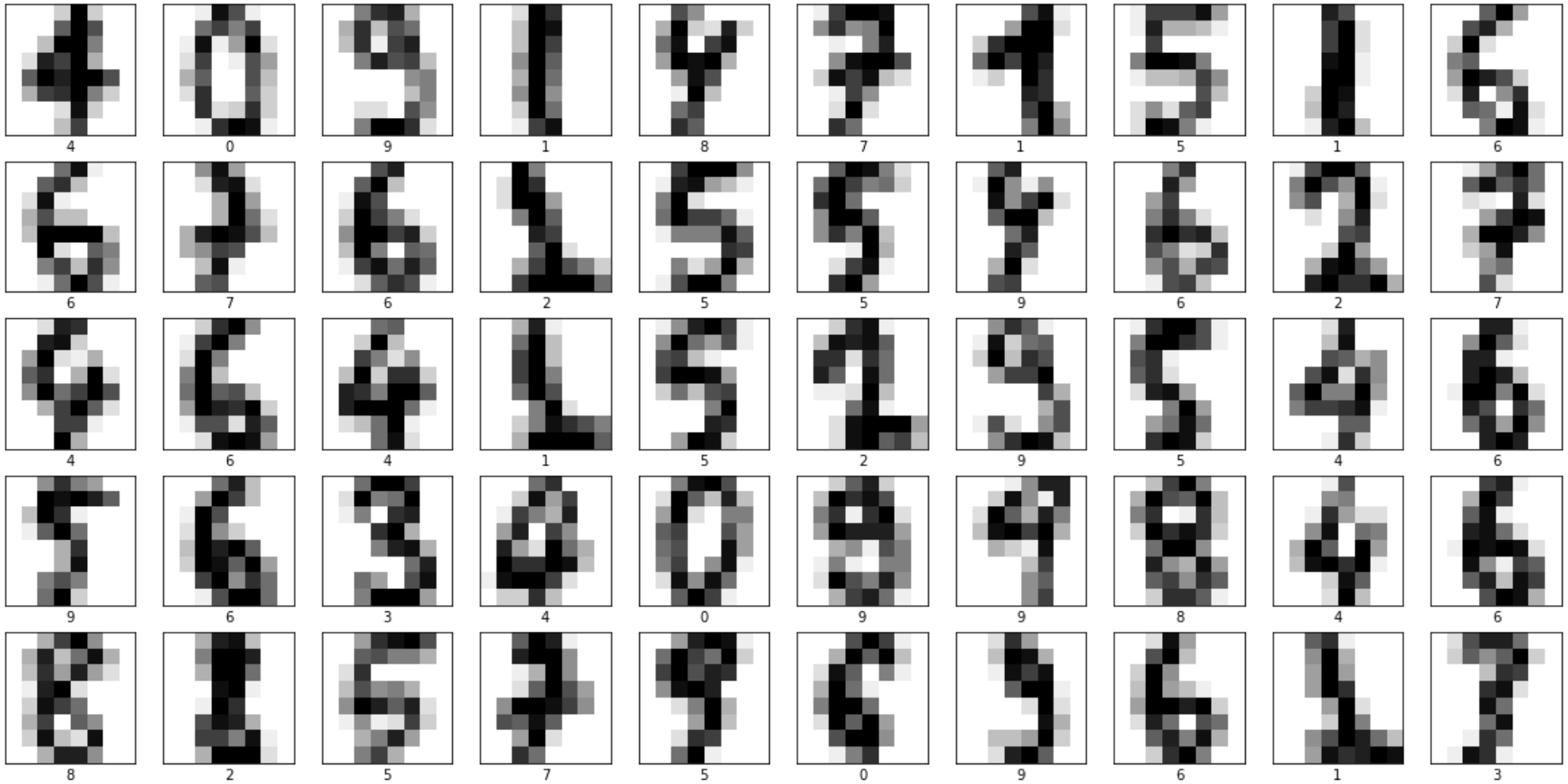
Out[29]:
```
0.8472222222222222
```

In [30]:
```
y_pred=lreg.predict(X_test_trans)
```

In [31]:
```
accuracy_score(y_test, y_pred)
```

Out[31]: 0.9333333333333333

In [32]:
```
plt.figure(figsize=(20,10))
for i in range(50):
    plt.subplot(5,10,i+1)
    plt.xticks([])
    plt.yticks([])
    plt.grid(True)
    x=X_test[i].reshape(8,8)
    plt.imshow(x, cmap=plt.cm.binary)
    plt.xlabel(y_pred[i])
plt.show()
```



