projekat

May 10, 2020

0.1 Bank Marketing Data Set

Podaci se odnose na direktne marketinške kampanje (telefonski pozivi) portugalske banke. Cilj klasifikacije je da predvidi da li će se klijent pretplatiti na oročeni depozit.

[1]:

```
import pandas as pd

import numpy as np

import matplotlib.pyplot as plt
%matplotlib inline
import seaborn as sns

from sklearn.ensemble import RandomForestClassifier
from sklearn.model_selection import train_test_split
```

0.2 ### Priprema i analiza podataka

[2]:

```
dataset = pd.read_csv('bank-full.csv', sep = ';')
dataset.replace(('yes', 'no'), (1, 0), True)

benchmark = False
if not benchmark:
    dataset = dataset.drop('duration', axis = 1)

dataset.head(11)
```

[2]:

```
    age           job  marital  education  default  balance  housing  loan  \
0    58    management  married   tertiary        0     2143        1     0
1    44    technician   single  secondary        0       29        1     0
2    33  entrepreneur  married  secondary        0        2        1     1
3    47   blue-collar  married    unknown        0     1506        1     0
4    33       unknown   single    unknown        0        1        0     0
5    35    management  married   tertiary        0      231        1     0
6    28    management   single   tertiary        0      447        1     1
7    42  entrepreneur divorced   tertiary        1        2        1     0
8    58       retired  married    primary        0      121        1     0
9    43    technician   single  secondary        0      593        1     0
```

```
10  41         admin.  divorced  secondary        0      270          1     0

    contact  day month  campaign  pdays  previous poutcome  y
0   unknown    5   may         1     -1         0  unknown  0
1   unknown    5   may         1     -1         0  unknown  0
2   unknown    5   may         1     -1         0  unknown  0
3   unknown    5   may         1     -1         0  unknown  0
4   unknown    5   may         1     -1         0  unknown  0
5   unknown    5   may         1     -1         0  unknown  0
6   unknown    5   may         1     -1         0  unknown  0
7   unknown    5   may         1     -1         0  unknown  0
8   unknown    5   may         1     -1         0  unknown  0
9   unknown    5   may         1     -1         0  unknown  0
10  unknown    5   may         1     -1         0  unknown  0
```

[3]:

```
dataset.describe()
```

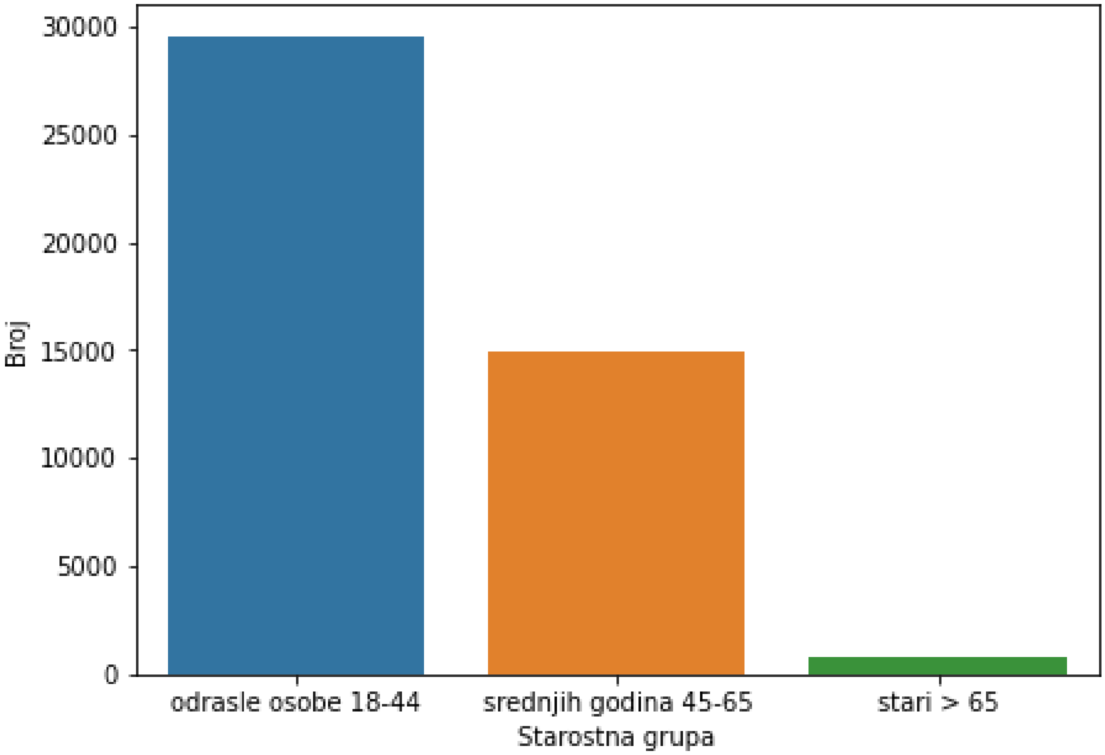
[3]:

```
                age       default        balance       housing          loan  \
count  45211.000000  45211.000000   45211.000000  45211.000000  45211.000000
mean      40.936210      0.018027    1362.272058      0.555838      0.160226
std       10.618762      0.133049    3044.765829      0.496878      0.366820
min       18.000000      0.000000   -8019.000000      0.000000      0.000000
25%       33.000000      0.000000      72.000000      0.000000      0.000000
50%       39.000000      0.000000     448.000000      1.000000      0.000000
75%       48.000000      0.000000    1428.000000      1.000000      0.000000
max       95.000000      1.000000  102127.000000      1.000000      1.000000

                day      campaign         pdays      previous             y
count  45211.000000  45211.000000  45211.000000  45211.000000  45211.000000
mean      15.806419      2.763841     40.197828      0.580323      0.116985
std        8.322476      3.098021    100.128746      2.303441      0.321406
min        1.000000      1.000000     -1.000000      0.000000      0.000000
25%        8.000000      1.000000     -1.000000      0.000000      0.000000
50%       16.000000      2.000000     -1.000000      0.000000      0.000000
75%       21.000000      3.000000     -1.000000      0.000000      0.000000
max       31.000000     63.000000    871.000000    275.000000      1.000000
```