In [33]:
```
print(classification_report(y_test, y_pred))
```

```
              precision    recall  f1-score   support

           0       0.97      0.97      0.97        32
           1       0.98      0.93      0.95        44
           2       0.91      1.00      0.95        31
           3       0.94      0.89      0.91        36
           4       0.94      0.89      0.91        35
           5       0.93      0.95      0.94        43
           6       1.00      0.94      0.97        35
           7       0.97      0.97      0.97        40
           8       0.85      0.92      0.88        36
           9       0.83      0.86      0.84        28

    accuracy                           0.93       360
   macro avg       0.93      0.93      0.93       360
weighted avg       0.94      0.93      0.93       360
```

In [34]:
```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer().fit(X_train)  # fit does nothing
normalizer
```

Out[34]:
```
Normalizer()
```

In [35]:
```
X_train_normalized = normalizer.transform(X_train)
X_test_normalized = normalizer.transform(X_test)
X_train_normalized
```

Out[35]:
```
array([[0.        , 0.        , 0.16224277, ..., 0.25958843, 0.12979422,
        0.        ],
       [0.        , 0.01663666, 0.19963986, ..., 0.1497299 , 0.06654662,
        0.        ],
       [0.        , 0.0625229 , 0.2500916 , ..., 0.2500916 , 0.1250458 ,
        0.        ],
       ...,
       [0.        , 0.        , 0.        , ..., 0.20416196, 0.05444319,
        0.        ],
       [0.        , 0.        , 0.10519842, ..., 0.28052912, 0.28052912,
        0.21039684],
       [0.        , 0.05035088, 0.23497078, ..., 0.        , 0.        ,
        0.        ]])
```