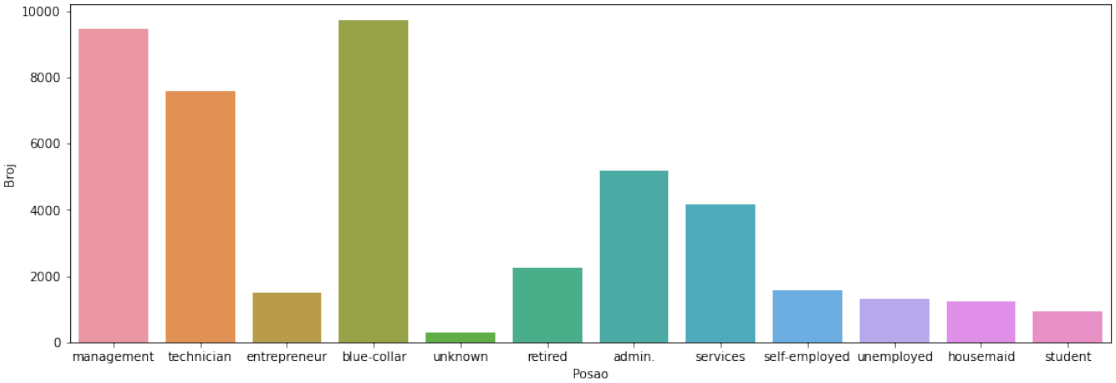
[4]:

```
ages, x = np.arange(3), np.arange(3)
for age in dataset['age']:
    if age >= 18 and age <= 44:
        ages[0] += 1
    elif age >= 45 and age <= 65:
        ages[1] += 1
    elif age >= 66:
        ages[2] += 1

plt.figure(figsize = (7, 5))
```

```
sns.barplot(x, ages)
plt.xticks(x, ('odrasle osobe 18-44', 'srednjih godina 45-65', 'stari > 65'))
plt.xlabel('Starostna grupa')
plt.ylabel('Broj')
plt.show()
```

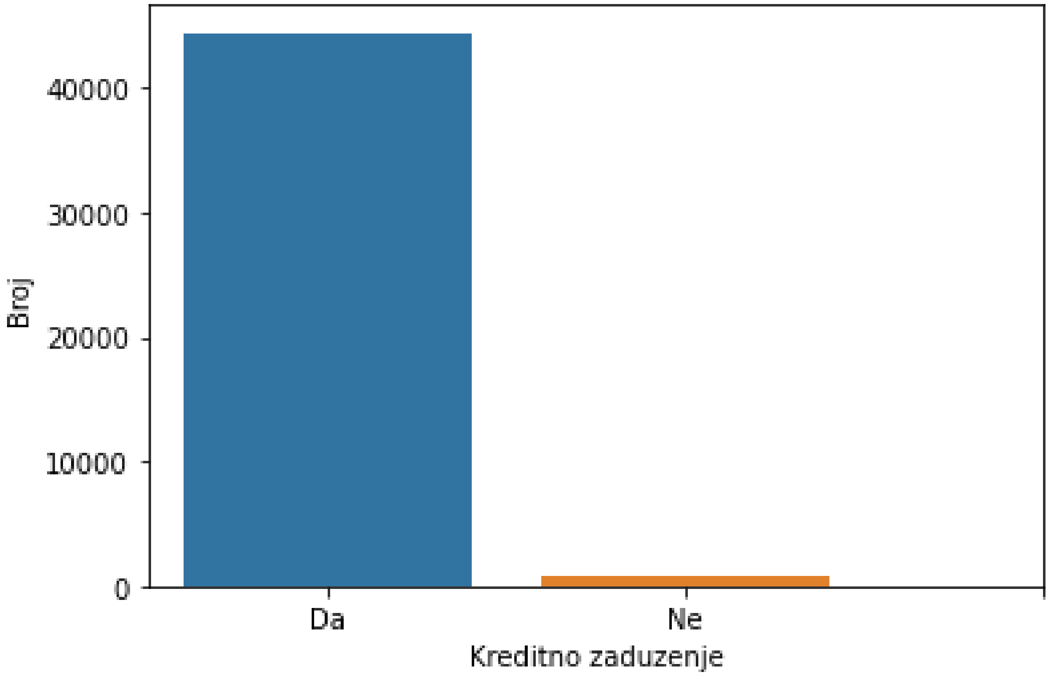


[5]:
```
plt.figure(figsize = (15, 5))
sns.countplot(x = 'job', data = dataset)
plt.xlabel('Posao')
plt.ylabel('Broj')
plt.show()
```



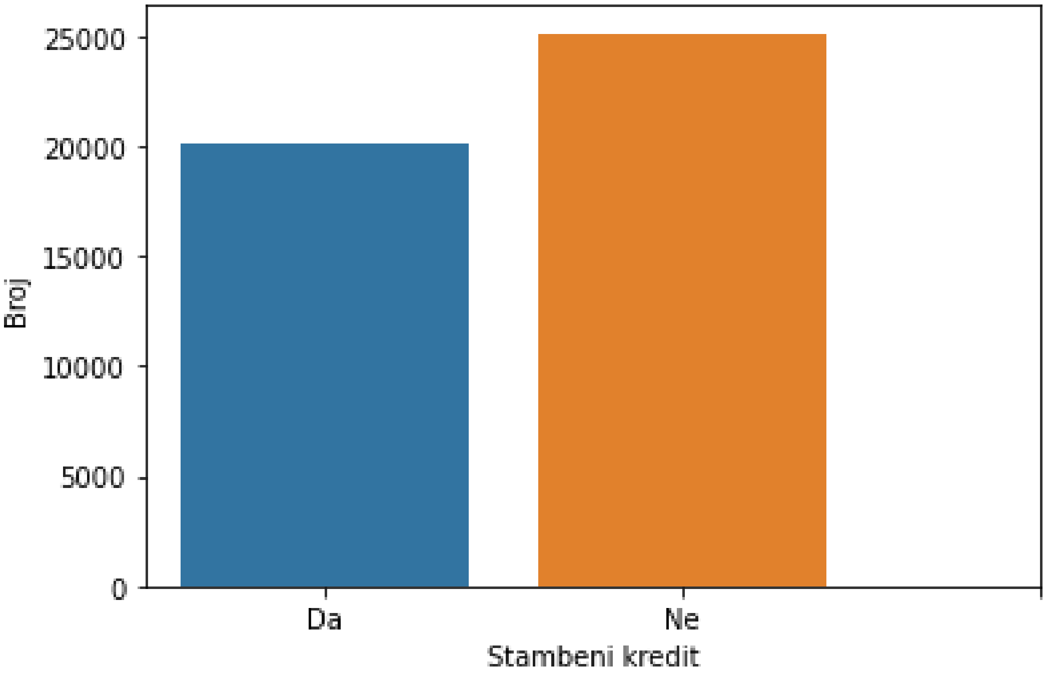
[6]:

```
sns.countplot(x = 'default', data = dataset)
plt.xticks(x, ('Da', 'Ne'))
plt.xlabel('Kreditno zaduzenje')
plt.ylabel('Broj')
plt.show()
```