In [36]:
```
lreg=LogisticRegression()
lreg.fit(X_train_normalized, y_train)
```

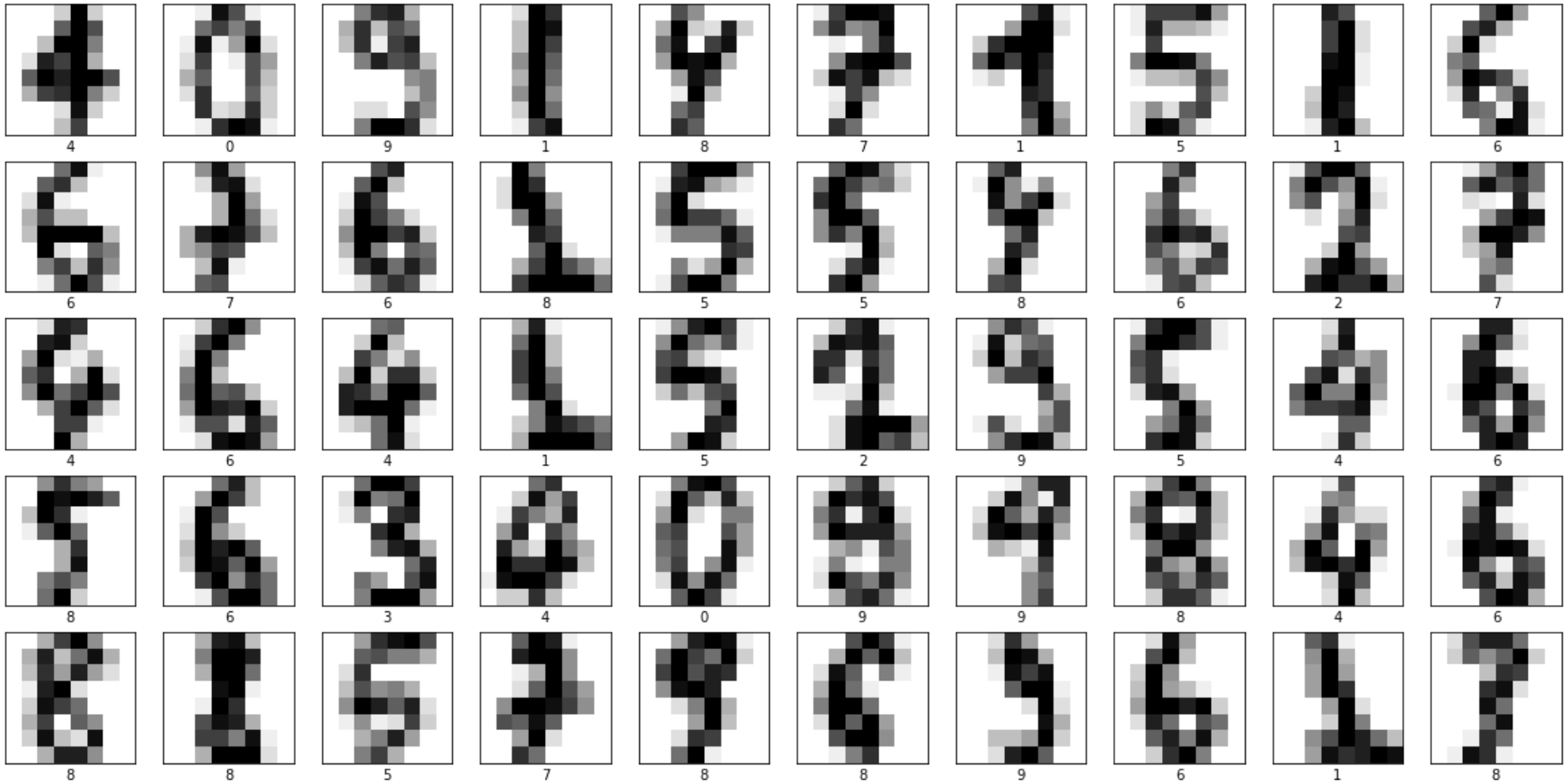
Out[36]:
```
LogisticRegression()
```

In [37]:
```
lreg.score(X_test, y_test)
```

Out[37]:
```
0.8444444444444444
```

In [38]:
```
y_pred=lreg.predict(X_test)
```