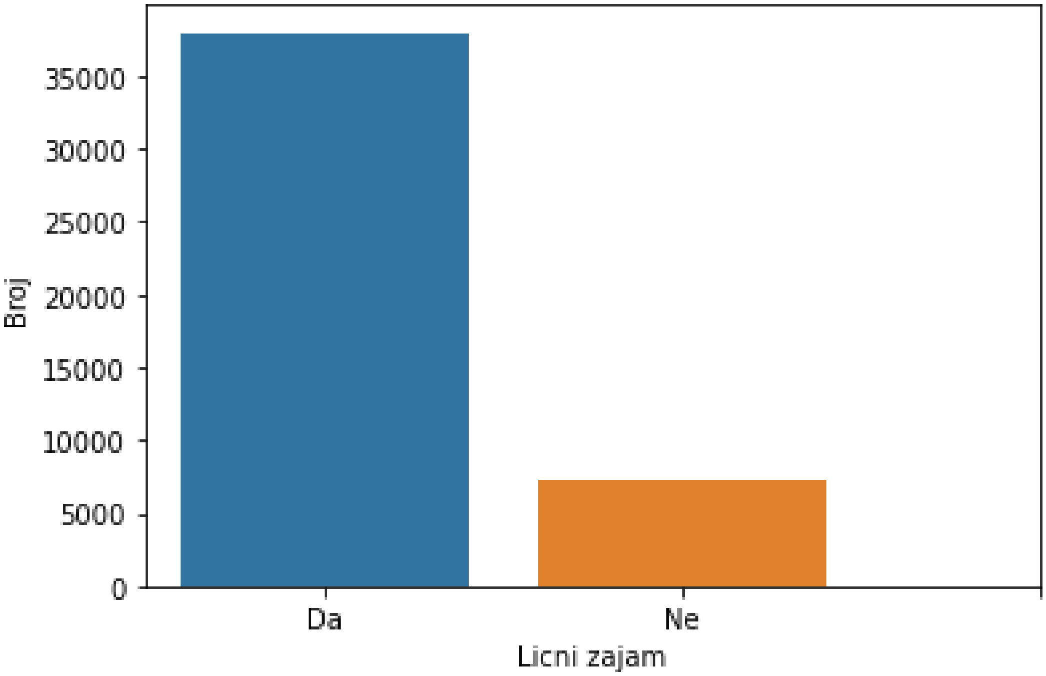


[7]:

```
sns.countplot(x = 'housing', data = dataset)
plt.xticks(x, ('Da', 'Ne'))
plt.xlabel('Stambeni kredit')
plt.ylabel('Broj')
plt.show()
```



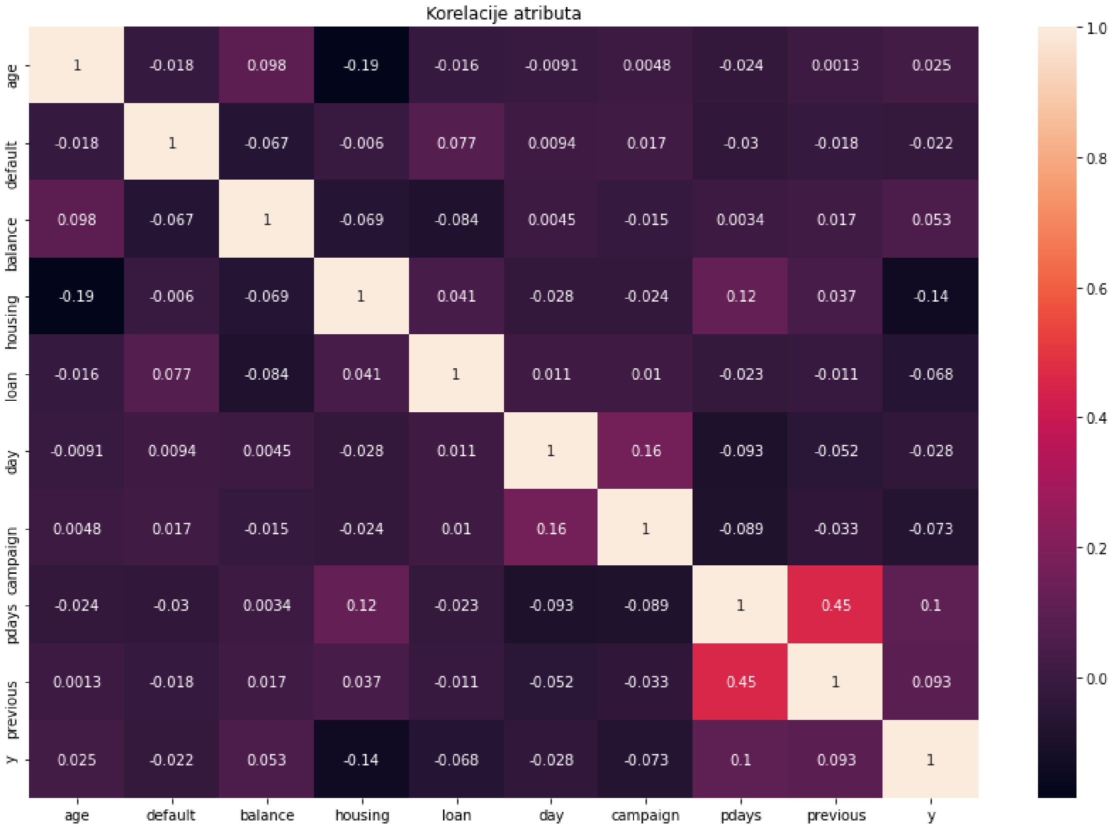
[8]:
```
sns.countplot(x = 'loan', data = dataset)
plt.xticks(x, ('Da', 'Ne'))
plt.xlabel('Licni zajam')
plt.ylabel('Broj')
plt.show()
```



0.3 ### Korelacije atributa

[9]:

```
correlations = dataset.corr()

plt.figure(figsize = (15, 10))
sns.heatmap(correlations, annot = True)
plt.xticks(fontsize = 10)
plt.yticks(fontsize = 10)
plt.title('Korelacije atributa')
plt.show()
```



0.4 ### Priprema seta za trening i predikciju

[10]:

```
cat_features = [[feature, .0] for feature in list(dataset.select_dtypes(object).
 ↪columns)]
num_features = [[feature, .0] for feature in list(dataset.select_dtypes(exclude␣
 ↪= object).columns)]
del num_features[-1]
```

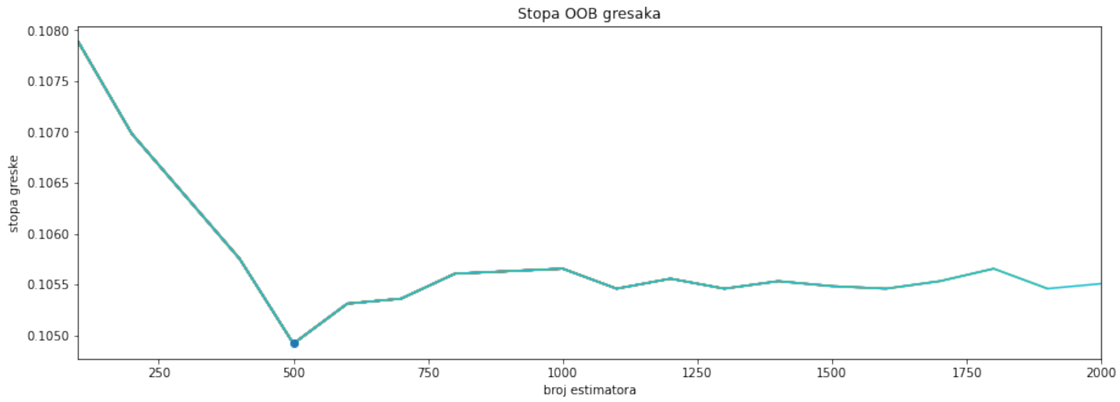
```
first_run = True # prvi put pokrecemo skriptu kada su vaznosti num i cat␣
 ↪features == .0

dataset_train, dataset_test = train_test_split(dataset, test_size = .1,␣
 ↪random_state = 42)

dataset_test_original = dataset_test.copy()

dataset_train = pd.get_dummies(dataset_train, columns = dataset_train.
 ↪select_dtypes(object).columns)
dataset_test = pd.get_dummies(dataset_test, columns = dataset_test.
 ↪select_dtypes(object).columns)

y = pd.factorize(dataset_train['y'])[0]
dataset_train = dataset_train.drop('y', axis = 1)

dataset_test = dataset_test.drop('y', axis = 1)
```

0.5 ### Trening

[11]:

```
clf = RandomForestClassifier(warm_start = True, oob_score = True)

min_estimators = 100
max_estimators = 2000

oob_errors = []
min_oob_error = 1.0
min_oob_estimator = min_estimators

plt.figure(figsize = (15, 5))
for index in range(min_estimators, max_estimators + 1, 100):
    clf.set_params(n_estimators = index)
    clf.fit(dataset_train, y)

    oob_error = 1 - clf.oob_score_
    oob_errors.append((index, oob_error))

    if (oob_error < min_oob_error):
        min_oob_error = oob_error
        min_oob_estimator = index
        importances = clf.feature_importances_

    xoob, yoob = zip(*oob_errors)
    plt.plot(xoob, yoob)

plt.plot(min_oob_estimator, min_oob_error, 'o')
plt.xlim(min_estimators, max_estimators)
plt.title('Stopa OOB gresaka')
plt.xlabel('broj estimatora')
plt.ylabel('stopa greske')
```

```
[11]: Text(0, 0.5, 'stopa greske')
```



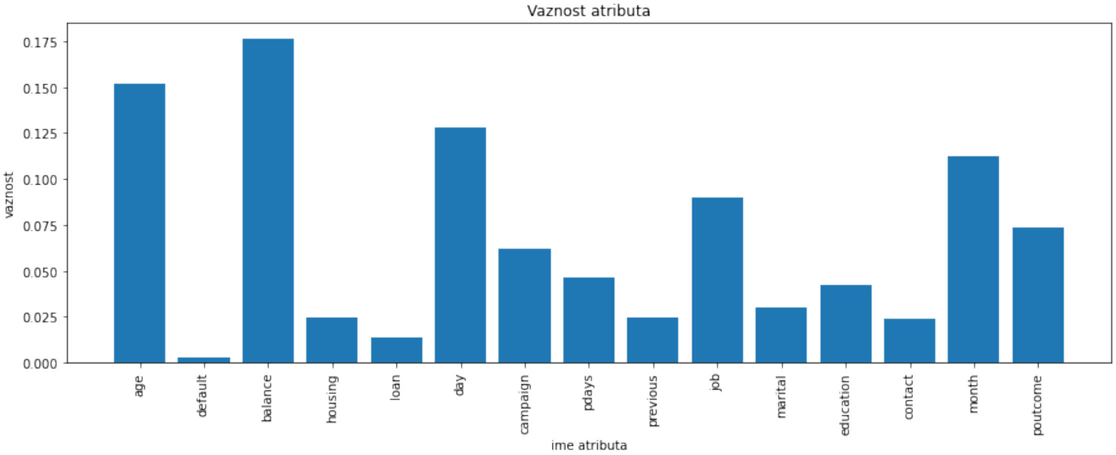
0.6 ### Izracunavanje vaznosti kategorijalnih i numerickih atributa

```
[12]: if first_run:
          index, cat_feature_index, num_feature_index = (0,) * 3
          last_cat_feature = cat_features[0][0]

          for feature in list(dataset_train):
              if feature.startswith(tuple(cat_feature.rsplit('_', 1)[0] for␣
       ↪cat_feature, importance in cat_features)):
                  if not feature.startswith(last_cat_feature):
                      last_cat_feature = feature.rsplit('_', 1)[0]
                      cat_feature_index += 1

                  cat_features[cat_feature_index][1] += importances[index]
              else:
                  num_features[num_feature_index][1] = importances[index]
                  num_feature_index += 1

              index += 1

          feature_importances = num_features + cat_features

          first_run = False

      plt.figure(figsize = (15, 5))
```

```
xfi, yfi = zip(*feature_importances)
plt.bar(xfi, yfi)
plt.xticks(rotation = 90)
plt.title('Vaznost atributa')
plt.xlabel('ime atributa')
plt.ylabel('vaznost')
```