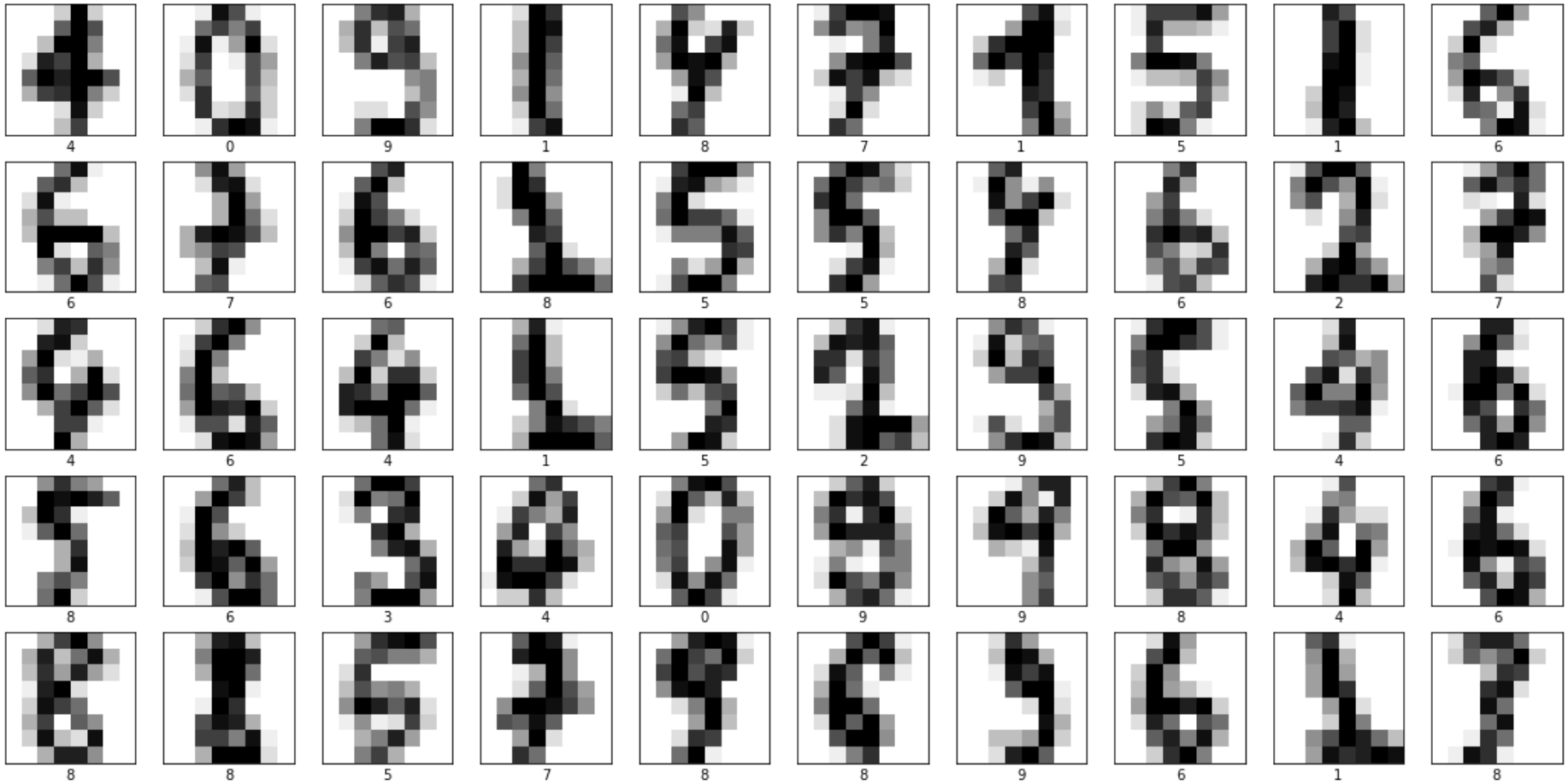
In [39]:
```
plt.figure(figsize=(20,10))
for i in range(50):
    plt.subplot(5,10,i+1)
    plt.xticks([])
    plt.yticks([])
    plt.grid(True)
    x=X_test[i].reshape(8,8)
    plt.imshow(x, cmap=plt.cm.binary)
    plt.xlabel(y_pred[i])
plt.show()
```