[12]:

```
Text(0, 0.5, 'vaznost')
```



0.7 ### Predikcija

[13]:

```
test_y = clf.predict(dataset_test)

dataset_test_original['y'] = test_y

dataset_test_original.loc[dataset_test_original['y'] == 1].head(10)
```

[13]:

```
       age          job   marital  education  default  balance  housing  loan  \
41828   30   management    single   tertiary        0      536        0     0
24088   37       admin.   married  secondary        0     1967        0     0
43708   65      retired   married    unknown        0      679        0     0
39774   33   management   married   tertiary        0     1323        0     0
40429   28   management    single   tertiary        0      492        0     0
44583   24      student    single  secondary        0      431        0     0
29183   36   management   married   tertiary        0       82        0     0
44501   56   technician  divorced  secondary        0     3450        0     0
43013   36   technician   married   tertiary        0      341        0     0
42269   46   management   married   tertiary        0     2671        0     0

         contact  day month  campaign  pdays  previous poutcome  y
41828   cellular   15   oct         1    105         1  success  1
```

```
24088  telephone   27   oct         1     -1         0  unknown  1
43708   cellular   13   may         2    178         1  success  1
39774   cellular    1   jun         1     -1         0  unknown  1
40429   cellular    2   jul         1     -1         0  unknown  1
44583   cellular   19   aug        11    185         5  success  1
29183   cellular    2   feb         1    178         4  success  1
44501   cellular   10   aug         1    181         2  success  1
43013   cellular   12   feb         2    183         1  success  1
42269   cellular   13   nov         3     91         4  success  1
```

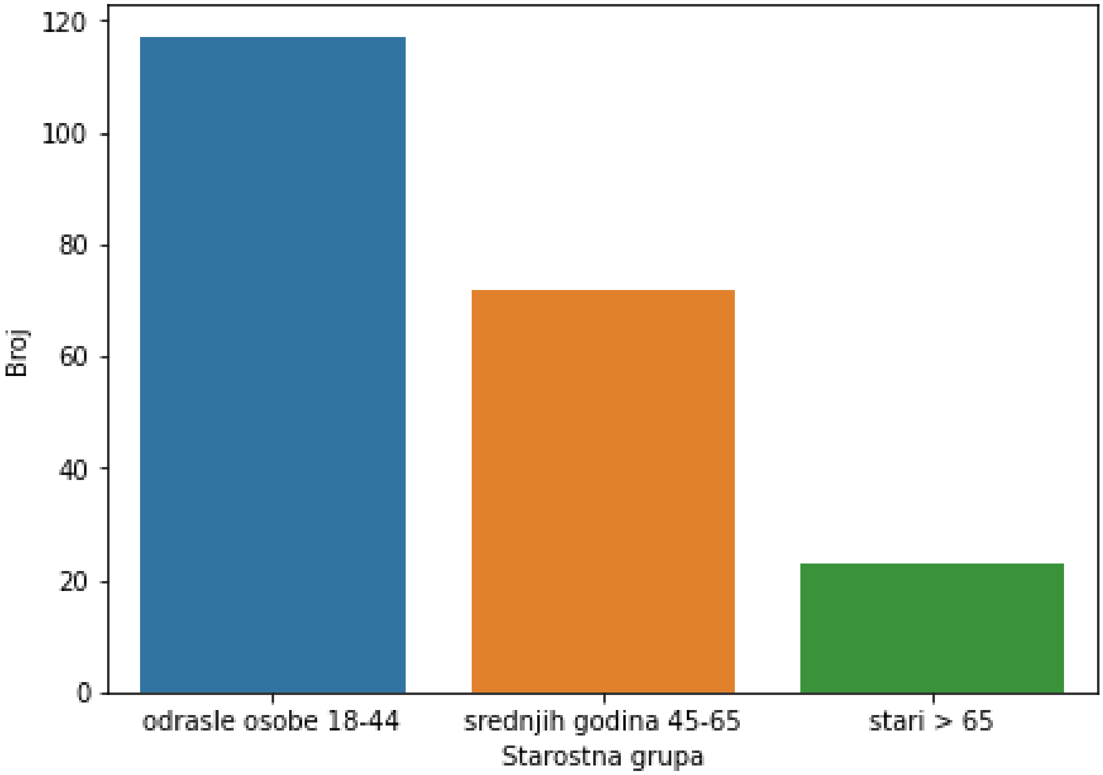
0.8 ### Analiza predikcije gde je $y = 1$ (pretplatio se na oročeni depozit)

[14]:

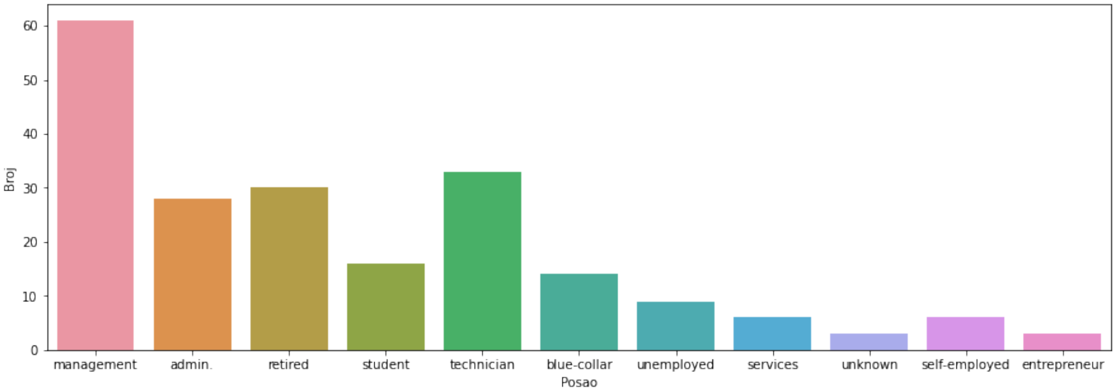
```
dataset_deposited = dataset_test_original.loc[dataset_test_original['y'] == 1]
```

[15]:

```
ages, x = np.arange(3), np.arange(3)
for age in dataset_deposited['age']:
    if age >= 18 and age <= 44:
        ages[0] += 1
    elif age >= 45 and age <= 65:
        ages[1] += 1
    elif age >= 66:
        ages[2] += 1

plt.figure(figsize = (7, 5))
sns.barplot(x, ages)
plt.xticks(x, ('odrasle osobe 18-44', 'srednjih godina 45-65', 'stari > 65'))
plt.xlabel('Starostna grupa')
plt.ylabel('Broj')
plt.show()
```

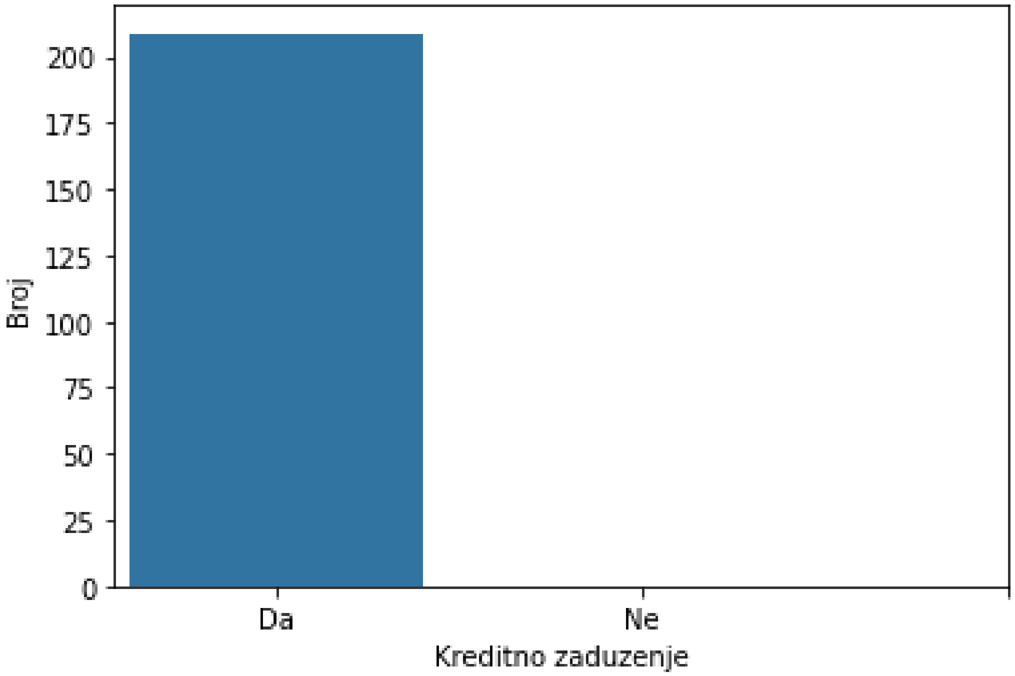


```
[16]: plt.figure(figsize = (15, 5))
      sns.countplot(x = 'job', data = dataset_deposited)
      plt.xlabel('Posao')
      plt.ylabel('Broj')
      plt.show()
```



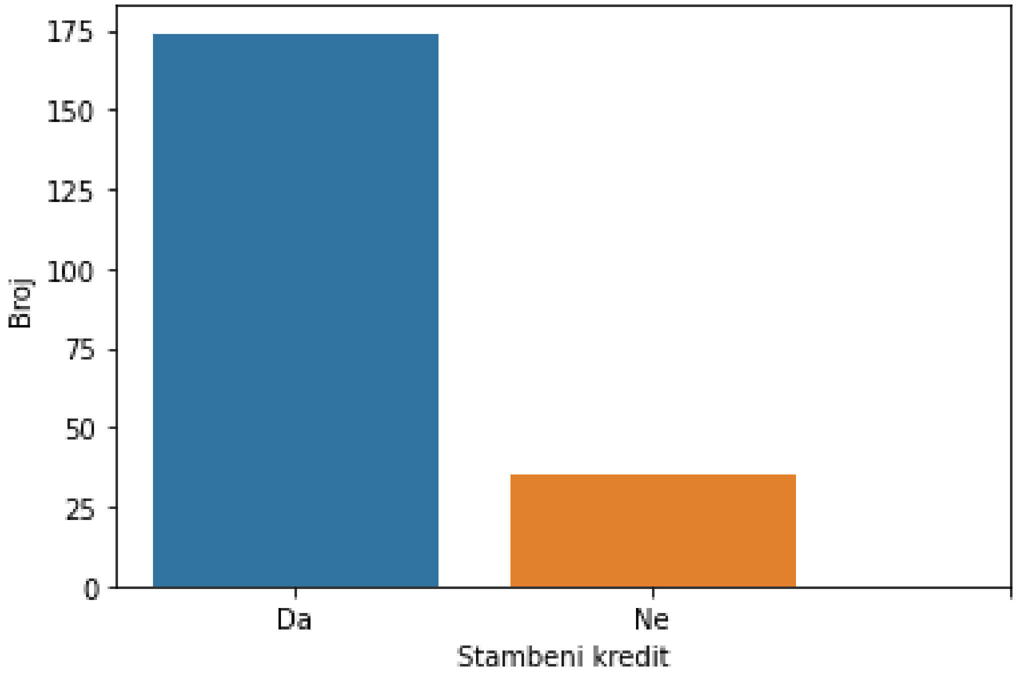
[17]:

```
sns.countplot(x = 'default', data = dataset_deposited)
plt.xticks(x, ('Da', 'Ne'))
plt.xlabel('Kreditno zaduzenje')
plt.ylabel('Broj')
plt.show()
```

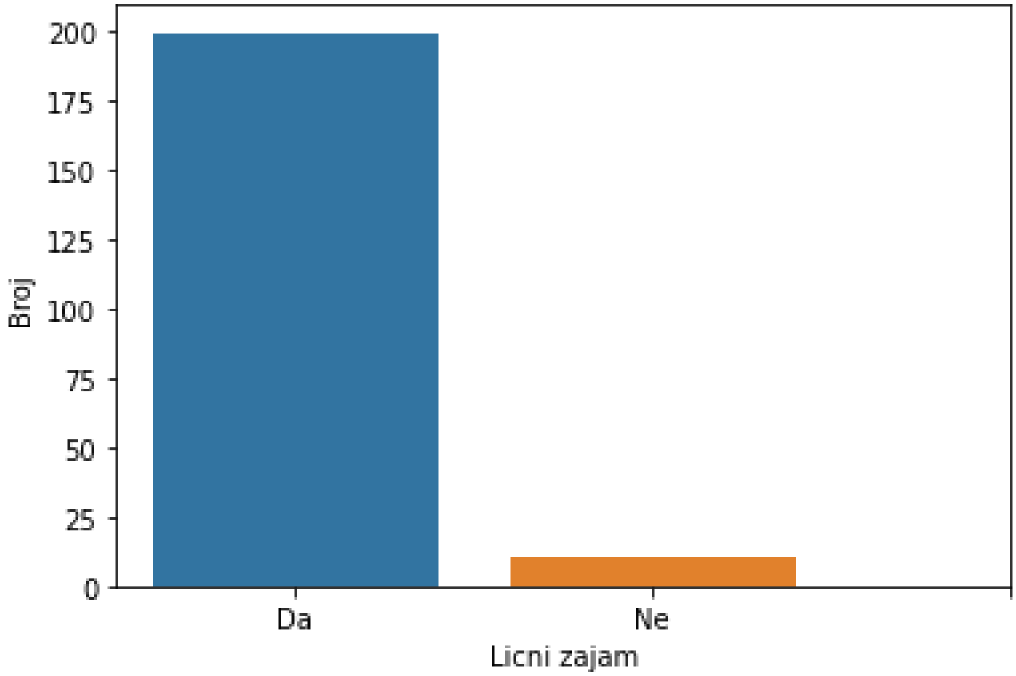


[18]:

```
sns.countplot(x = 'housing', data = dataset_deposited)
plt.xticks(x, ('Da', 'Ne'))
plt.xlabel('Stambeni kredit')
plt.ylabel('Broj')
plt.show()
```



[19]:
```
sns.countplot(x = 'loan', data = dataset_deposited)
plt.xticks(x, ('Da', 'Ne'))
plt.xlabel('Licni zajam')
plt.ylabel('Broj')
plt.show()
```


Broj
Da
Ne
Licni zajam