In [40]:
```
print(classification_report(y_test, y_pred))
```

	precision	recall	f1-score	support
0	1.00	1.00	1.00	32
1	0.96	0.61	0.75	44
2	1.00	0.81	0.89	31
3	0.94	0.81	0.87	36
4	0.97	0.83	0.89	35
5	1.00	0.86	0.92	43
6	0.92	0.94	0.93	35
7	1.00	0.88	0.93	40
8	0.45	0.97	0.61	36
9	0.79	0.79	0.79	28
accuracy			0.84	360
macro avg	0.90	0.85	0.86	360
weighted avg	0.91	0.84	0.86	360

In [41]:
```
plt.figure(figsize=(20,10))
for i in range(50):
    plt.subplot(5,10,i+1)
    plt.xticks([])
    plt.yticks([])
    plt.grid(True)
    x=X_test[i].reshape(8,8)
    plt.imshow(x, cmap=plt.cm.binary)
    plt.xlabel(y_pred[i])
plt.show()
```



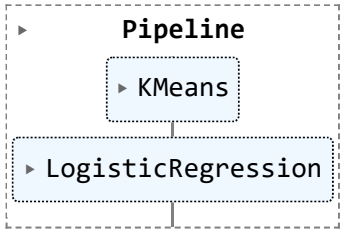
- **Without Normalization giving better accuracy**

In [42]:
```
from sklearn.cluster import KMeans
from sklearn.pipeline import Pipeline

pipeline =Pipeline([
    ('kmeans', KMeans(n_clusters = 50)),
    ('log_red', LogisticRegression()),
])
```

In [43]:
```
pipeline.fit(X_train, y_train)
```

Out[43]:



In [44]:
```
pipeline.score(X_test, y_test)
```

Out[44]:
```
0.9472222222222222
```

In [45]:
```
y_pred=pipeline.predict(X_test)
y_pred
```

Out[45]:
```
array([4, 0, 9, 1, 9, 7, 1, 5, 1, 6, 6, 7, 6, 1, 5, 5, 9, 6, 2, 7, 4, 6,
       4, 1, 5, 2, 9, 5, 4, 6, 5, 6, 3, 4, 0, 9, 9, 8, 4, 6, 8, 2, 5, 7,
       9, 4, 9, 6, 1, 7, 0, 1, 9, 7, 3, 3, 1, 8, 8, 8, 9, 8, 5, 9, 4, 8,
       3, 5, 8, 4, 3, 9, 3, 8, 7, 3, 3, 0, 8, 7, 2, 8, 5, 3, 8, 7, 6, 4,
       6, 2, 2, 0, 1, 1, 5, 3, 5, 7, 1, 8, 2, 2, 6, 4, 6, 7, 3, 7, 3, 9,
       4, 7, 0, 3, 5, 1, 5, 0, 3, 9, 2, 7, 3, 2, 0, 8, 1, 9, 2, 1, 5, 1,
       0, 3, 4, 3, 0, 9, 3, 2, 2, 7, 3, 1, 6, 7, 2, 8, 3, 1, 1, 6, 4, 8,
       2, 1, 8, 4, 1, 3, 1, 1, 9, 5, 4, 8, 7, 4, 8, 9, 5, 7, 6, 9, 4, 0,
       4, 0, 0, 9, 0, 6, 5, 8, 8, 3, 7, 9, 2, 0, 3, 2, 7, 3, 0, 2, 6, 5,
       2, 7, 0, 6, 9, 3, 1, 1, 3, 5, 2, 3, 5, 2, 1, 2, 9, 4, 6, 5, 5, 5,
       9, 7, 1, 5, 9, 6, 3, 7, 1, 7, 5, 1, 7, 2, 7, 5, 5, 4, 8, 6, 6, 2,
       8, 7, 3, 7, 8, 0, 3, 5, 7, 4, 3, 4, 1, 0, 3, 3, 5, 4, 1, 3, 1, 2,
       5, 1, 4, 0, 3, 1, 5, 5, 7, 4, 0, 1, 0, 8, 5, 5, 5, 4, 0, 1, 8, 6,
       2, 1, 1, 1, 7, 9, 6, 7, 9, 7, 0, 4, 8, 6, 9, 2, 7, 2, 1, 0, 8, 2,
       8, 6, 5, 7, 8, 4, 5, 7, 8, 6, 4, 2, 6, 9, 3, 0, 0, 8, 0, 6, 6, 7,
       1, 4, 5, 6, 9, 7, 2, 8, 5, 1, 2, 4, 1, 8, 8, 3, 6, 0, 8, 0, 6, 5,
       5, 7, 8, 0, 4, 1, 4, 5])
```

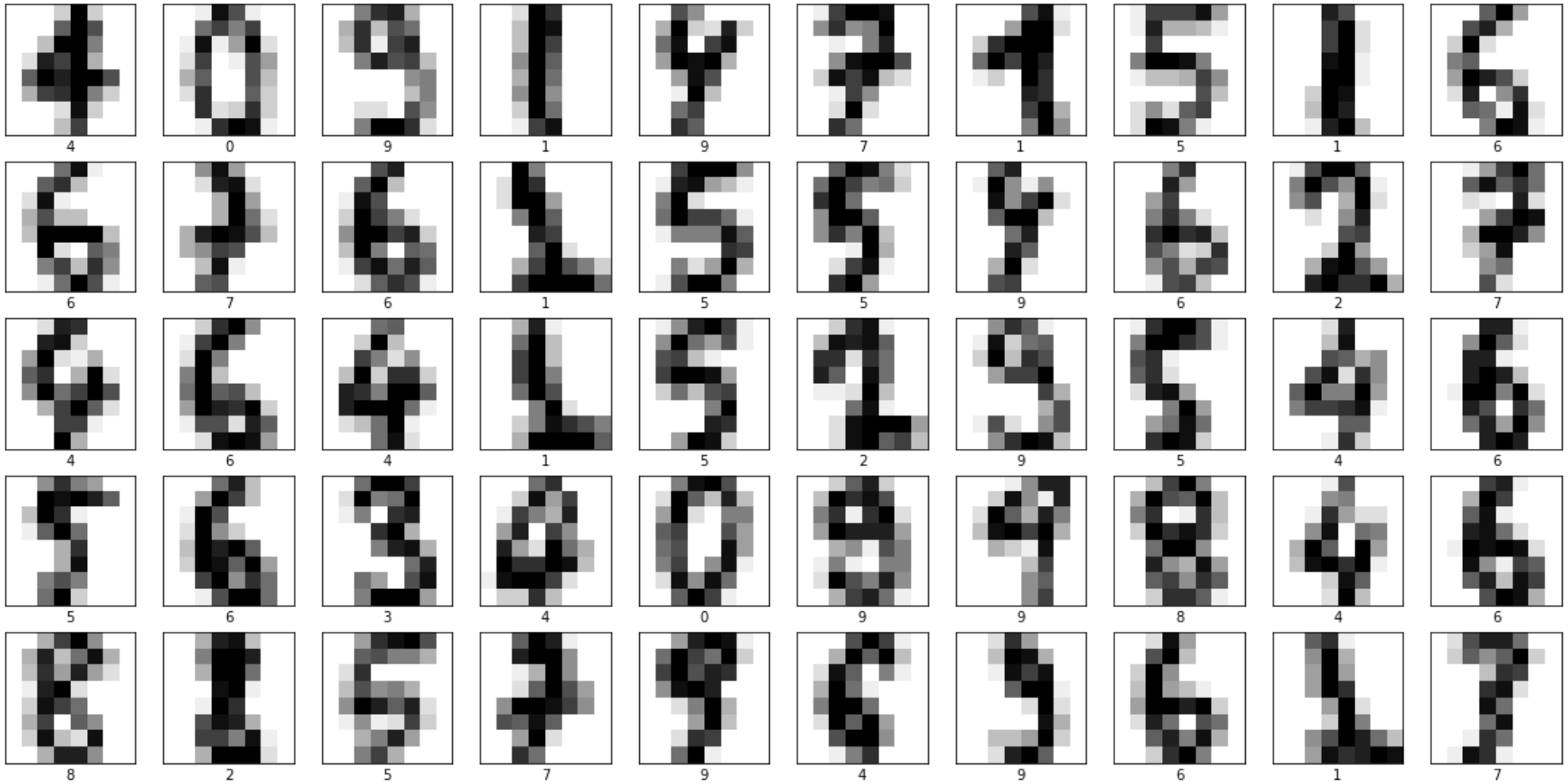
In [46]:
```
accuracy_score(y_test, y_pred)
```

Out[46]:
```
0.9472222222222222
```

In [47]:
```
print(classification_report(y_test, y_pred))
```

	precision	recall	f1-score	support
0	1.00	0.97	0.98	32
1	0.95	0.93	0.94	44
2	0.97	1.00	0.98	31
3	0.95	0.97	0.96	36
4	0.91	0.89	0.90	35
5	0.98	0.98	0.98	43
6	0.97	0.94	0.96	35
7	0.97	0.95	0.96	40
8	0.92	0.94	0.93	36
9	0.83	0.89	0.86	28
accuracy			0.95	360
macro avg	0.95	0.95	0.95	360
weighted avg	0.95	0.95	0.95	360

In [48]:
```
plt.figure(figsize=(20,10))
for i in range(50):
    plt.subplot(5,10,i+1)
    plt.xticks([])
    plt.yticks([])
    plt.grid(True)
    x=X_test[i].reshape(8,8)
    plt.imshow(x, cmap=plt.cm.binary)
    plt.xlabel(y_pred[i])
plt.show()
```



In [49]:
```
from sklearn.model_selection import GridSearchCV
param_grid = dict(kmeans__n_clusters=range(2, 100))
grid_clf = GridSearchCV(pipeline, param_grid, cv=3, verbose=2)
grid_clf.fit(X_train, y_train)
```

```
Fitting 3 folds for each of 98 candidates, totalling 294 fits
[CV] END ..............................kmeans__n_clusters=2; total time=   0.0s
[CV] END ..............................kmeans__n_clusters=2; total time=   0.0s
[CV] END ..............................kmeans__n_clusters=2; total time=   0.0s
[CV] END ..............................kmeans__n_clusters=3; total time=   0.0s
[CV] END ..............................kmeans__n_clusters=3; total time=   0.0s
[CV] END ..............................kmeans__n_clusters=3; total time=   0.0s
[CV] END ..............................kmeans__n_clusters=4; total time=   0.0s
[CV] END ..............................kmeans__n_clusters=4; total time=   0.0s
[CV] END ..............................kmeans__n_clusters=4; total time=   0.0s
[CV] END ..............................kmeans__n_clusters=5; total time=   0.0s
[CV] END ..............................kmeans__n_clusters=5; total time=   0.0s
[CV] END ..............................kmeans__n_clusters=5; total time=   0.0s
[CV] END ..............................kmeans__n_clusters=6; total time=   0.0s
[CV] END ..............................kmeans__n_clusters=6; total time=   0.0s
[CV] END ..............................kmeans__n_clusters=6; total time=   0.0s
[CV] END ..............................kmeans__n_clusters=7; total time=   0.0s
[CV] END ..............................kmeans__n_clusters=7; total time=   0.0s
[CV] END ..............................kmeans__n_clusters=7; total time=   0.0s
[CV] END ..............................kmeans__n_clusters=8; total time=   0.0s
[CV] END ..............................kmeans__n_clusters=8; total time=   0.0s
[CV] END ..............................kmeans__n_clusters=8; total time=   0.0s
[CV] END ..............................kmeans__n_clusters=9; total time=   0.0s
[CV] END ..............................kmeans__n_clusters=9; total time=   0.0s
[CV] END ..............................kmeans__n_clusters=9; total time=   0.0s
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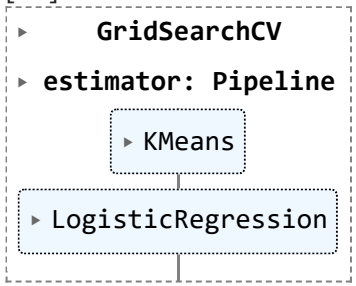
Out[49]:



In [50]:
```
grid_clf.best_params_
```

Out[50]:
```
{'kmeans__n_clusters': 55}
```

In [51]:
```
grid_clf.score(X_test, y_test)
```

Out[51]:
```
0.9555555555555556
```

In [52]:
```
y_pred = grid_clf.predict(X_test)
```

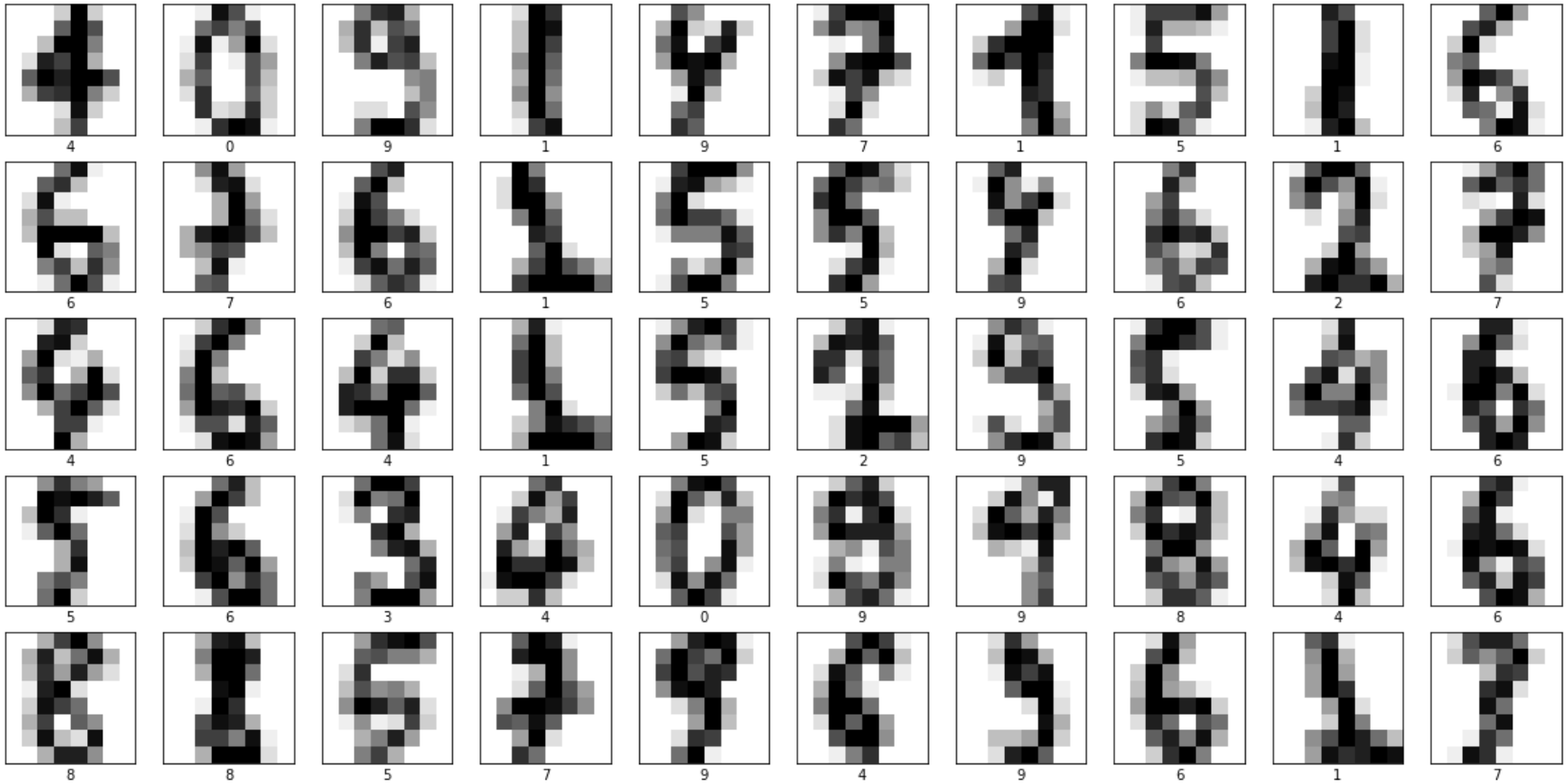
In [53]:
```
print(classification_report(y_test, y_pred))
```

```
              precision    recall  f1-score   support

           0       1.00      0.97      0.98        32
           1       0.96      0.98      0.97        44
           2       1.00      1.00      1.00        31
           3       0.95      0.97      0.96        36
           4       0.91      0.89      0.90        35
           5       0.98      0.98      0.98        43
           6       0.97      0.94      0.96        35
           7       0.97      0.95      0.96        40
           8       0.95      0.97      0.96        36
           9       0.86      0.89      0.88        28

    accuracy                           0.96       360
   macro avg       0.95      0.95      0.95       360
weighted avg       0.96      0.96      0.96       360
```

In [54]:
```
plt.figure(figsize=(20,10))
for i in range(50):
    plt.subplot(5,10,i+1)
    plt.xticks([])
    plt.yticks([])
    plt.grid(True)
    x=X_test[i].reshape(8,8)
    plt.imshow(x, cmap=plt.cm.binary)
    plt.xlabel(y_pred[i])
plt.show()
```

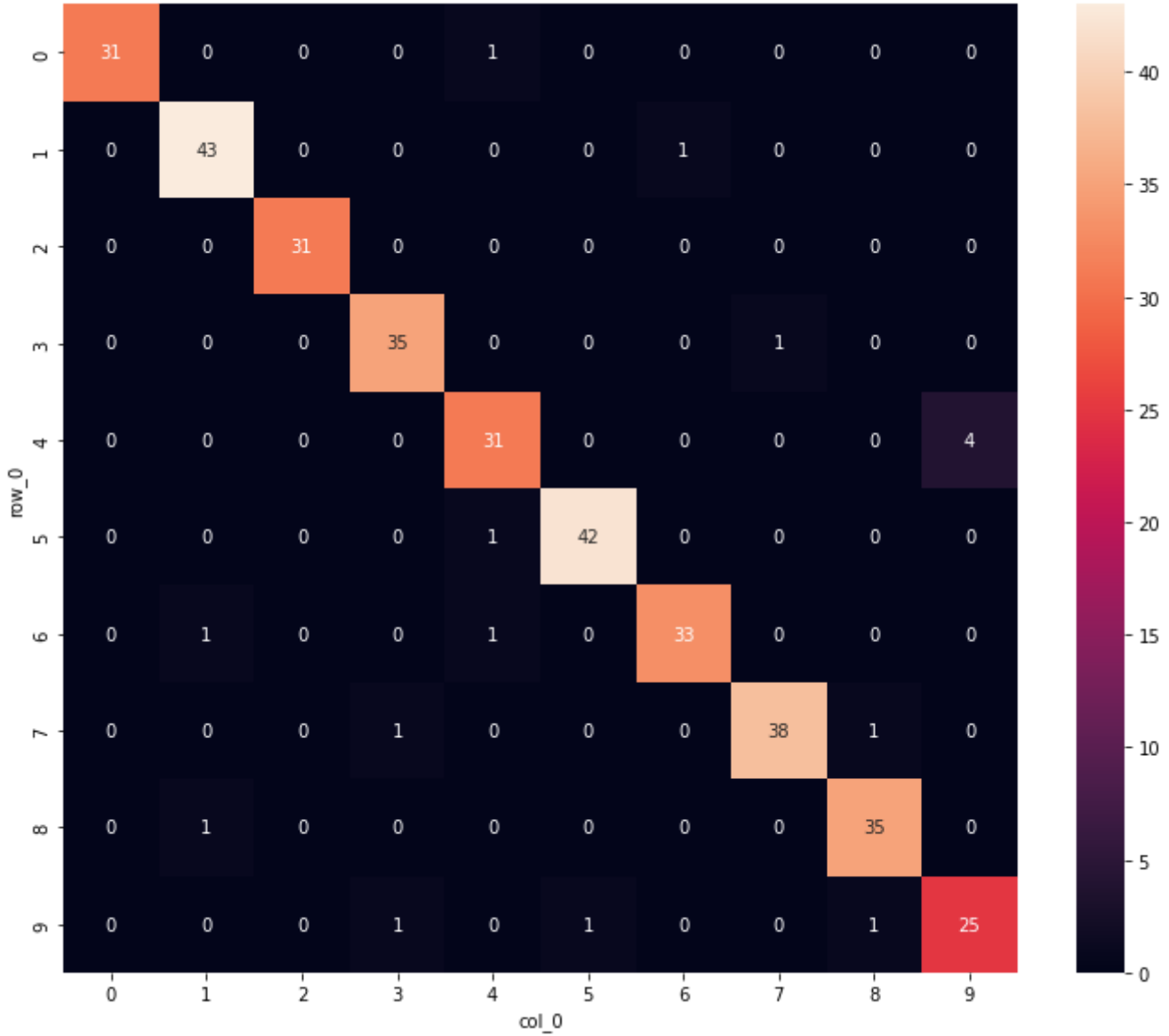


In [55]:
```
conf_matrix = pd.crosstab(y_test, y_pred)
conf_matrix
```

Out[55]:

col_0	0	1	2	3	4	5	6	7	8	9
row_0										
0	31	0	0	0	1	0	0	0	0	0
1	0	43	0	0	0	0	1	0	0	0
2	0	0	31	0	0	0	0	0	0	0
3	0	0	0	35	0	0	0	1	0	0
4	0	0	0	0	31	0	0	0	0	4
5	0	0	0	0	1	42	0	0	0	0
6	0	1	0	0	1	0	33	0	0	0
7	0	0	0	1	0	0	0	38	1	0
8	0	1	0	0	0	0	0	0	35	0
9	0	0	0	1	0	1	0	0	1	25

In [56]:
```
plt.figure(figsize=(12,10))
sns.heatmap(conf_matrix, annot=True, fmt ='')
plt.show()
```


row_0
col_0
0 1 2 3 4 5 6 7 8 9
31 0 0 0 1 0 0 0 0 0
0 43 0 0 0 0 1 0 0 0
0 0 31 0 0 0 0 0 0 0
0 0 0 35 0 0 0 1 0 0
0 0 0 0 31 0 0 0 0 4
0 0 0 0 1 42 0 0 0 0
0 1 0 0 1 0 33 0 0 0
0 0 0 1 0 0 0 38 1 0
0 1 0 0 0 0 0 0 35 0
0 0 0 1 0 1 0 0 1 25
40 35 30 25 20 15 10 5 0

In [ ]: