

# Bank\_Marketing\_Raport

February 9, 2021

## 1 Bank Marketing Data Science Solution

In this notebok, will be presented step-by-step analysis, explaining each step for the best understanding problem and solution. The data is related with direct marketing campaigns of a Portuguese banking institution. The marketing campaigns were based on phone calls. Often, more than one contact to the same client was required, in order to access if the product (bank term deposit) would be ('yes') or not ('no') subscribed. Benefit of creating model should be to increase the efficiency of the choice of customers to whom the offer will be presented what it means separating group of customers who can be targeted with specific offer.

### 1.1 Workflow stages

In this notebook, workflow goes through six stages:

1. Definition of problem.
2. Obtaining data.
3. Analyze, identify patterns and explore the data.
4. Prepare and cleanse the data.
5. Model, predict and solve the problem.
6. Visualize, report, and present the problem solving steps and final solution.

Additionally, we may combine workflow stage, for example analyze by visualizing data. Also stage may perform multiple times, for example visualizing data.

Based on dataset, our model, creating in this notebook, should predict if the client will subscribe a term deposit.

### 1.2 Workflow goals

To better understanding proccess our analysis, below, main goals were presented. There are steps which we should always use.

There is a couple of main goals:

#### **Classifying:**

We may classify or categorize our sample.

#### **Correlating:**

Witch feature in our dataset significantly affect to our goal? Is there correlation amont feature and goal or features? This can be tested for numerical (function `corr()`) and categorical features

(function `phik_matrix()` - it will be explained during analysis). Correlating may help in creating or correcting features.

### **Converting:**

All features have to be converted to numerical values. For example text variables converting to numeric.

### **Completing:**

Data mostly have missing values so it require us to fill any missing value in features. Thanks to this, model may work best.

### **Correcting:**

We may analyze dataset for possible error or outliers and remove samles. Also we can discard if this feature skew the results.

### **Creating:**

We may create new features based on existing feature.

### **Charting:**

Selecting the right visualisaton plots and charts.

## **1.3 Description of dataset**

### **1.3.1 Data consists of 20 inputs which we can separate to:**

#### **Bank client data:**

1. age
2. job : type of job
3. marital : marital status
4. education: type of education
5. default: has credit in default?
6. housing: has housing loan?
7. loan: has personal loan

#### **Related with the last contact of the current campaign:**

8. contact: contact communication type
9. month: last contact month of year
10. day\_of\_week: last contact day of the week
11. duration: last contact duration, in seconds

#### **Other attributes:**

12. campaign: number of contacts performed during this campaign and for this client)
13. pdays: number of days that passed by after the client was last contacted from a previous campaign
14. previous: number of contacts performed before this campaign and for this client
15. poutcome: outcome of the previous marketing campaign

#### **Social and economic context attributes**

- 16. emp.var.rate: employment variation rate
- 17. cons.price.idx: consumer price index
- 18. cons.conf.idx: consumer confidence index
- 19. euribor3m: euribor 3 month rate
- 20. nr.employed: number of employees

### 1.3.2 1 output (target)

- 21. y - has the client subscribed a term deposit?

## 1.4 Load Data

Thanks to Pandas packages, we load data. We create copy our data to work on copy dataset. Additionally we create dataframe for names to receive quick access during our analysis.

```
[5]:
```

	Column \	
1	age	
2	job	
3	marital	
4	education	
5	default	
6	housing	
7	loan	
8	contact	
9	month	
10	day_of_week	
11	duration	
12	campaign	
13	pdays	
14	previous	
15	poutcome	
16	emp.var.rate	
17	cons.price.idx	
18	cons.conf.idx	
19	euribor3m	
20	nr.employed	

	Explanation
1	(numeric)
2	type of job (categorical: "admin.", "blue-collar", "entrepreneur", "housemaid", "management", "retired", "self-employed", "services", "student", "technici...
3	marital status (categorical: "divorced", "married", "single", "unknown"; note: "divorced" means divorced or widowed)
4	(categorical: "basic.4y", "basic.6y", "basic.9y", "high.school", "illiterate", "professional.course", "university.degree", "unknown")

```

5
has credit in default? (categorical: "no","yes","unknown")
6
has housing loan? (categorical: "no","yes","unknown")
7
has personal loan? (categorical: "no","yes","unknown")
8
contact communication type (categorical: "cellular","telephone")
9
contact month of year (categorical: "jan", "feb", "mar", ..., "nov", "dec")
10
last contact day of the week (categorical: "mon","tue","wed","thu","fri")
11 last contact duration, in seconds (numeric). Important note: this
attribute highly affects the output target (e.g., if duration=0 then y="no").
...
12
number of contacts performed
during this campaign and for this client (numeric, includes last contact)
13 number of days that passed by after the client was last contacted from a
previous campaign (numeric; 999 means client was not previously contacted)
14
number
of contacts performed before this campaign and for this client (numeric)
15
outcome of the
previous marketing campaign (categorical: "failure","nonexistent","success")
16
employment variation rate - quarterly indicator (numeric)
17
consumer price index - monthly indicator (numeric)
18
consumer confidence index - monthly indicator (numeric)
19
euribor 3 month rate - daily indicator (numeric)
20
number of employees - quarterly indicator (numeric)

```

## 1.5 Analyze by describing data

Pandas helps us describe dataset. Now we check all available feature in our dataset.

```

['age' 'job' 'marital' 'education' 'default' 'housing' 'loan' 'contact'
 'month' 'day_of_week' 'duration' 'campaign' 'pdays' 'previous' 'poutcome'
 'emp.var.rate' 'cons.price.idx' 'cons.conf.idx' 'euribor3m' 'nr.employed'
 'y']

```

First of all, rename output y to obvious name

Check number of rows and columns in our data

Dataset consists of 41188 rows and 21 columns

**Categorical features**

These values classify the samples into sets of similar samples. Categorical features are the values nominal, ordinal, ratio or interval.

- Categorical: job, marital, housing, loan, contact, month, day of week, term deposit, poutcome
- Ordinal: education

## Numerical features

These values change from sample to sample. Within numerical features are the values discrete, continuous or timeseries.

- Continuous: age, duration, campaign, pdays, previous, nr.employed
- Discrete: emp.var.rate, cons.price.idx, cons.conf.idx, euribor3m

Number of categorical columns: 11,  
list this columns: ['job', 'marital', 'education', 'default', 'housing', 'loan', 'contact', 'month', 'day\_of\_week', 'poutcome', 'term deposit'].

Number of numeric columns: 10,  
list this columns: ['age', 'duration', 'campaign', 'pdays', 'previous', 'emp.var.rate', 'cons.price.idx', 'cons.conf.idx', 'euribor3m', 'nr.employed'].

We can conclude from the above results that half of our data is categorical (object), for this reason, during data cleaning and feature engineering we can check exactly this columns and transform them to predict model.

```
[10]:
```

	age	job	marital	education	default	housing	loan	contact	\
0	56	housemaid	married	basic.4y	no	no	no	telephone	
1	57	services	married	high.school	unknown	no	no	telephone	
2	37	services	married	high.school	no	yes	no	telephone	
3	40	admin.	married	basic.6y	no	no	no	telephone	
4	56	services	married	high.school	no	no	yes	telephone	

	month	day_of_week	...	campaign	pdays	previous	poutcome	emp.var.rate	\
0	may	mon	...	1	999	0	nonexistent	1.1	
1	may	mon	...	1	999	0	nonexistent	1.1	
2	may	mon	...	1	999	0	nonexistent	1.1	
3	may	mon	...	1	999	0	nonexistent	1.1	
4	may	mon	...	1	999	0	nonexistent	1.1	

	cons.price.idx	cons.conf.idx	euribor3m	nr.employed	term deposit
0	93.994	-36.4	4.857	5191.0	no
1	93.994	-36.4	4.857	5191.0	no
2	93.994	-36.4	4.857	5191.0	no
3	93.994	-36.4	4.857	5191.0	no
4	93.994	-36.4	4.857	5191.0	no

[5 rows x 21 columns]

Any of features are mixed data types, all features are numeric and alphanumeric.

We can conclude base on describe of numerical values:

- mean of age is 40, as we can see, age has probably outliers (98 old),
- contact in this campaign also has outliers,
- most of the clients in this campaign had had no contact with the bank previous.
- consumer confidence index is value above 0. This can be mistake because all of values in this feature is below 0

```
[11]:
```

	count	mean	std	min	25%	\
age	41188.0	40.024060	10.421250	17.000	32.000	
duration	41188.0	258.285010	259.279249	0.000	102.000	
campaign	41188.0	2.567593	2.770014	1.000	1.000	
pdays	41188.0	962.475454	186.910907	0.000	999.000	
previous	41188.0	0.172963	0.494901	0.000	0.000	
emp.var.rate	41188.0	0.081886	1.570960	-3.400	-1.800	
cons.price.idx	41188.0	93.575664	0.578840	92.201	93.075	
cons.conf.idx	41188.0	-40.502600	4.628198	-50.800	-42.700	
euribor3m	41188.0	3.621291	1.734447	0.634	1.344	
nr.employed	41188.0	5167.035911	72.251528	4963.600	5099.100	

	50%	75%	max
age	38.000	47.000	98.000
duration	180.000	319.000	4918.000
campaign	2.000	3.000	56.000
pdays	999.000	999.000	999.000
previous	0.000	0.000	7.000
emp.var.rate	1.100	1.400	1.400
cons.price.idx	93.749	93.994	94.767
cons.conf.idx	-41.800	-36.400	-26.900
euribor3m	4.857	4.961	5.045
nr.employed	5191.000	5228.100	5228.100

We can conclude base on describe of categorical values:

- feature job has the most unique values from categorical
- freature default, housing, loan and poutcome have 3 unique values, yes, no and unknown
- term deposit is categorical with yes or no values

```
[12]:
```

	count	unique	top	freq
job	41188	12	admin.	10422
marital	41188	4	married	24928
education	41188	8	university.degree	12168
default	41188	3	no	32588
housing	41188	3	yes	21576
loan	41188	3	no	33950
contact	41188	2	cellular	26144
month	41188	10	may	13769
day_of_week	41188	5	thu	8623

poutcome	41188	3	nonexistent	35563
term deposit	41188	2	no	36548

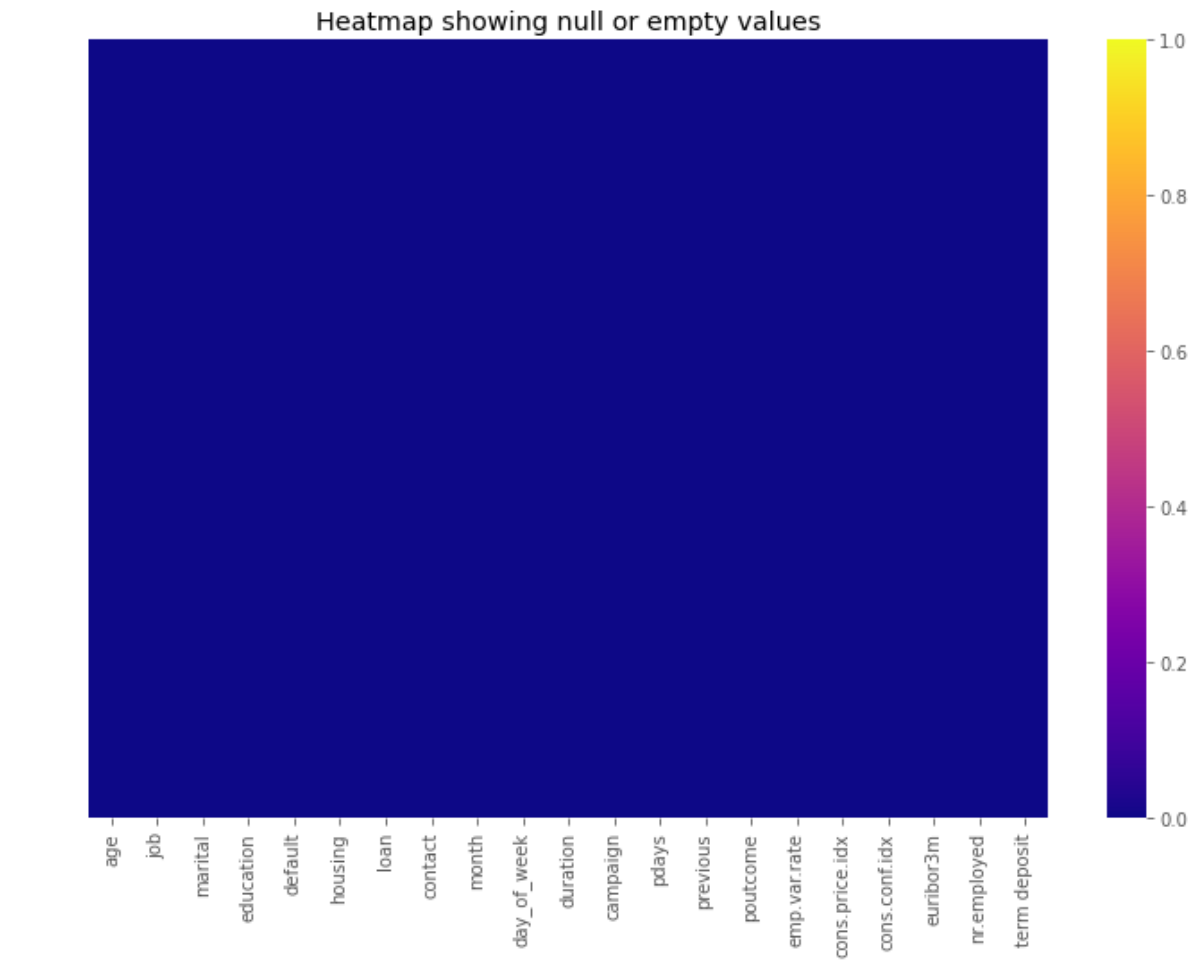
```

job: ['housemaid' 'services' 'admin.' 'blue-collar' 'technician' 'retired'
      'management' 'unemployed' 'self-employed' 'unknown' 'entrepreneur'
      'student']
marital: ['married' 'single' 'divorced' 'unknown']
education: ['basic.4y' 'high.school' 'basic.6y' 'basic.9y' 'professional.course'
            'unknown' 'university.degree' 'illiterate']
default: ['no' 'unknown' 'yes']
housing: ['no' 'yes' 'unknown']
loan: ['no' 'yes' 'unknown']
contact: ['telephone' 'cellular']
month: ['may' 'jun' 'jul' 'aug' 'oct' 'nov' 'dec' 'mar' 'apr' 'sep']
day_of_week: ['mon' 'tue' 'wed' 'thu' 'fri']
poutcome: ['nonexistent' 'failure' 'success']
term deposit: ['no' 'yes']

```

As we can see, categorical variables doesn't have much variation in variables so, at this stage we can't reject some of features.

Check information about missing values (NaN) in specific columns



age	0
job	0
marital	0
education	0
default	0
housing	0
loan	0
contact	0
month	0
day_of_week	0
duration	0
campaign	0
pdays	0
previous	0
poutcome	0
emp.var.rate	0
cons.price.idx	0



```

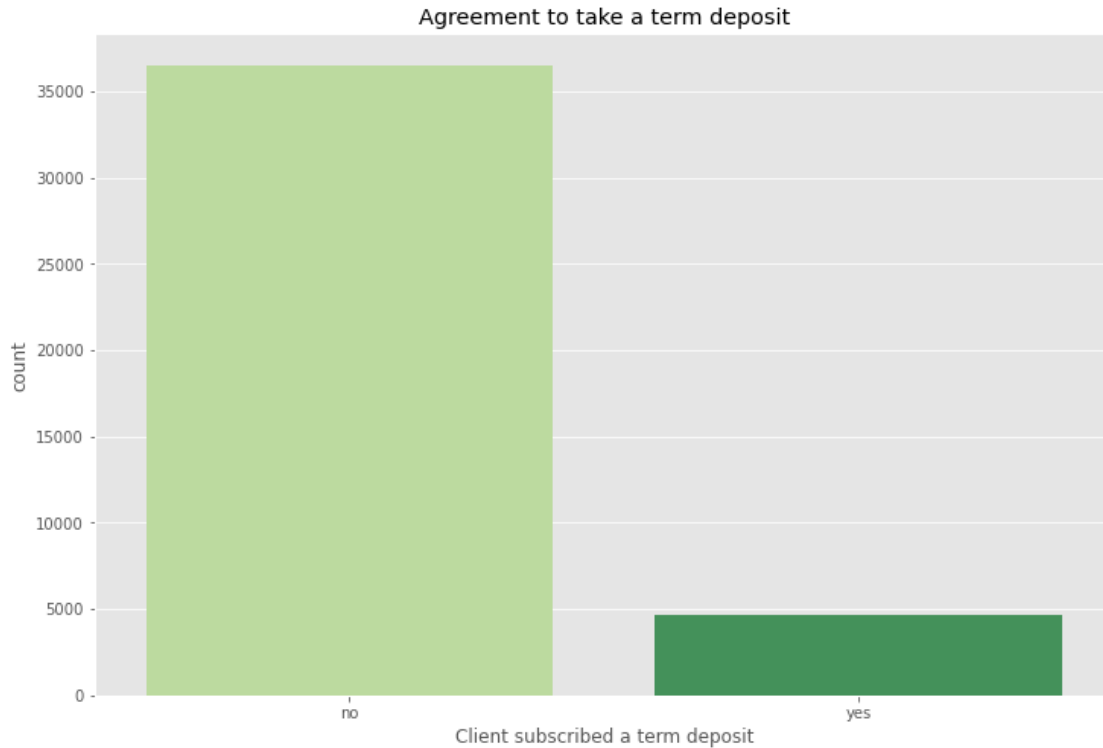
cons.conf.idx      0
euribor3m          0
nr.employed        0
term deposit       0
dtype: int64
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 41188 entries, 0 to 41187
Data columns (total 21 columns):
 #   Column                Non-Null Count  Dtype
---  -
 0   age                   41188 non-null  int64
 1   job                   41188 non-null  object
 2   marital               41188 non-null  object
 3   education             41188 non-null  object
 4   default               41188 non-null  object
 5   housing               41188 non-null  object
 6   loan                  41188 non-null  object
 7   contact               41188 non-null  object
 8   month                 41188 non-null  object
 9   day_of_week           41188 non-null  object
10   duration              41188 non-null  int64
11   campaign              41188 non-null  int64
12   pdays                 41188 non-null  int64
13   previous              41188 non-null  int64
14   poutcome              41188 non-null  object
15   emp.var.rate          41188 non-null  float64
16   cons.price.idx        41188 non-null  float64
17   cons.conf.idx         41188 non-null  float64
18   euribor3m             41188 non-null  float64
19   nr.employed           41188 non-null  float64
20   term deposit          41188 non-null  object
dtypes: float64(5), int64(5), object(11)
memory usage: 4.9+ MB

```

There we can see, our data not include missing value (NaN). Our data has missing value coded by string, during analysis we will fill it.

## 1.6 Analyze by pivoting and vizualization

Make a hypothesis that overwhelming majority of answers if client subscribed a term deposit will be 'no'.



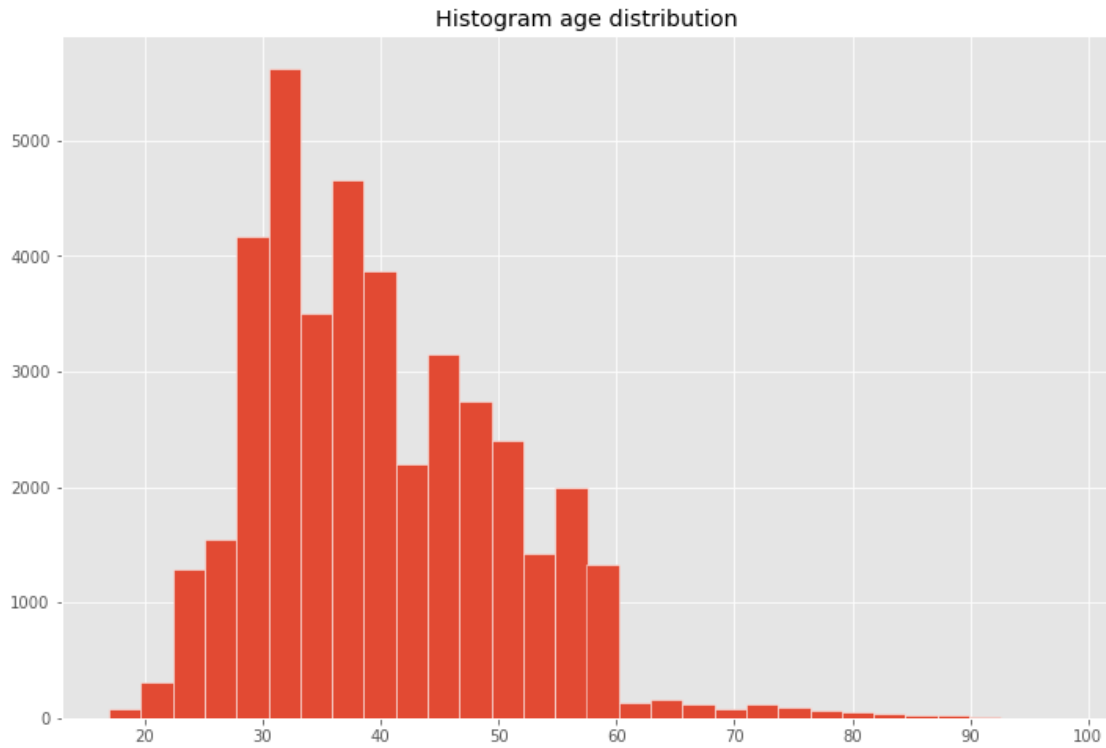
```
[17]: term deposit
no          0.887346
yes         0.112654
dtype: float64
```

Countplot confirm our hypothesis. Here is not balance, so accuracy not will be great measure, looking at accuracy, our score will should above 88%. Better option will be for example F-score, which is calculated:

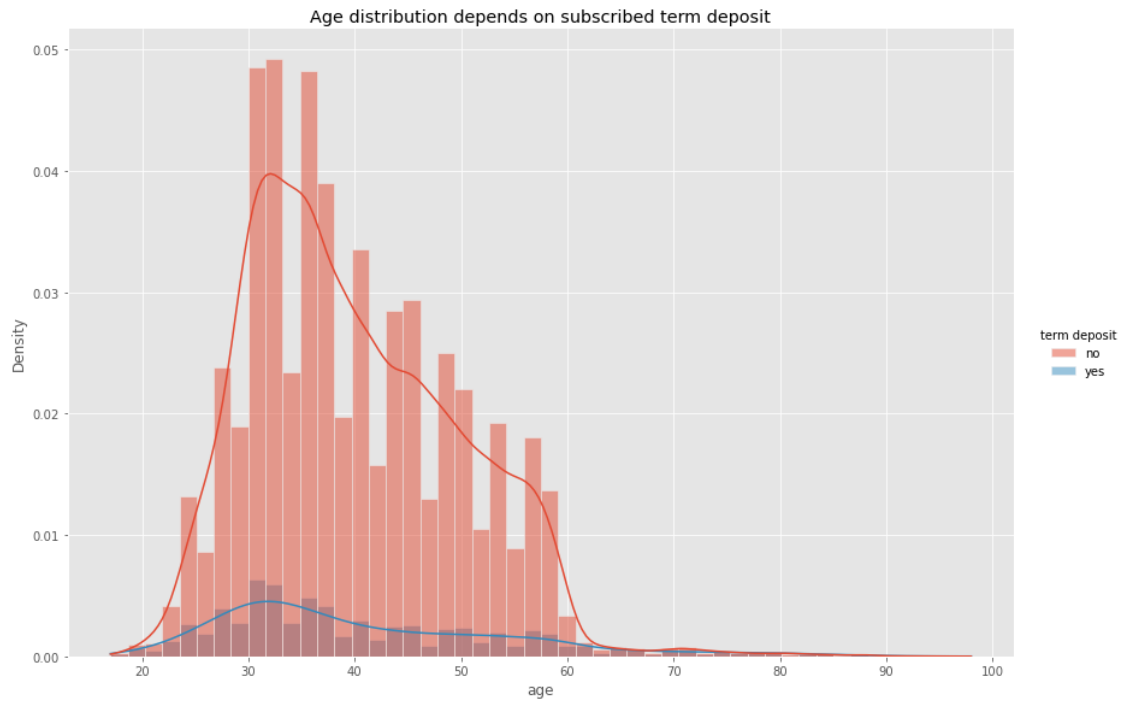
$$F = 2 * \frac{precision * recall}{precision + recall}$$

### 1.6.1 Age

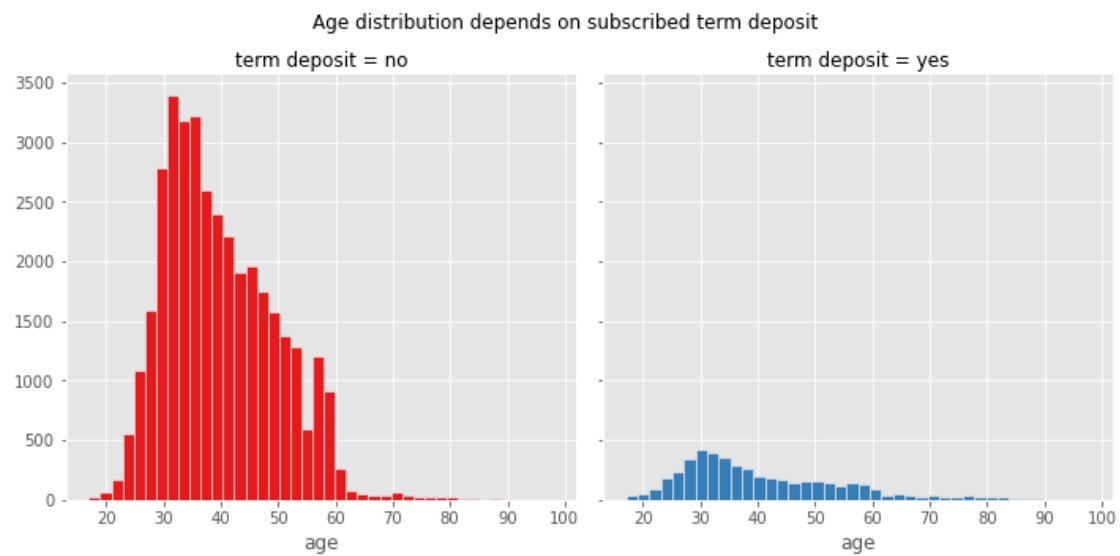
In this visualization will be presented feature age, means the age of the people who were called by bank representatives.

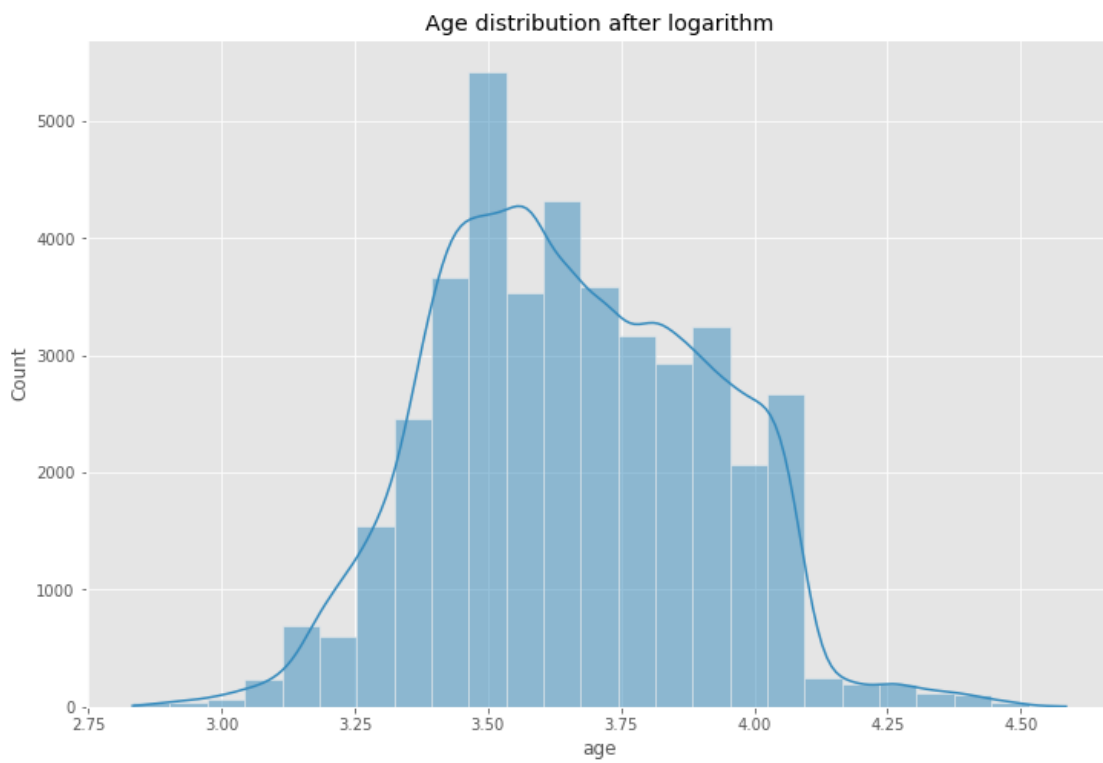
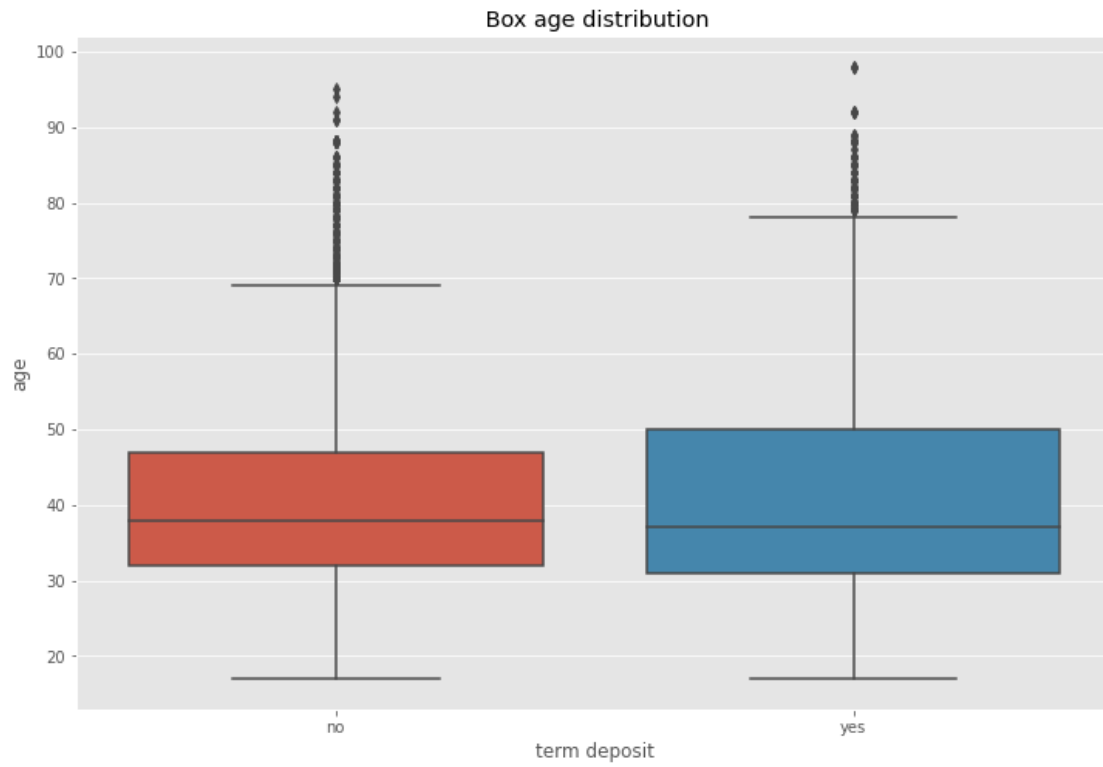


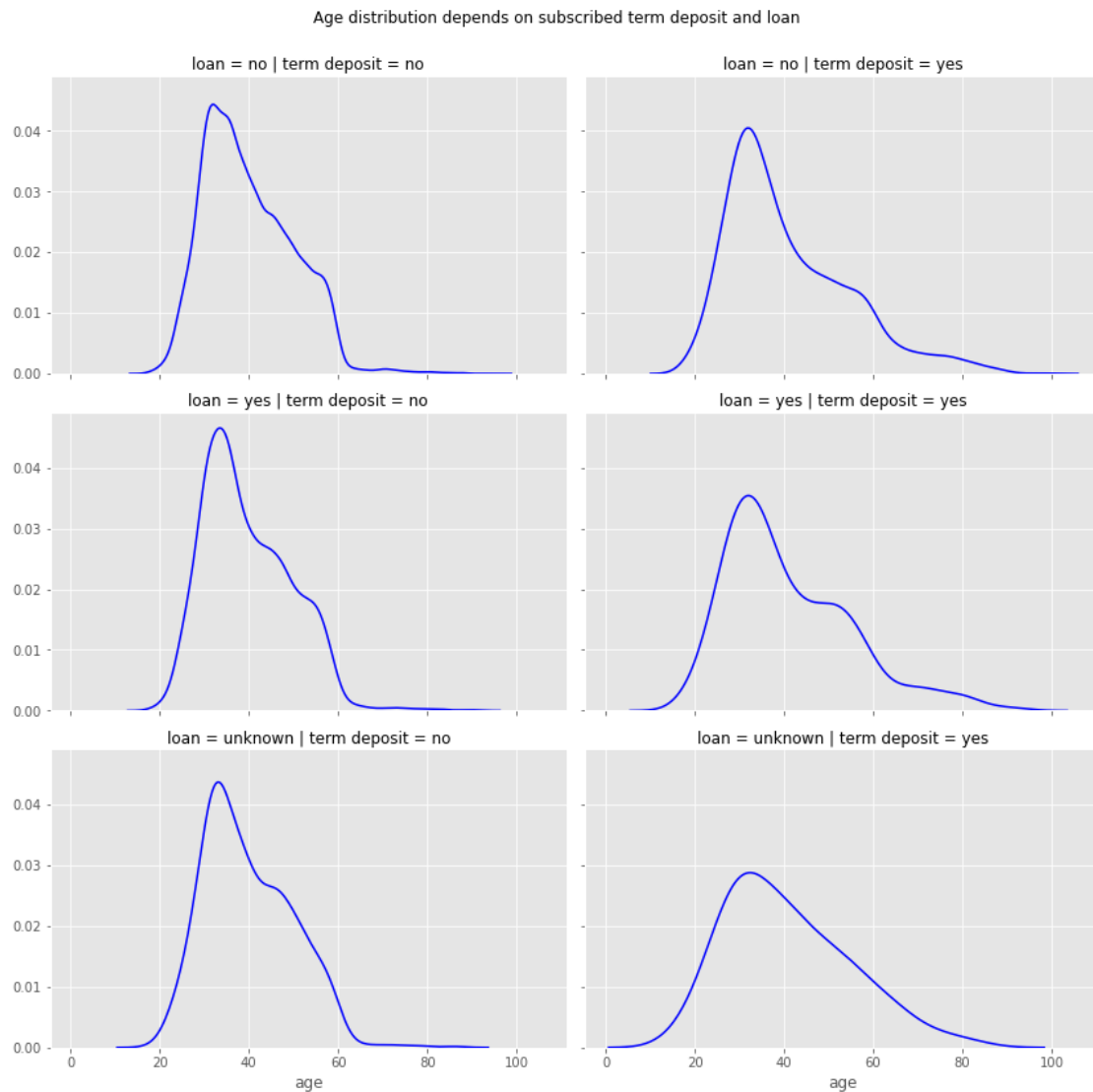
```
[19]: 75      41
      83      49
      88      49
     129      41
     139      45
      ..
    41174      62
    41178      62
    41181      37
    41183      73
    41186      44
Name: age, Length: 4640, dtype: int64
```



To see exactly how it unfolds age above 60, we create 2 plots depends on term deposit





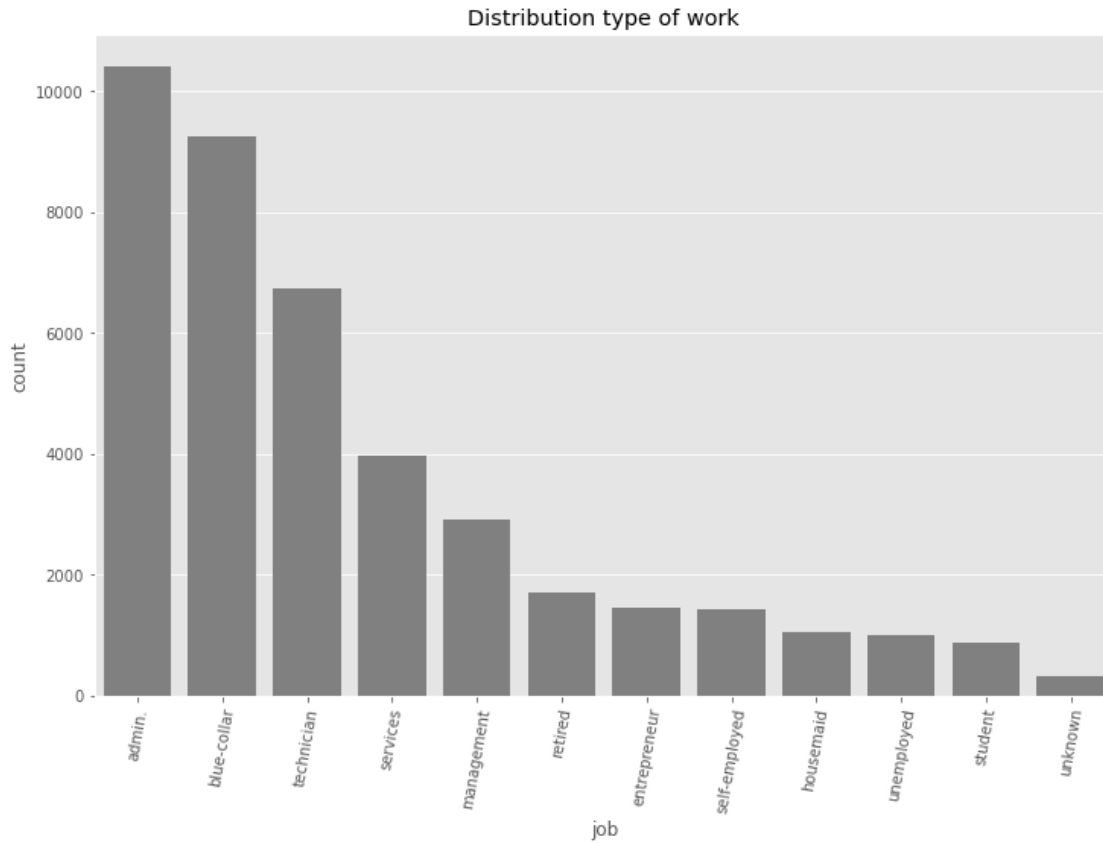


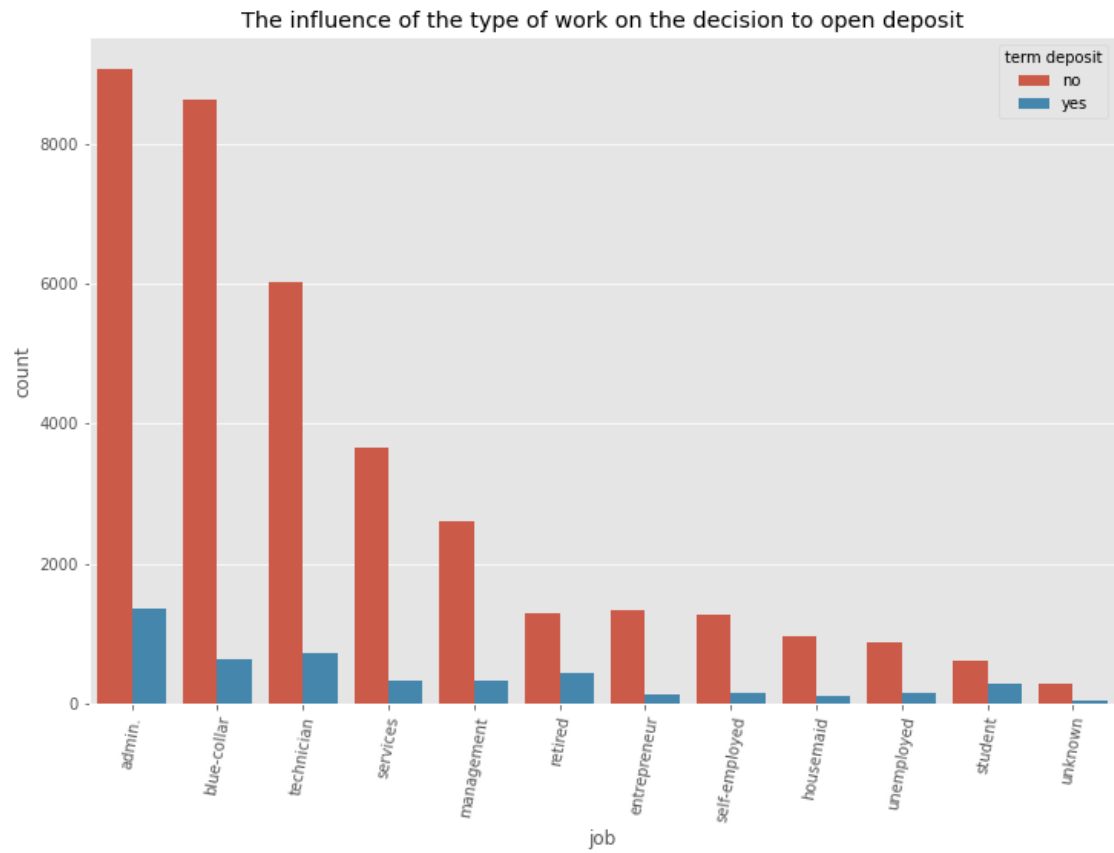
Observations:

- Ratio response yes/no is highest below 20 and above 80 age.
- Histogram of age shows that it is skewed right. There is also a lot of outliers.
- A great decision will be to transform age by log, then the data will be almost in normal distribution.
- In the boxplot, we can see also a lot of outliers. Additionally, this plot shows similarity in the mean of age between response 'no' and 'yes'.
- Feature loan rather has no effect on age and response.

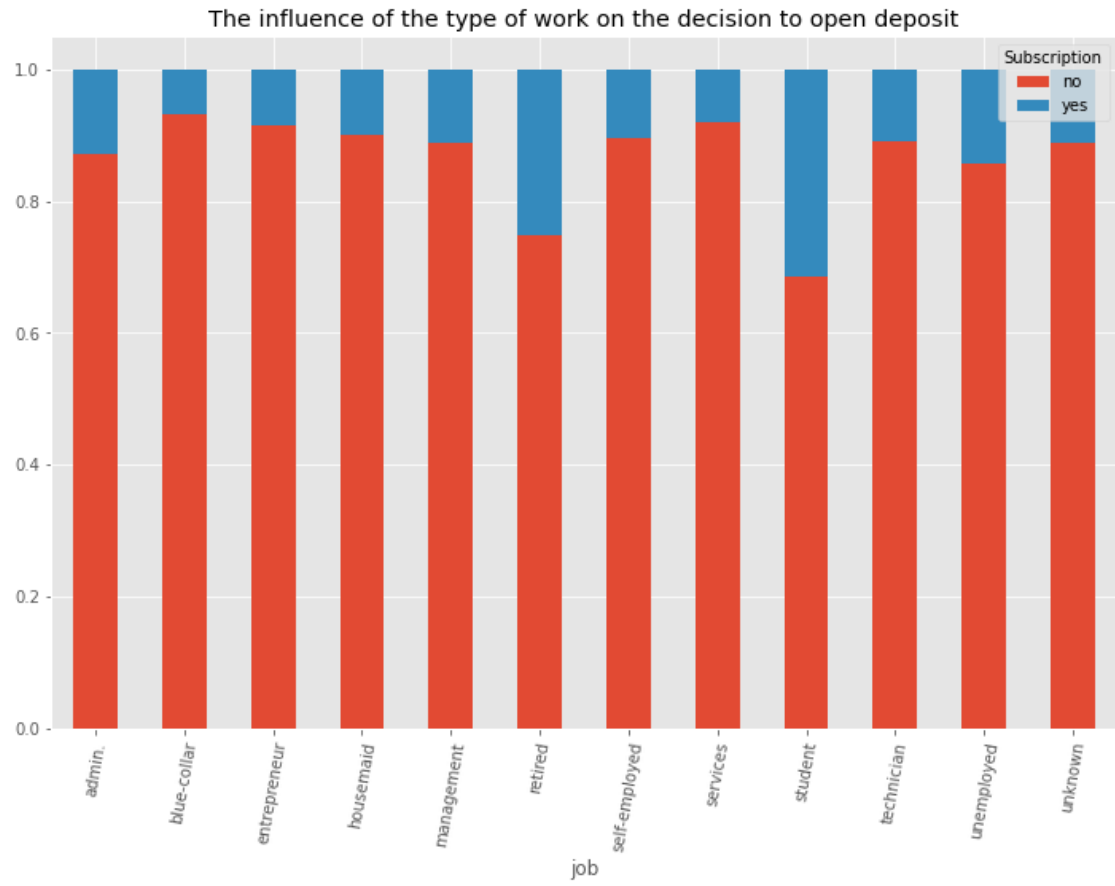
### 1.6.2 Job

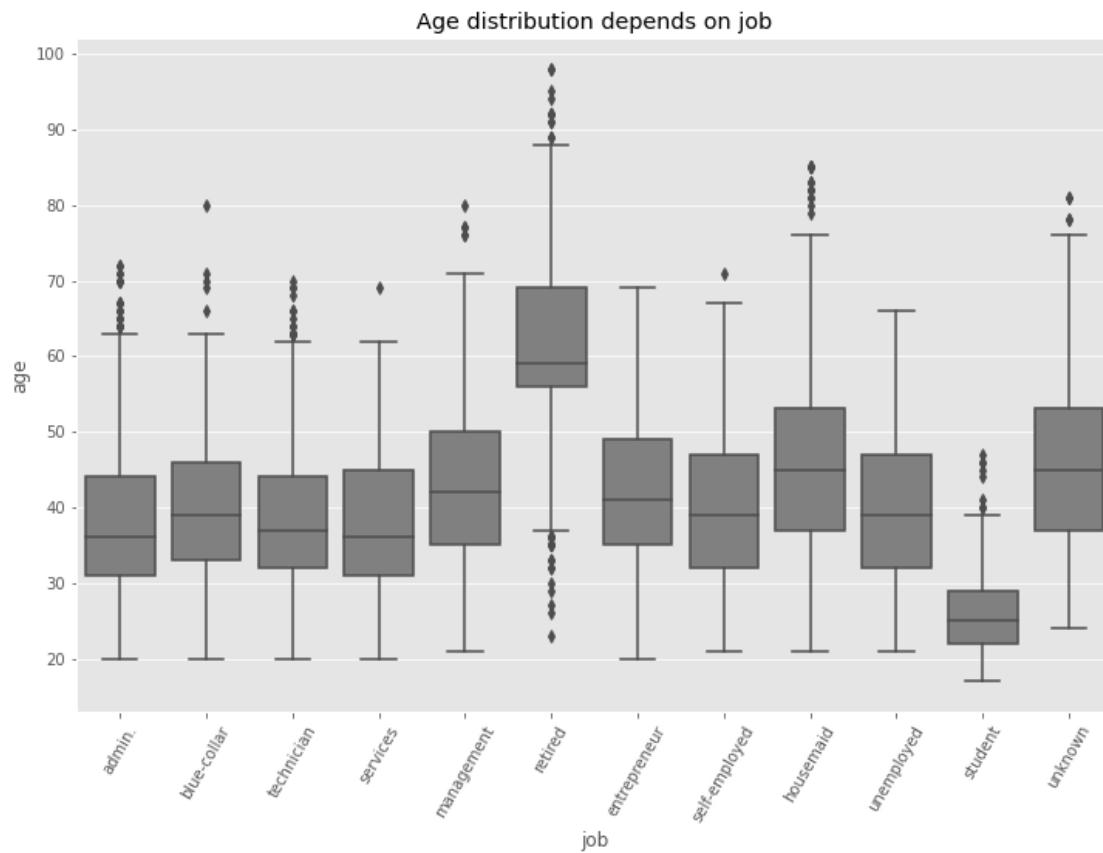
In this section will be presented feature job. Feature means the type of work of the people who were called by bank representatives. Value of this feature: admin., blue-collar, entrepreneur, housemaid, management, retired, selfemployed, services, student, technician, unemployed, unknown.

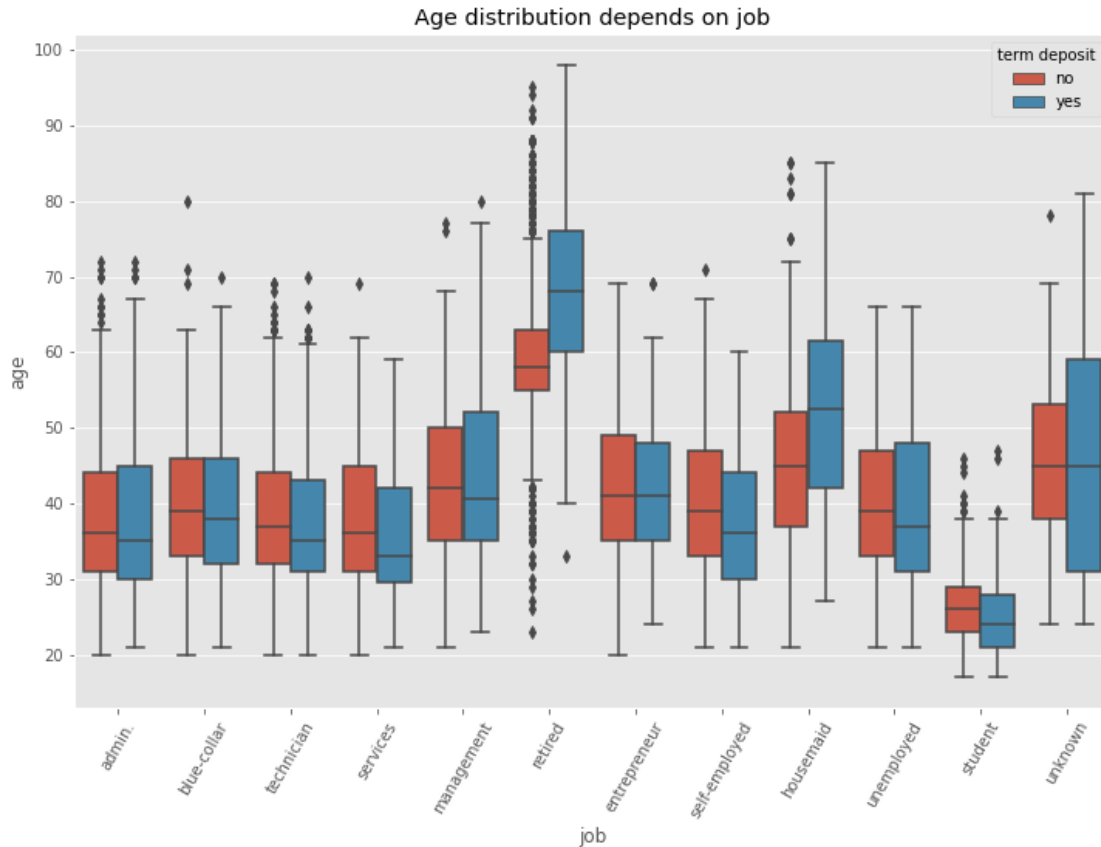










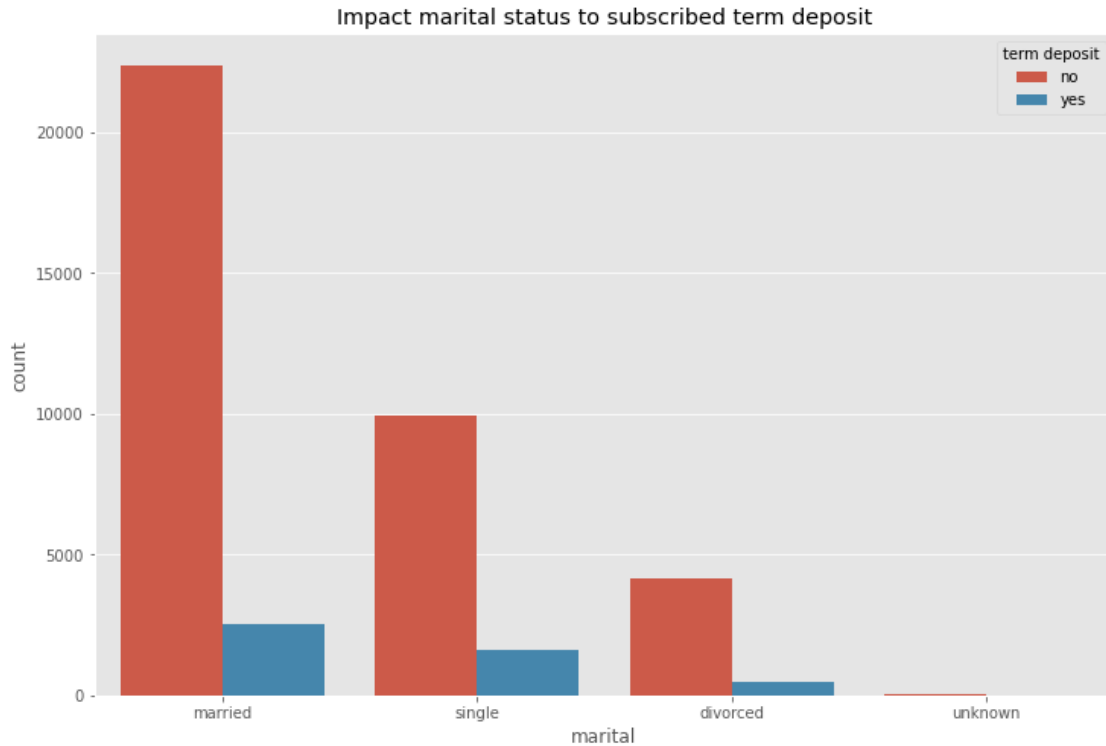


Observations:

- The most frequency job is administator
- In the plot we can notice assumed correctness as students have about 25 years old also retired people have more years than other.
- We can notice wired outliers in retired. Of course, outliers above upper limit is understanding. Outliers below 35 years old may be error.

### 1.6.3 Marital

Marital is feature which present us marital status people. Value of this feature: divorced, married, single, unknown.



Comparison ratio term deposit in each group in marital

```
[32]: marital
      unknown    0.176471
      single    0.162847
      divorced  0.115087
      married   0.113056
      Name: term deposit, dtype: float64
```

Observations:

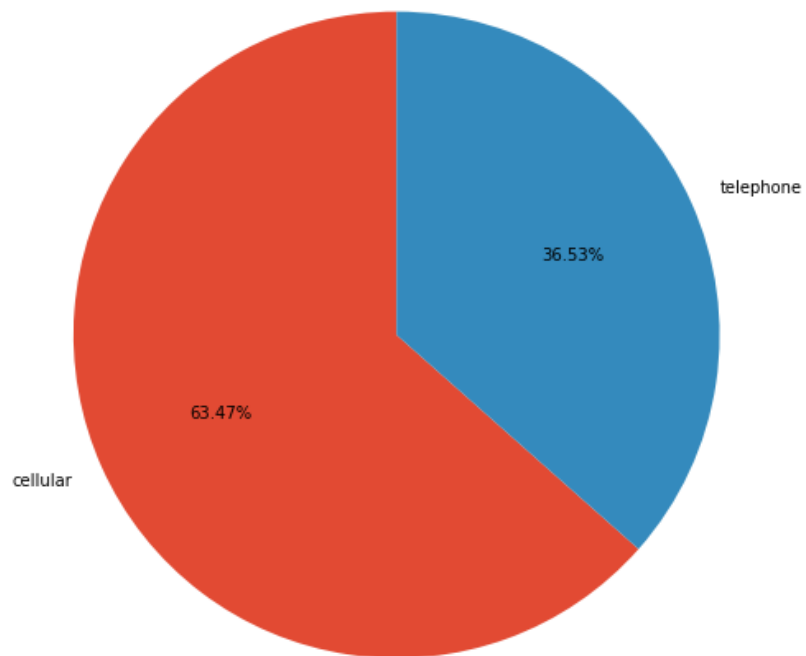
- Base on more accurate calculate, single marital status has influence to output.

#### 1.6.4 Contact

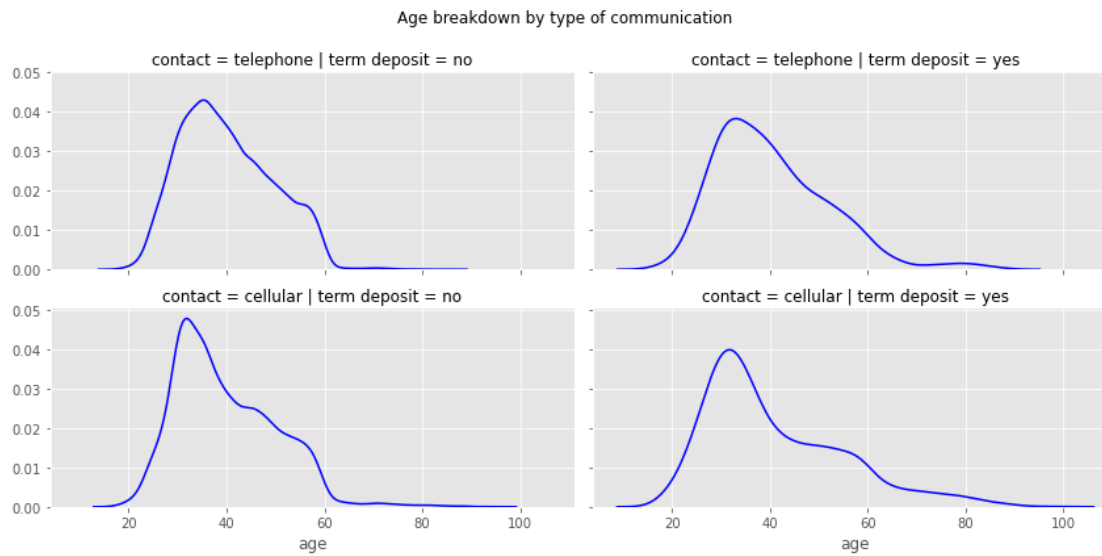
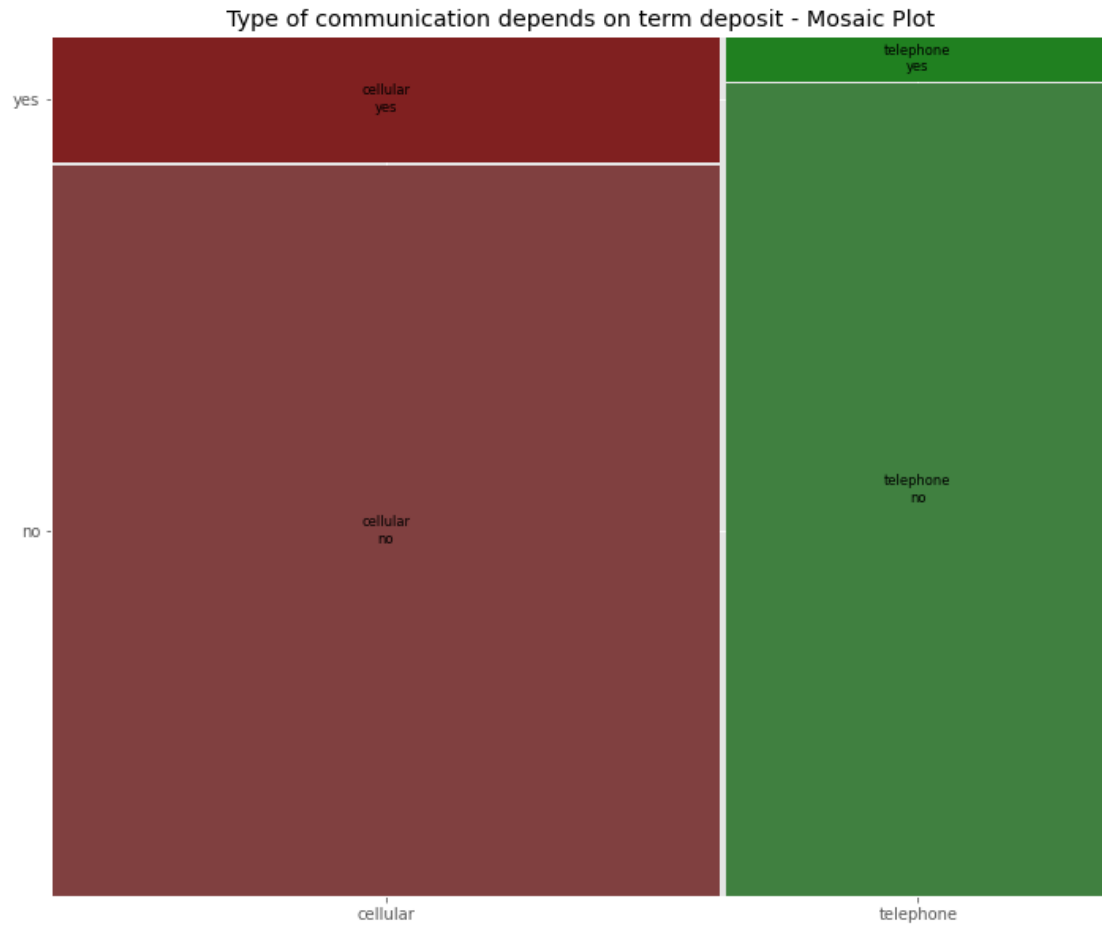
Feature contact consist of information about type of communication. Value of this feature: cellular, telephone.

```
[33]: array([26144, 15044], dtype=int64)
```

Percentage of choice type of communication



As pie plot show, about 64% use cellular so we can conclude there are young people, below 40 years.

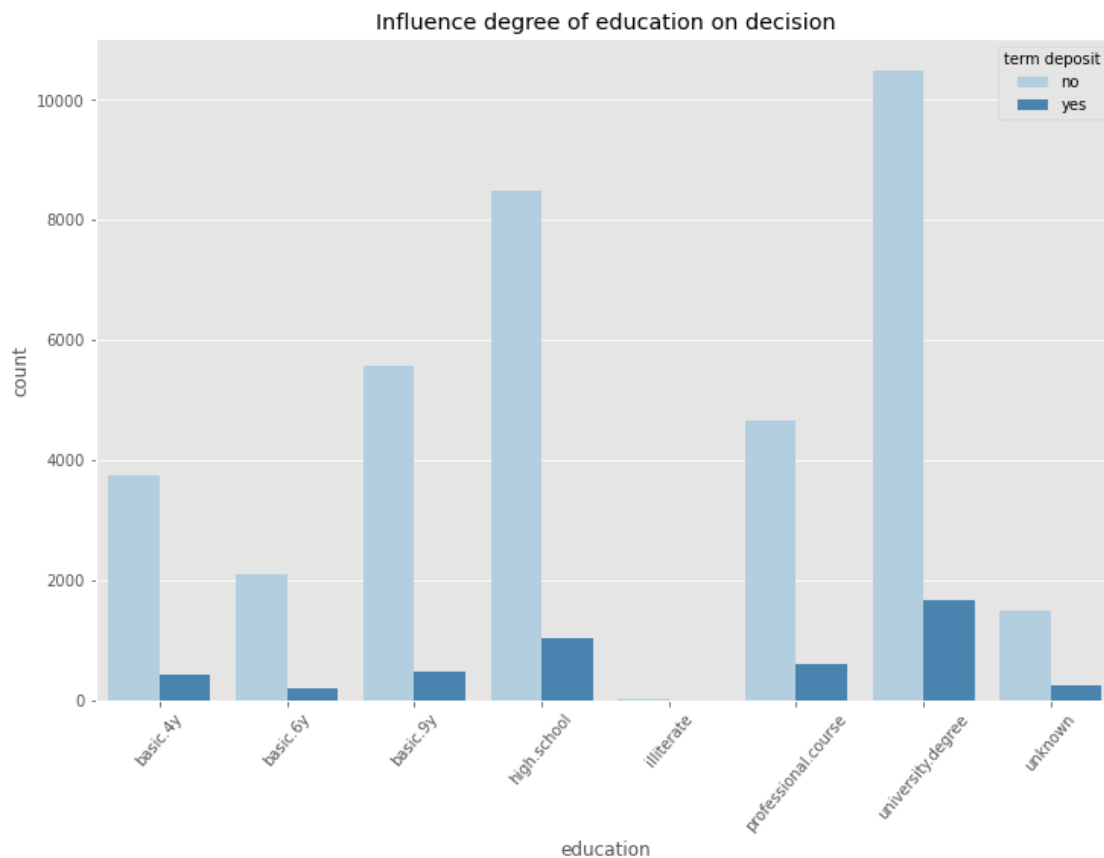


Observation:

- Our assumption about influence type of contact to age was wrong. Both in contact cellular and telephone dominate people about 40 years.
- Only old people contact by cellular (retired people). The older it is, the more often it subscribes

### 1.6.5 Education

This feature includes information about degree of education people. Value of this feature: basic.4y, basic.6y, basic.9y, high.school, illiterate, professional.course, university.degree, unknown.



```
[39]: education
      illiterate      0.285714
      unknown        0.169595
      university.degree 0.159078
      professional.course 0.128012
      high.school      0.121523
      basic.4y         0.114194
      basic.6y         0.089354
      basic.9y         0.084889
```

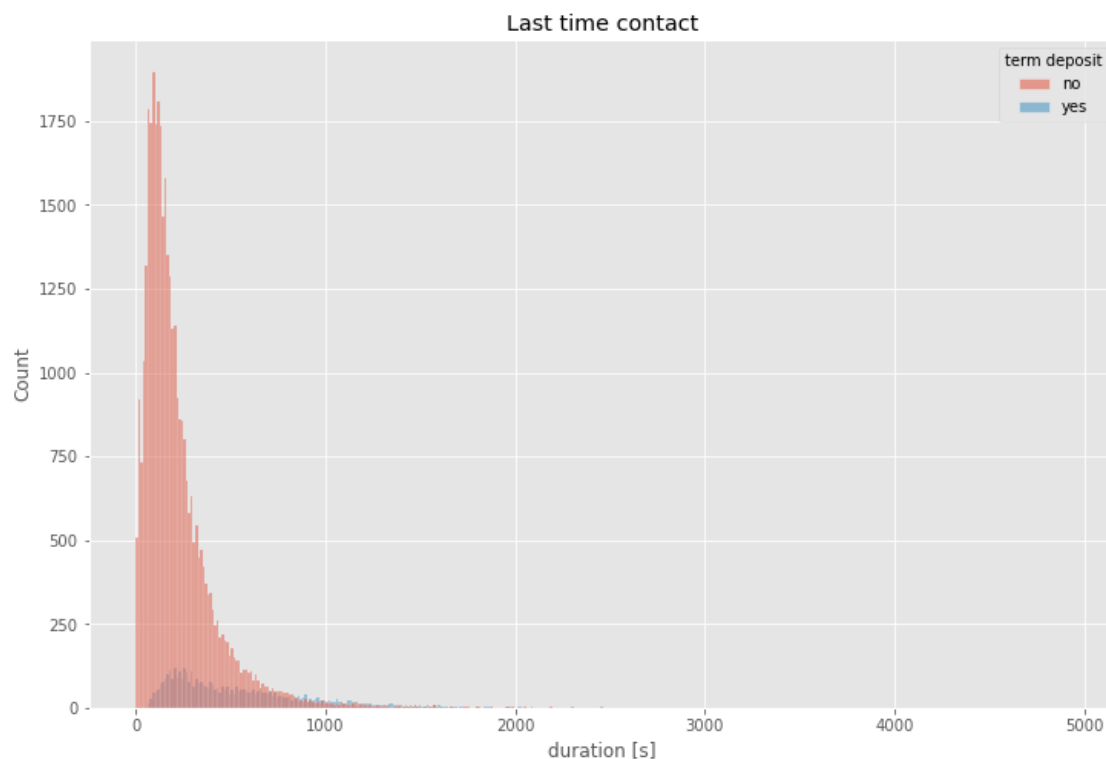
Name: term deposit, dtype: float64

Observations:

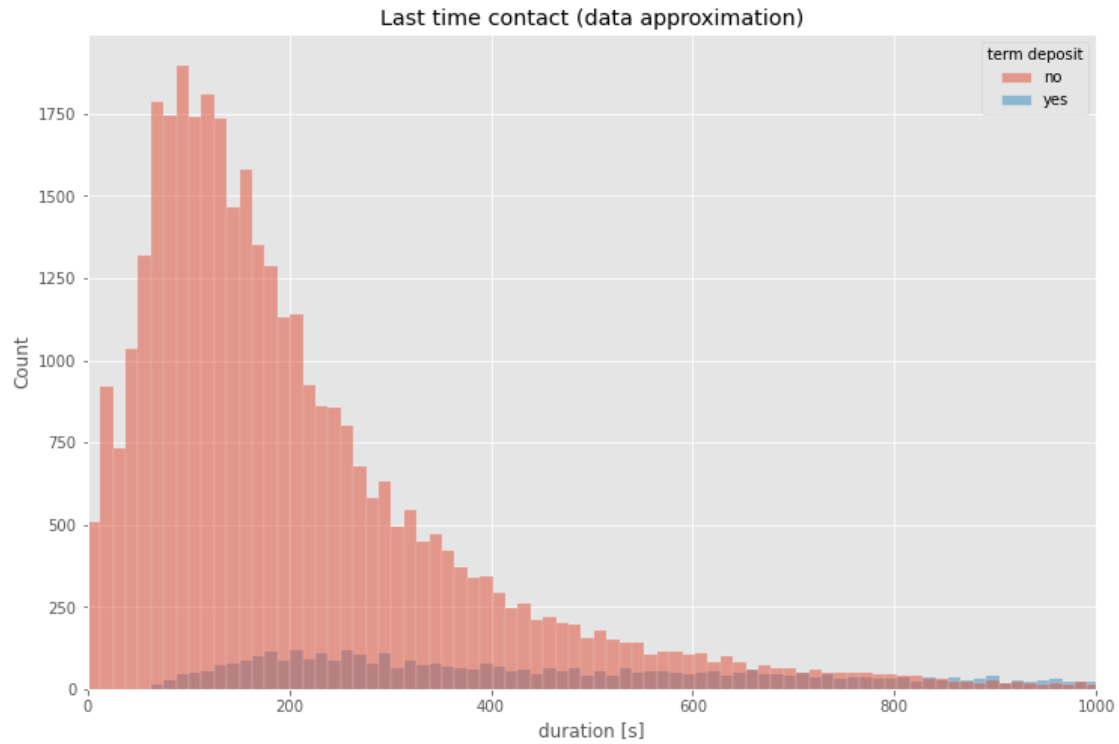
- That most of the people who were called were people with higher education (more chance to agree subscribed term deposit due to higher earnings)
- during our conclusion, we have to reject variable illiterate due to insufficient data, so the higher degree of education, the heigher propability to subscribe term deposit

### 1.6.6 Duration

This feature includes information about last contact duration in second.



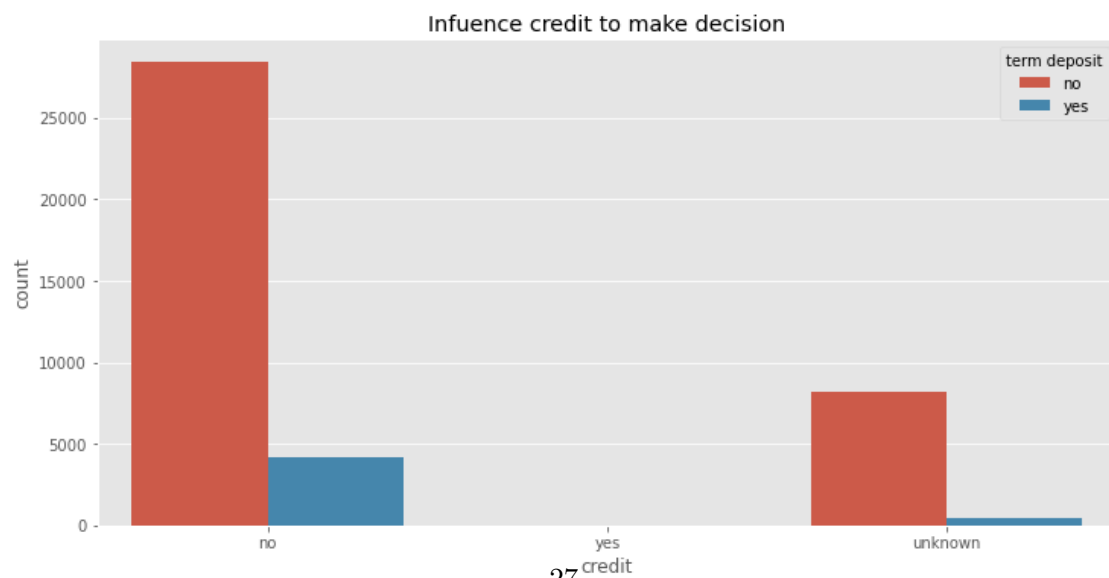
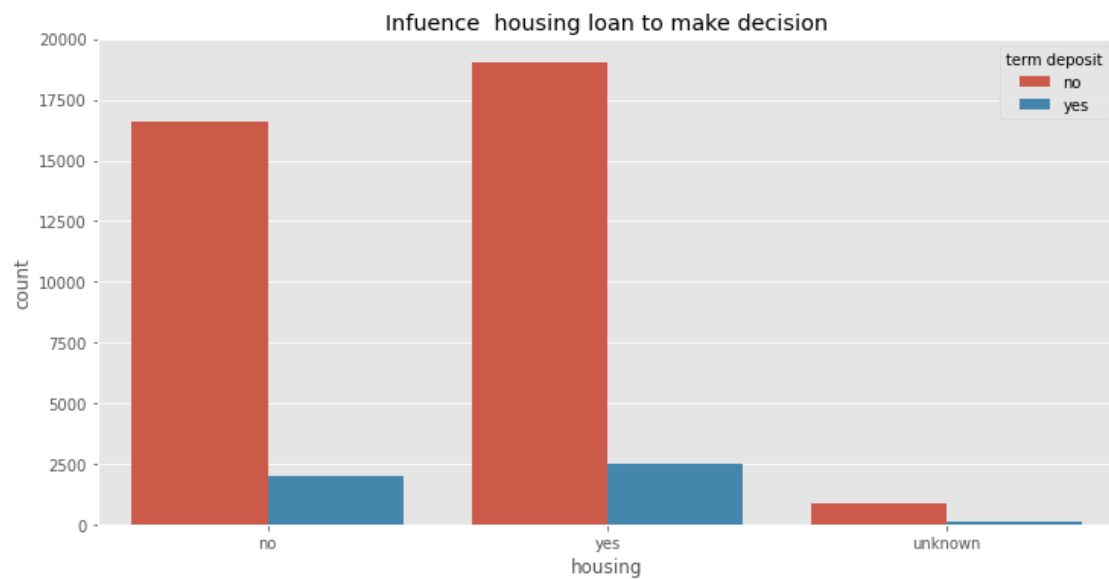
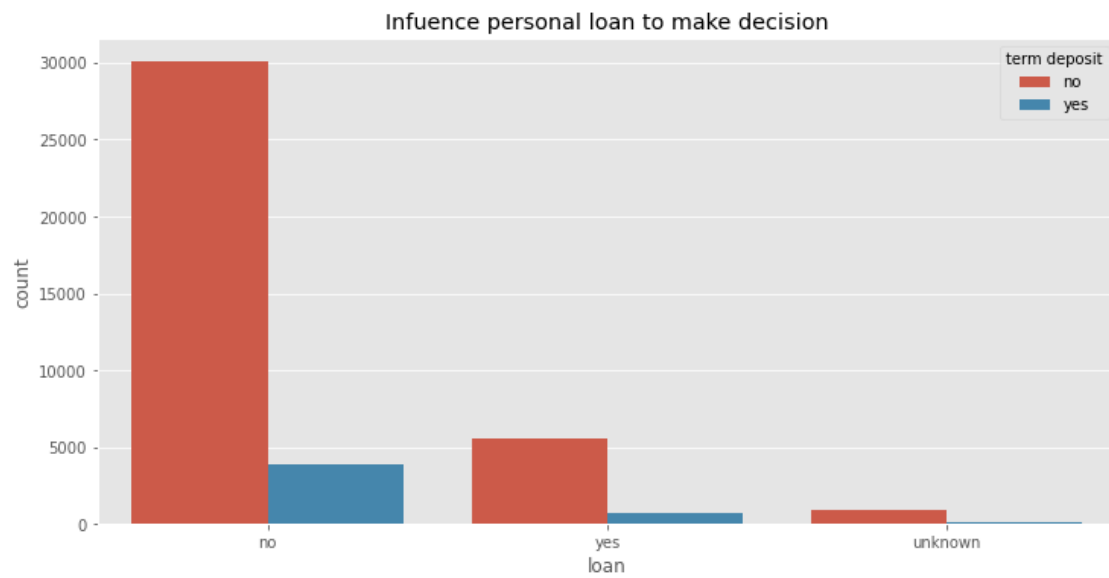




Distribution of last contact duration for response term deposit = 0 is skewed right. The most common value of contact is value about 200 s. Is a lot outliers that contact lasts > 1000s. Then probably people subscribed term deposit. Also we can see that all contact < 50s, ending response 'no', so like as in description, this variable highly affects the output.



### 1.6.7 All type of credits



In plot we can see few response yes in column credit, so we can reject this variable

Comparison ratio term deposit in each group in loan

loan

no 0.127907

yes 0.122731

unknown 0.121178

Name: term deposit, dtype: float64

Comparison ratio term deposit in each group in housing

housing

yes 0.131470

no 0.122078

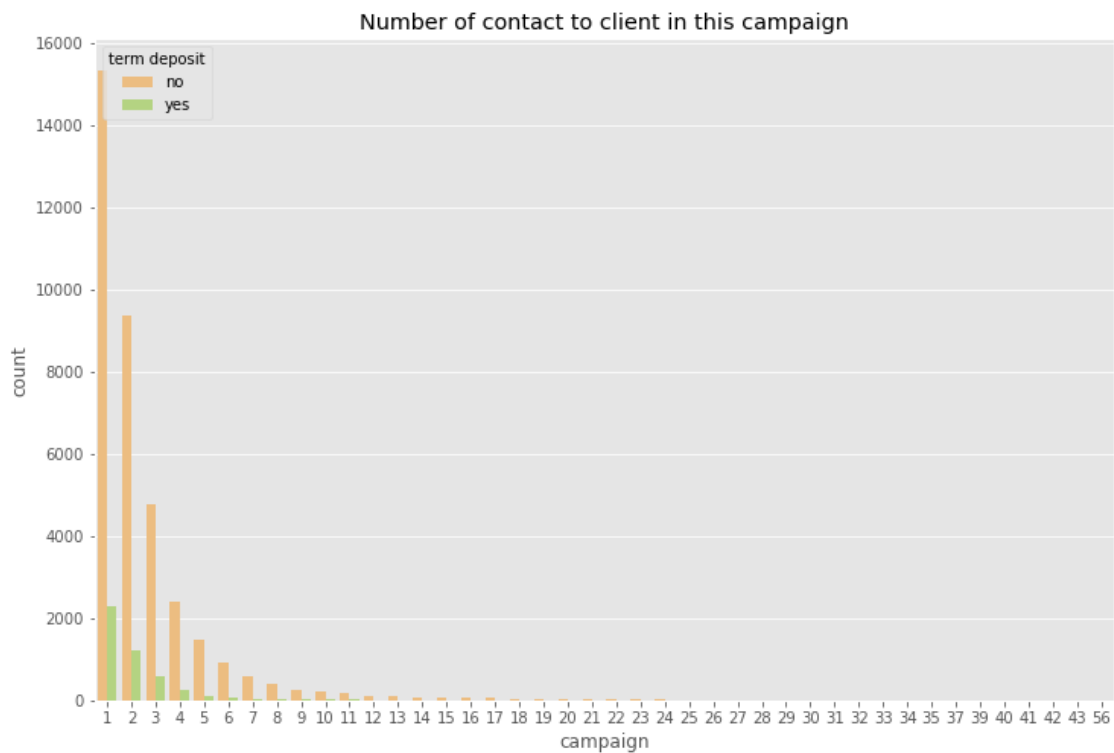
unknown 0.121178

Name: term deposit, dtype: float64

None of this variables has no significant on output.

### 1.6.8 Campaign

This feature includes information about number of contacts performed during this campaign and for client.



```
[45]: no      399
      yes       7
      Name: term deposit, dtype: int64
```

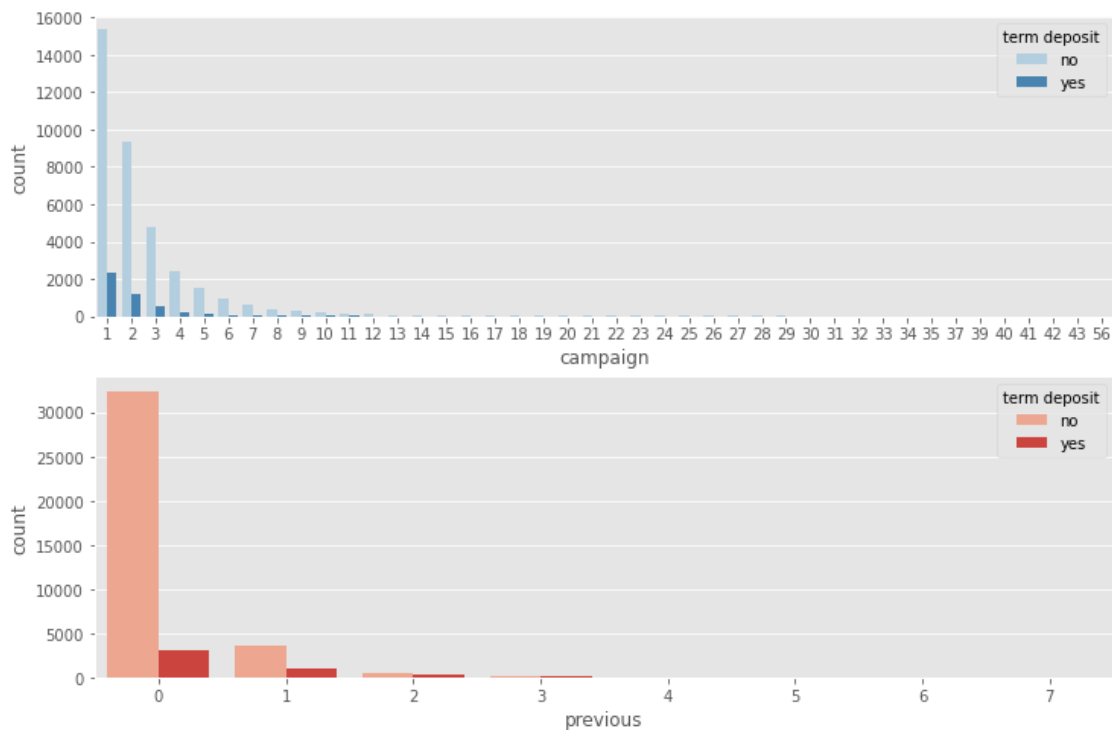
Observations:

- The most frequency number of contact is 1.
- All this people no subscribed term deposit. only 7 people from 408 subscribed. Probably they were undecided or they like talk.

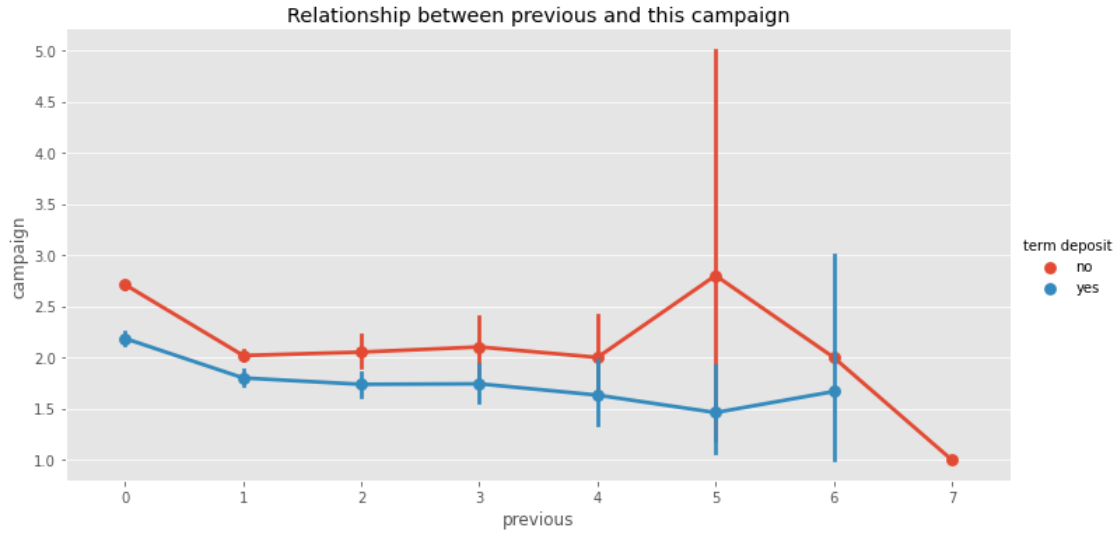
### 1.6.9 Previous and campaign

Previous feature includes information about number of contacts performed before this campaign and for client.

Comparison contact from previous campaign and this campaign



```
[47]: term deposit  previous
      0           no      8
      1           yes     16
```

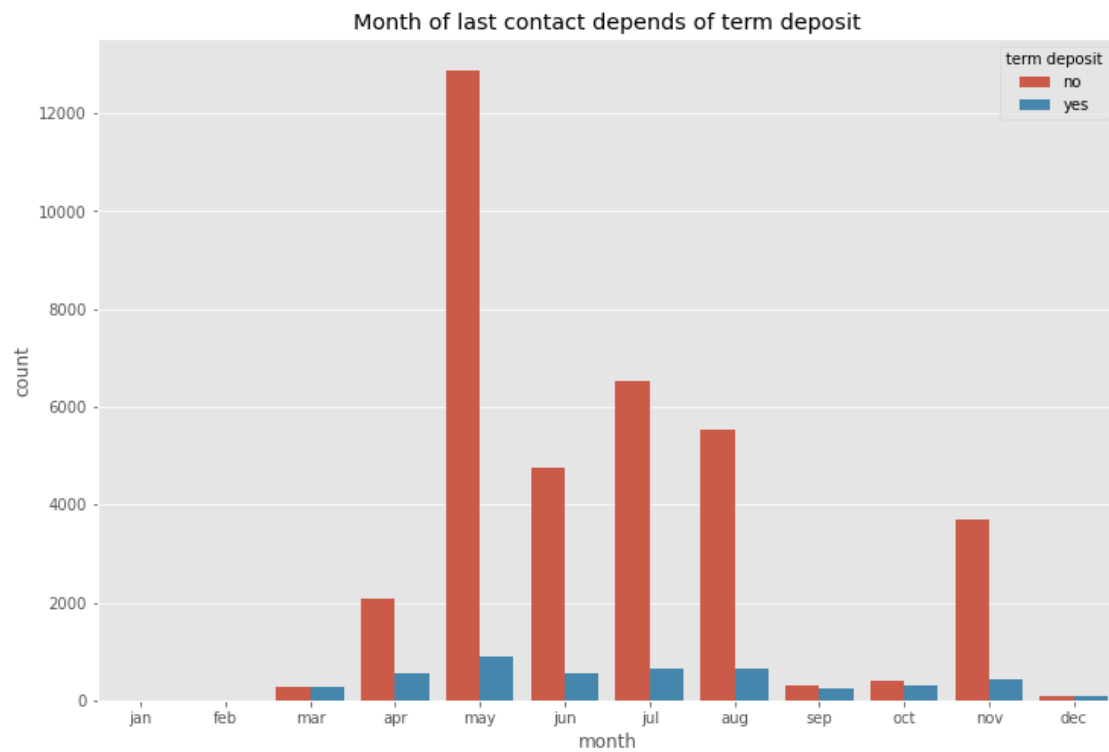
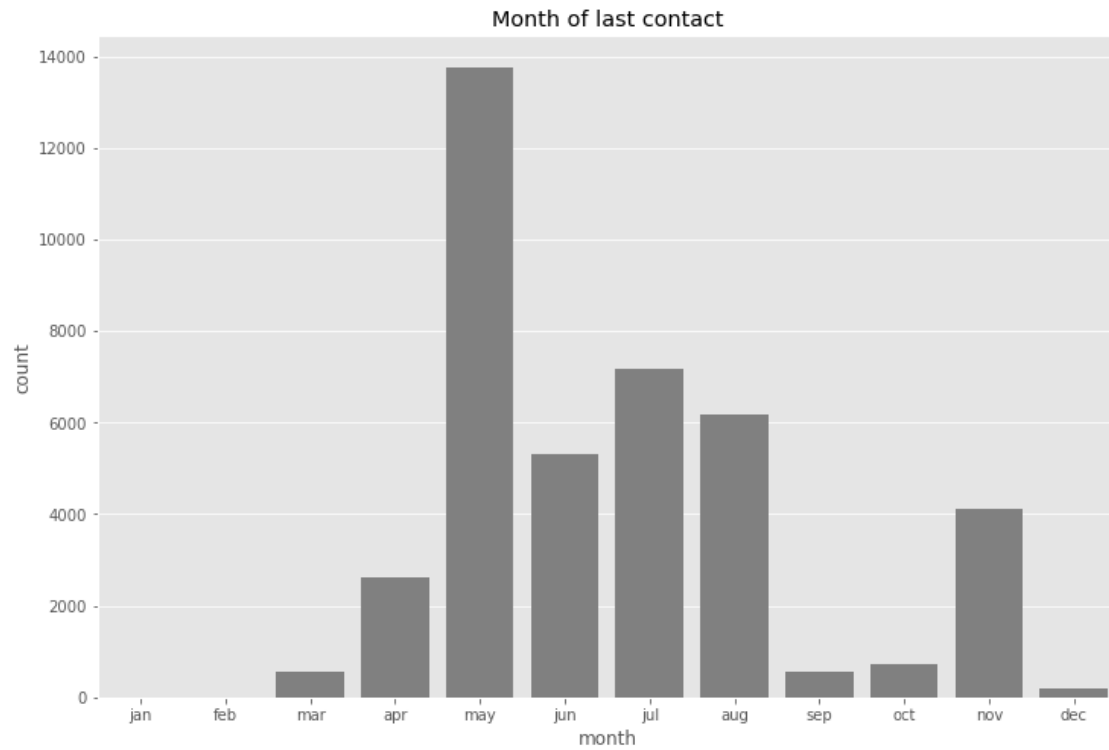


#### Observations

- This plot shows that in this campaign ratio response yes/no is higher than in a previous campaign. Also, based on previous and this plot, we can notice that the maximum number of contacts in the previous campaign was 7, in this 56.
- There is no relationship between the present and previous campaign.

#### 1.6.10 Month

This feature includes information about which month was last contacted. Value of this feature: January, February, March, April, May, June, July, August, September, October, November, December.

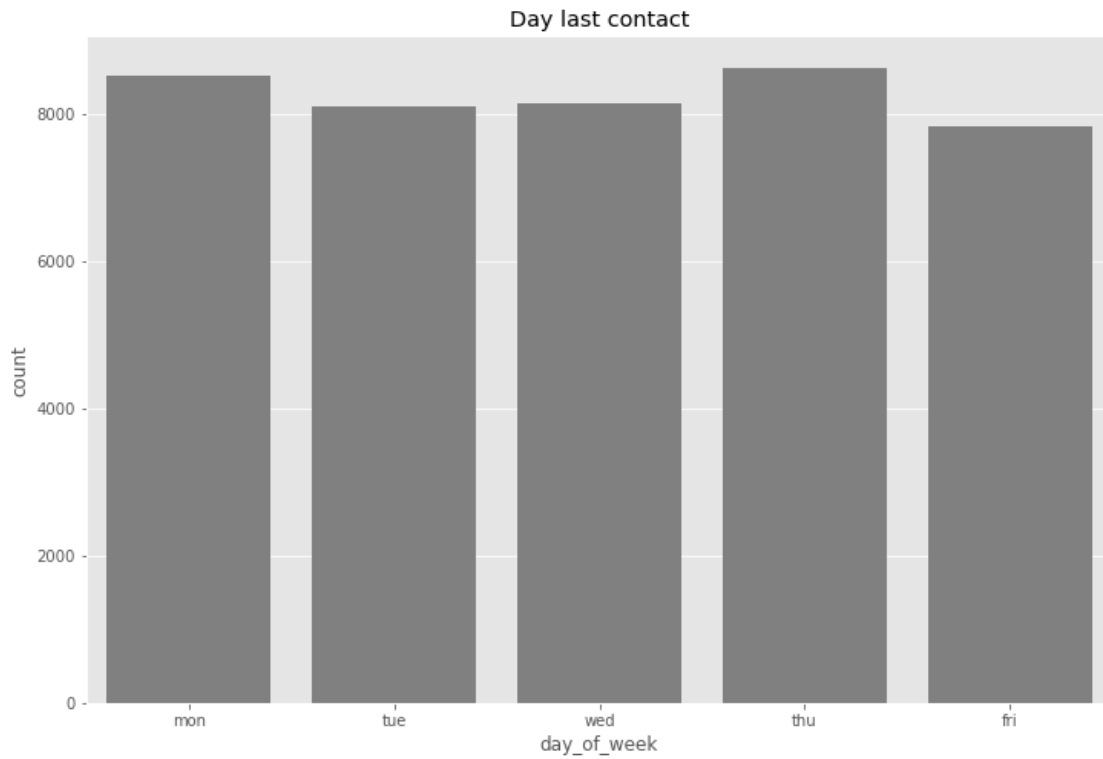


Observations

- The most month of contact is may and summer months, due to higher probability of agree to subscribe
- In january and february, there was no contact, probably closing cases from last year

### 1.6.11 Day of week

This feature includes information about which month was last contacted. Value of this feature: Monday, Tuesday, Wednesday, Thursday, Friday.



```
[52]: term deposit      no      yes      All
      day_of_week
      fri          0.169491  0.020540  0.190031
      mon          0.186146  0.020564  0.206711
      thu          0.183986  0.025371  0.209357
      tue          0.173279  0.023138  0.196416
      wed          0.174444  0.023041  0.197485
      All          0.887346  0.112654  1.000000
```

Observations:

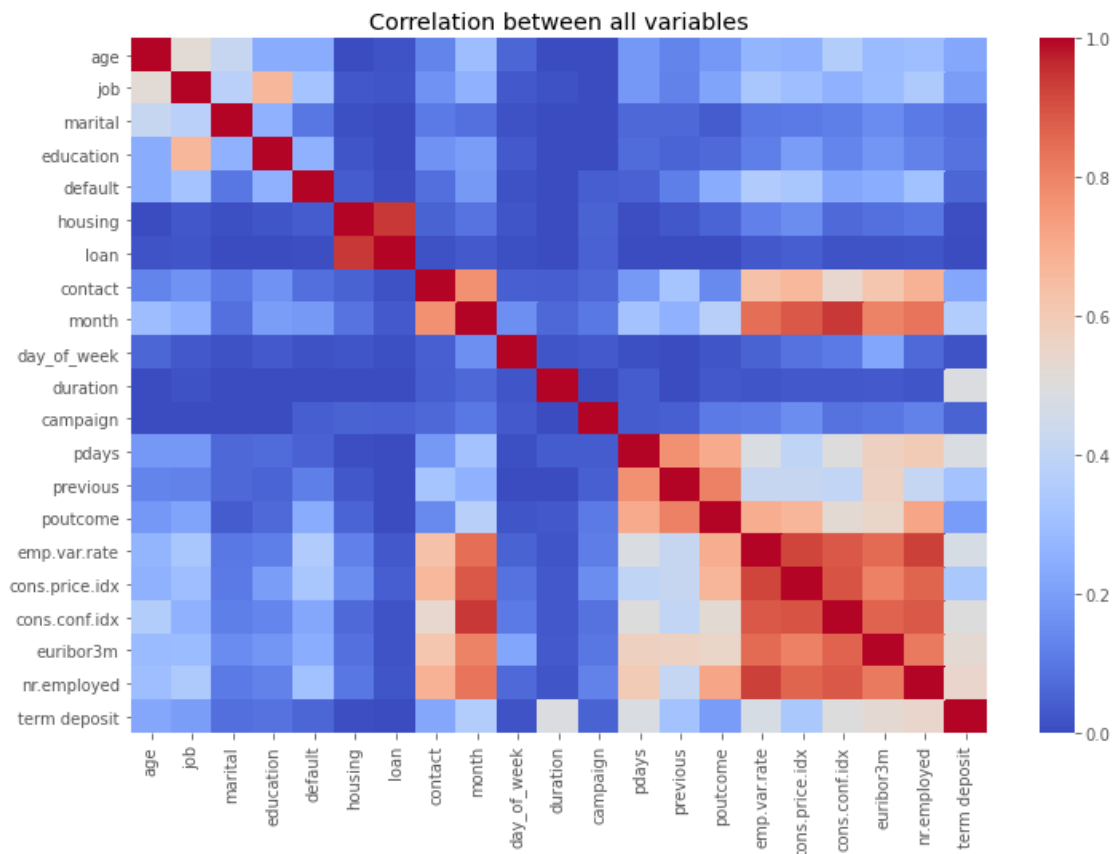
- As we can see, in feature day\_od\_week is only five days, these are working days. Bank doesn't work in weekend, so we don't have error in this feature.

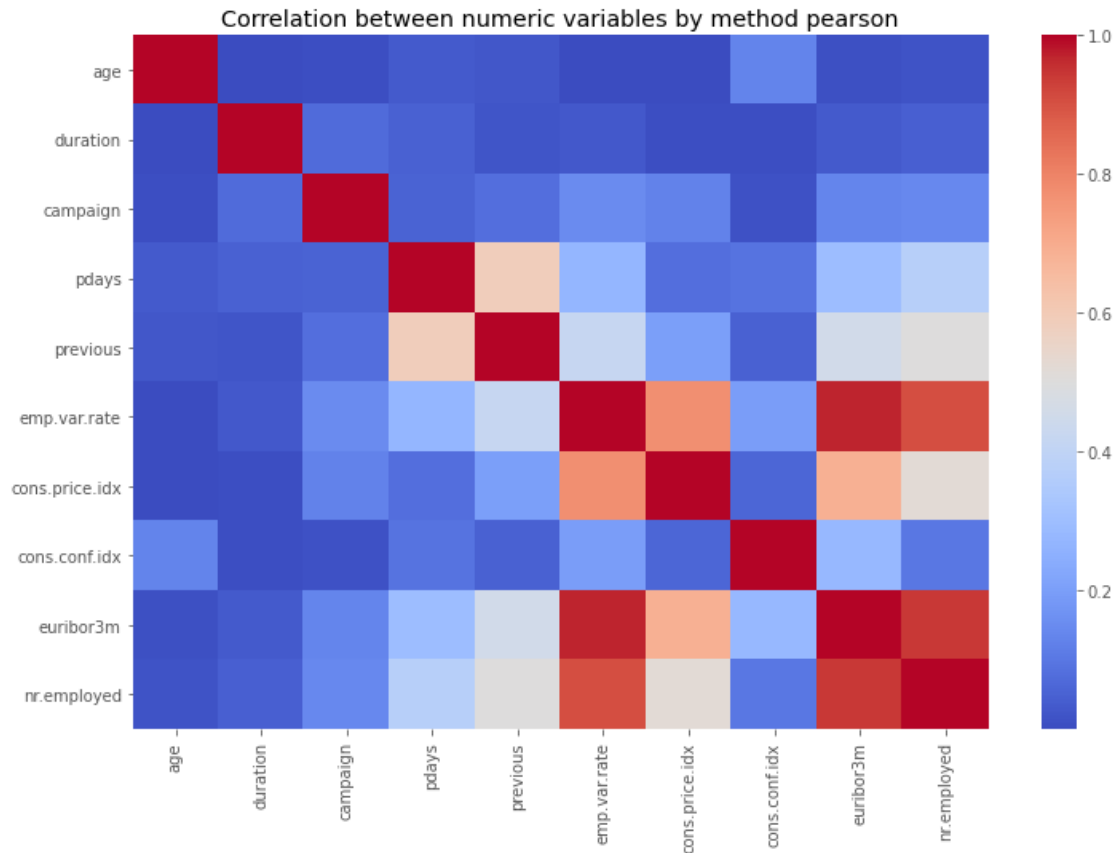


- Distribution all value in this feature is similar, so this feature doesn't have impact to output

### 1.6.12 Correlation between features

For the first plot we use special function from libraries `phik` - `phik_matrix`. The combined features of `Phi_K` form an advantage over existing coefficients. First, it works consistently between categorical, ordinal and interval variables. Second, it captures non-linear dependency. Third, it reverts to the Pearson correlation coefficient in case of a bi-variate normal input distribution. These are useful features when studying the correlation matrix of variables with mixed types. It is orrelation matrix of bivariate gaussian derived from `chi2`-value.





Observation:

- As we can see on both correlation plot, same variables are highly correlate each other. Later variables will be remove.

```
loan          housing          0.943147
cons.conf.idx month          0.942669
nr.employed   emp.var.rate    0.929844
cons.price.idx emp.var.rate    0.921977
dtype: float64
```

Data variables to drop due to high correlation: ['loan', 'cons.price.idx', 'cons.conf.idx', 'nr.employed']

Observation:

- We may remove one from highly correlated variables. During testing model we try predict with both features and with removed one of this freatures

```
[58]: term deposit    1.000000
      nr.employed     0.547178
      euribor3m       0.529597
```

```

cons.conf.idx    0.501193
duration         0.489394
pdays          0.488128
emp.var.rate    0.474448
month           0.357098
cons.price.idx  0.336131
previous        0.314234
contact         0.225206
age             0.224248
job             0.195808
poutcome        0.195178
education        0.089572
marital         0.081401
default         0.059741
campaign        0.052260
day_of_week     0.018948
housing         0.005695
loan            0.000000
Name: term deposit, dtype: float64

```

Observations:

- There is couple of features that have very low correlation, so this feature will be removed and compare model with and without.

## 1.7 Feature engineering

In this section of this project, we filled our data (Nan) and transformed to numeric. Result of this part is dataframe:

```

[98]:
   age  education  campaign  previous  poutcome  emp.var.rate  \
0  4.025352      0        1         0         0          1.1
1  4.043051      3        1         0         0          1.1
2  3.610918      3        1         0         0          1.1
3  3.688879      1        1         0         0          1.1
4  4.025352      3        1         0         0          1.1

   cons.price.idx  cons.conf.idx  term deposit  month_jul  month_may  \
0          93.994          36.4             0         0.0         1.0
1          93.994          36.4             0         0.0         1.0
2          93.994          36.4             0         0.0         1.0
3          93.994          36.4             0         0.0         1.0
4          93.994          36.4             0         0.0         1.0

   month_nov  contact_telephone  marital_married  marital_single  \
0         0.0                1.0             1.0              0.0
1         0.0                1.0             1.0              0.0
2         0.0                1.0             1.0              0.0

```

3	0.0	1.0	1.0	0.0
4	0.0	1.0	1.0	0.0

	job fill_blue-collar	job fill_entrepreneur	job fill_retired	\
0	0.0	0.0	0.0	
1	0.0	0.0	0.0	
2	0.0	0.0	0.0	
3	0.0	0.0	0.0	
4	0.0	0.0	0.0	

	job fill_services
0	0.0
1	1.0
2	1.0
3	0.0
4	1.0

## 1.8 Model predict and solve

Now we are ready to train a model and predict the required solution. Our problem is a classification problem. We want to identify relationship between output (term deposit) with other variables or features. We are also performing a category of machine learning which is called supervised learning as we are training our model with a given dataset. With these two criteria - Supervised Learning plus Classification, we can narrow down our choice of models to a few. These include:

- Logistic Regression
- Random Forest
- Support Vector Machines

First of all we should divide data to X, y to train and test data. We should do because our model is trained all time on train data. After training we can check our predict on test data. If we have only one data, our prediction will not be a reliable. So now we divide our data to train and test

We can standarize data. Without standarize model base on logistic regression has little worse results.

### 1.8.1 Logistic Regression

Logistic Regression is a useful model to run early in the workflow. Logistic regression measures the relationship between the categorical dependent variable (feature) and one or more independent variables (features) by estimating probabilities using a logistic function, which is the cumulative logistic distribution.

We can try, thanks to Grid Search CV we can choose the best parameters for model base on logistic regression. After that, we also try model base on default parameters for logistic regression and we can choose better option.

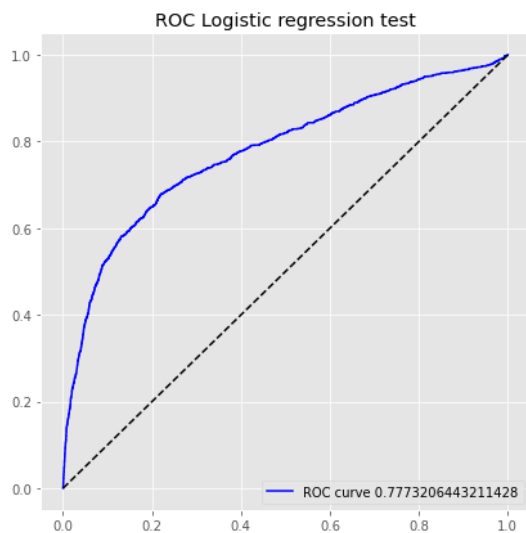
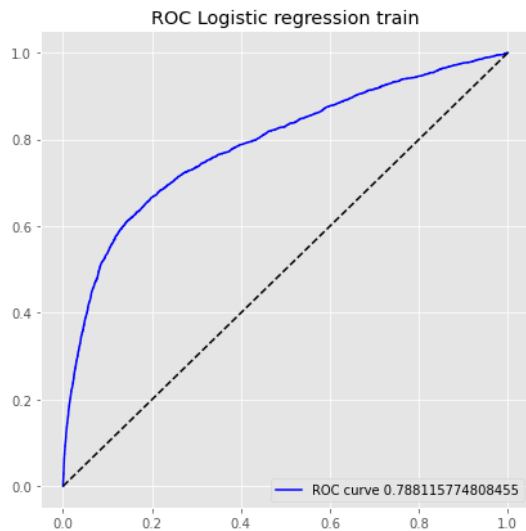
The best parameters: {'C': 10, 'penalty': 'l2', 'solver': 'liblinear'}

Results for Logistic Regression:

Logistic Regression accuracy: 0.8954

Logistic Regression f-score: 0.2798  
Logistic Regression recall: 0.182  
Logistic Regression log\_loss: 0.2855

-----  
Results for Logistic Regression with param:  
Logistic Regression with param accuracy: 0.8954  
Logistic Regression with param f-score: 0.2797  
Logistic Regression with param recall: 0.182  
Logistic Regression with param log\_loss: 0.2855



Observations:

- Default setting for parameters give us the same result like the best chosen parameters.
- Base accuracy (all response the same like output == 'no') is 88%. In our model accuracy is

91%, what it means we have better model.

- As we can see, on train and test dataset, model works similar, so it isn't overfitted or underfitted.
- F-score is the same for both model
- ROC curve (also great measure for imbalanced data) can efficiently give us the score that how our model is performing in classifying the labels. The best ROC is 1. We have 0.93 so it is great (all above black line is better)

We can use Logistic Regression to validate our assumptions and decisions for feature creating and completing goals. This can be done by calculating the coefficient of the features in the decision function.

Positive coefficients increase the log-odds of the response (and thus increase the probability), and negative coefficients decrease the log-odds of the response (and thus decrease the probability).

[105]:	Feature	Correlation
6	cons.price.idx	0.692342
4	poutcome	0.277350
16	job fill_retired	0.089689
8	month_jul	0.038767
13	marital_single	0.032228
1	education	0.024581
12	marital_married	0.004611
15	job fill_entrepreneur	-0.017538
0	age	-0.052548
17	job fill_services	-0.083188
14	job fill_blue-collar	-0.089371
2	campaign	-0.124699
10	month_nov	-0.135021
3	previous	-0.137798
7	cons.conf.idx	-0.184723
9	month_may	-0.284131
11	contact_telephone	-0.356394
5	emp.var.rate	-1.179958

Observations:

- Cons.price.idx is highest positive coefficient, the higher the value, the more likely the answer is yes.
- Inversely as emp.var.rate increases, probability of response yes decreases the most.

## 1.9 Resampling Technique

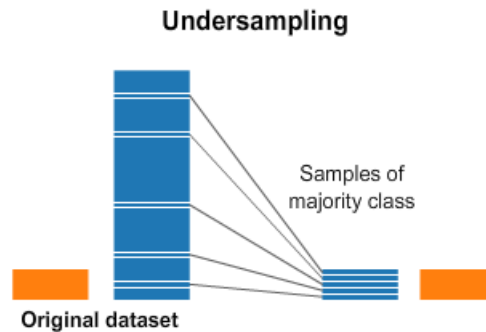
Due to highly imbalanced data, now we can try deal with them. One of possibilities is resampling technique.

Resampling consists of removing samples from the majority class (under-sampling) and adding more examples from the minority class (over-sampling). The simplest implementation of over-sampling

is to duplicate random records from the minority class, which can cause overfitting. In under-sampling, the simplest technique involves removing random records from the majority class, which can cause loss of information.

In this project we can use a couple of resampling technique describe below. Additionally, in this raport we can see confusion matrix only for the best result (SVC). A list of the remaining confusion matrix for all of them can be found in an additional file *confusion\_matrix\_appendix.pdf*

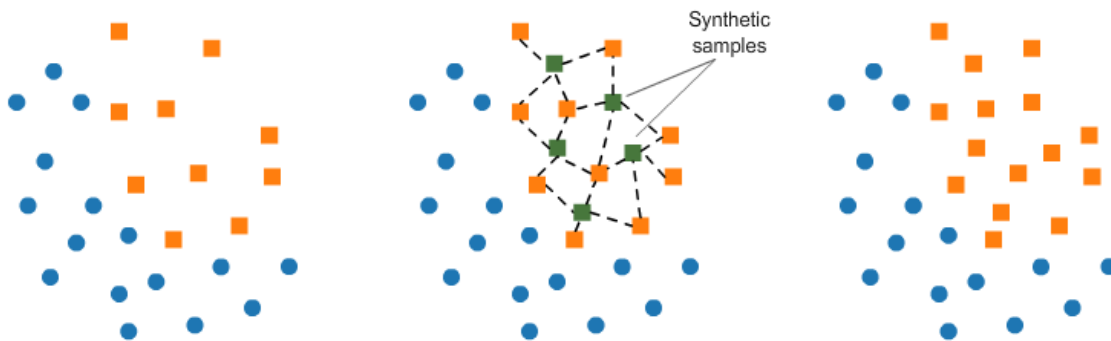
### 1.9.1 Random Under-Sampling



Undersampling can be defined as removing some observations of the majority class. This is done until the majority and minority class is balanced out.

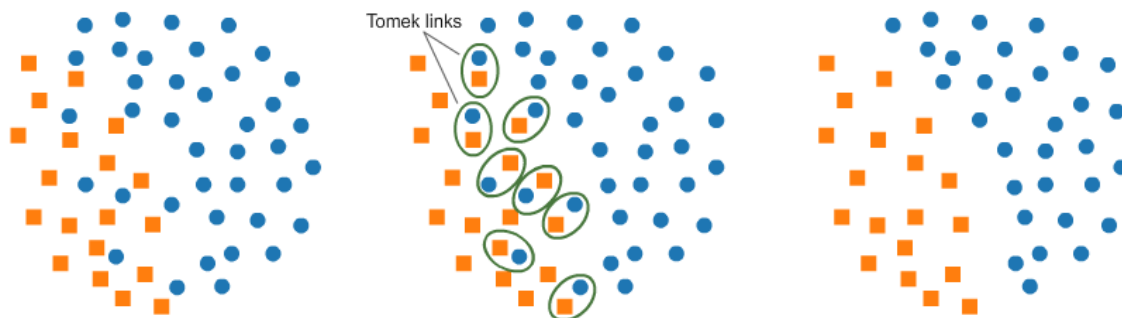
### 1.9.2 Synthetic Minority Oversampling Technique (SMOTE)

This technique generates synthetic data for the minority class.



SMOTE (Synthetic Minority Oversampling Technique) works by randomly picking a point from the minority class and computing the k-nearest neighbors for this point. The synthetic points are added between the chosen point and its neighbors.

### 1.9.3 Under-sampling: Tomek links



Tomek links are pairs of very close instances, but of opposite classes. Removing the instances of the majority class of each pair increases the space between the two classes, facilitating the classification process.

### 1.9.4 Over-sampling followed by under-sampling

Now, we try combination of over-sampling and under-sampling, using the SMOTE and Tomek links techniques.

[110]: Classifier	Accuracy	F-score	Recall	Log_loss
Logistic Regression under Sample	0.8104	0.4185	0.6113	0.5306
Logistic Regression SMOTE	0.8087	0.4172	0.6135	0.5299
Logistic Regression SMOTETomek	0.8059	0.4159	0.6193	0.5296
Logistic Regression TomekLinks	0.8948	0.3428	0.2458	0.2860
Logistic Regression	0.8954	0.2798	0.1820	0.2855

Observations:

- Used sampling method proved to be right, because all of these methods are better than without sampling
- Tree methods are similar: basic under sample, smote and combination smote and tomesk links.

### 1.9.5 Principal Component Analysis

Principal component analysis is a technique to convert high dimensional data to low dimensional data by selecting the most important features that capture maximum information about the dataset. The features are selected on the basis of variance that they cause in the output. The feature that causes highest variance is the first principal component. The feature that is responsible for second highest variance is considered the second principal component, and so on. It is important to mention that principal components do not have any correlation with each other.

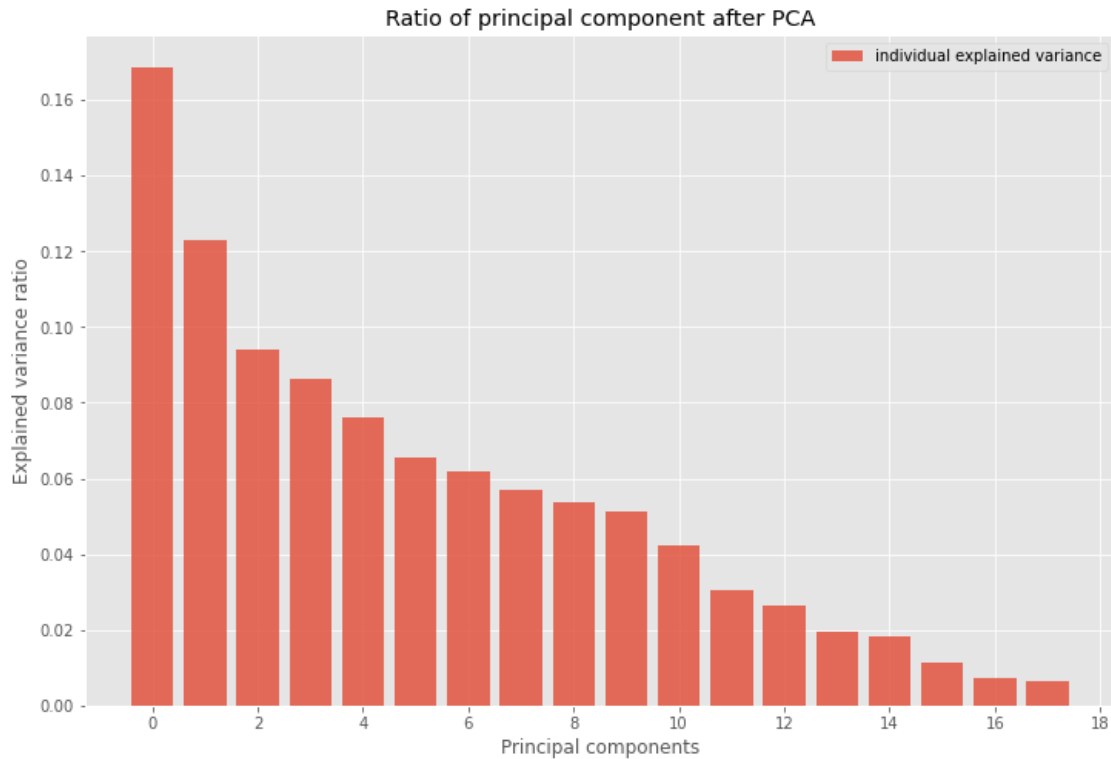
Now we can check PCA for our model.

After fitting and transforming our data, check principal component.

```
[112]: array([0.16871878, 0.12298779, 0.09409119, 0.08636436, 0.0759825 ,
              0.06567283, 0.06200362, 0.05702128, 0.05358525, 0.0514317 ,
              0.04232106, 0.03050809, 0.02632848, 0.0195717 , 0.01838795,
```



0.01137576, 0.00733059, 0.00631709])



As we can see two last components have less than 0.01, so we can use 16 components.

Check our best result from logistic regression with PCA.

[116]: Classifier	Accuracy	F-score	Recall	Log_loss
Logistic Regression under Sample	0.8104	0.4185	0.6113	0.5306
Logistic Regression SMOTE	0.8087	0.4172	0.6135	0.5299
Logistic Regression SMOTETomek	0.8059	0.4159	0.6193	0.5296
Logistic Regression SMOTETomek PCA	0.7871	0.3961	0.6258	0.5589
Logistic Regression TomekLinks	0.8948	0.3428	0.2458	0.2860
Logistic Regression	0.8954	0.2798	0.1820	0.2855

Observation:

- Model base on PCA is one of the worst so we reject this method for our model.

### 1.9.6 Random Forest

Random forests or random decision forests are an ensemble learning method for classification, regression and other tasks, that operate by constructing a multitude of decision trees ( $n\_estimators=50$ ) at training time and outputting the class that is the mode of the classes (classification) or mean prediction (regression) of the individual trees

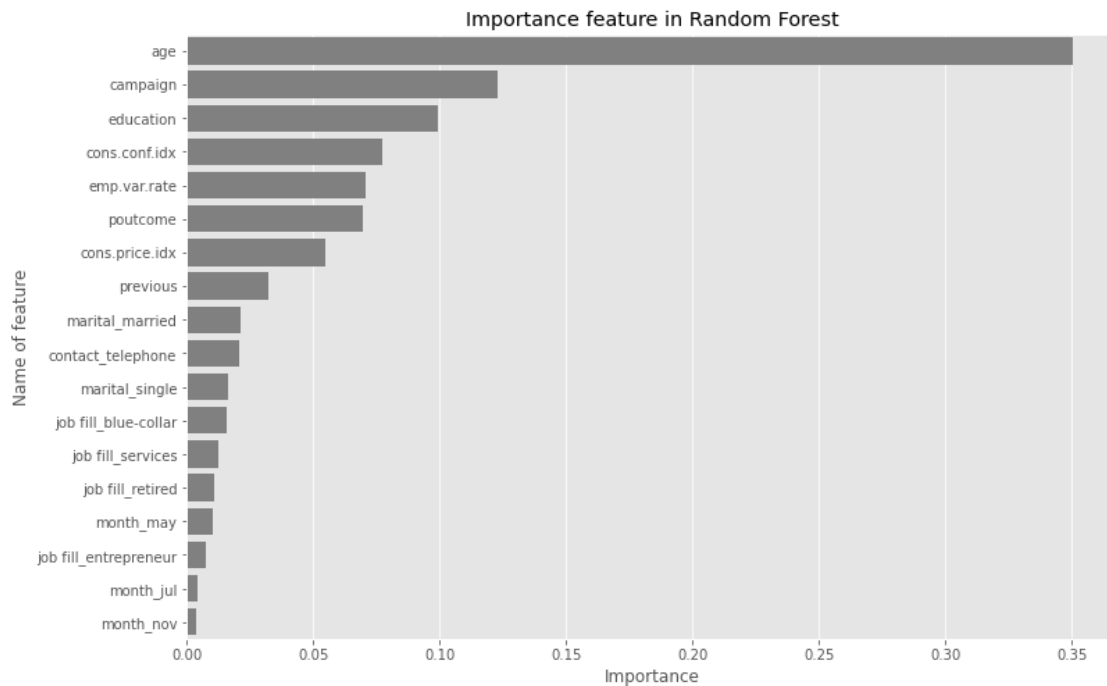
Observations:

- Random forest with set parameters (search by grid search cv) gave us worst results than random forest with default parameters so, we reject this method.

Now, we will use feature importance variable to see feature importance scores.

```
[119]:
```

	feature	importance
0	age	0.350387
2	campaign	0.122710
1	education	0.099390
7	cons.conf.idx	0.077225
5	emp.var.rate	0.070833
4	poutcome	0.069587
6	cons.price.idx	0.054611
3	previous	0.032278
12	marital_married	0.021328
11	contact_telephone	0.020847
13	marital_single	0.016515
14	job fill_blue-collar	0.015637
17	job fill_services	0.012519
16	job fill_retired	0.010696
9	month_may	0.009990
15	job fill_entrepreneur	0.007769
8	month_jul	0.004151
10	month_nov	0.003525



[121]: Classifier	Accuracy	F-score	Recall	Log_loss
Logistic Regression under Sample	0.8104	0.4185	0.6113	0.5306
Logistic Regression SMOTE	0.8087	0.4172	0.6135	0.5299
Logistic Regression SMOTETomek	0.8059	0.4159	0.6193	0.5296
Logistic Regression SMOTETomek PCA	0.7871	0.3961	0.6258	0.5589
Random Forest	0.8787	0.3457	0.2872	1.0826
Logistic Regression TomekLinks	0.8948	0.3428	0.2458	0.2860
Logistic Regression	0.8954	0.2798	0.1820	0.2855

Observations:

- Random Forest (without sampling) gives us better results than Logistic Regression (F-score, recall), so now we can check this model with sampling
- Age is highest positive coefficient, the higher the value, the more likely the answer is yes.
- Random Forest not requires standardize of data, but during testing model, better results (a little) our model achieves with the standardization.

[128]: Classifier	Accuracy	F-score	Recall	Log_loss
Logistic Regression under Sample	0.8104	0.4185	0.6113	0.5306
Logistic Regression SMOTE	0.8087	0.4172	0.6135	0.5299
Logistic Regression SMOTETomek	0.8059	0.4159	0.6193	0.5296
Logistic Regression SMOTETomek PCA	0.7871	0.3961	0.6258	0.5589
Random Forest TomekLinks	0.8780	0.3770	0.3307	1.5218
Random Forest SMOTETomek PCA	0.8347	0.3614	0.4191	1.8288
Random Forest SMOTETomek	0.8572	0.3590	0.3582	1.6882
Random Forest SMOTE	0.8611	0.3554	0.3430	1.7068
Random Forest	0.8787	0.3457	0.2872	1.0826
Logistic Regression TomekLinks	0.8948	0.3428	0.2458	0.2860
Random Forest under Sample	0.7215	0.3348	0.6280	1.8183
Logistic Regression	0.8954	0.2798	0.1820	0.2855

Observations:

- Random Forest with resampling give us better results than without resampling.
- Random Forest with PCA give us a little better results than without but still Logistic Regression is better.
- Logistic Regression with resample SMOTETomek gives us the best result (almost the same like SMOTE).
- In table we can see that we have tree similar models. They have similar measure important for us: F-score, also recall is important.
- In random forest standardize data also give us better results.

### 1.9.7 SVM

Support vector machines (SVM) are particular linear classifiers which are based on the margin maximization principle. They perform structural risk minimization, which improves the complexity of

the classifier with the aim of achieving excellent generalization performance. The SVM accomplishes the classification task by constructing, in a higher dimensional space, the hyperplane that optimally separates the data into two categories.

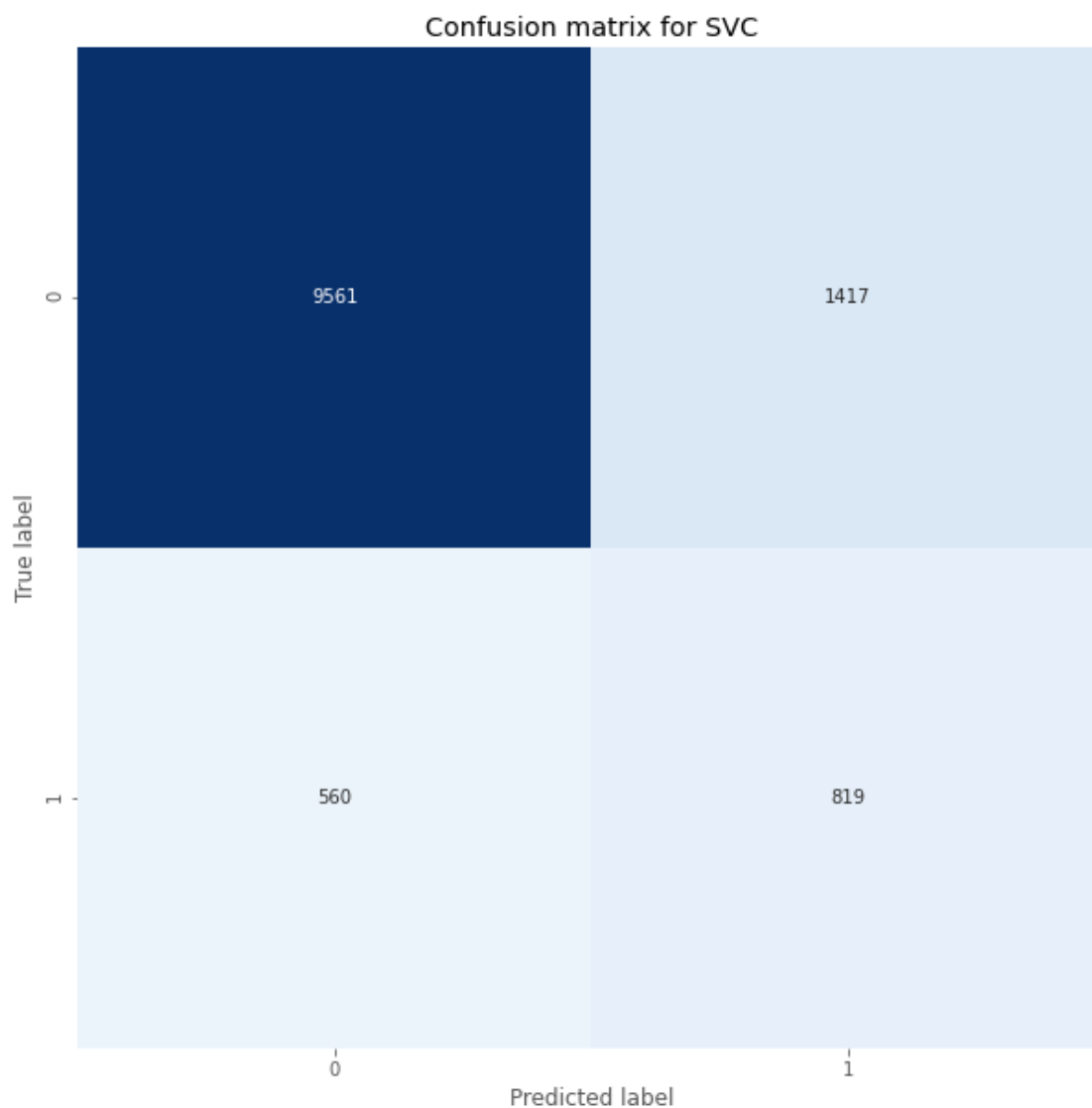
Results for SVC:

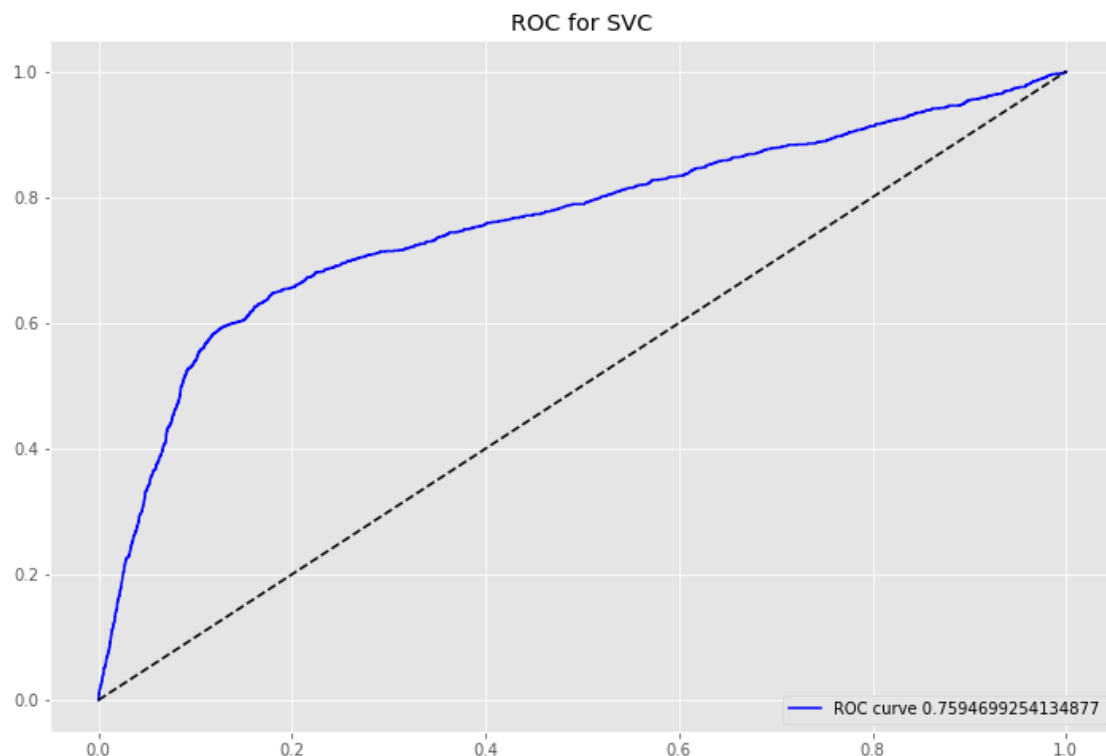
SVC accuracy: 0.84

SVC f-score: 0.4531

SVC recall: 0.5939

SVC log\_loss: 0.2892





[131]: Classifier	Accuracy	F-score	Recall	Log_loss
SVC	0.8400	0.4531	0.5939	0.2892
SVC SMOTETomek	0.8334	0.4428	0.5932	0.5159
Logistic Regression under Sample	0.8104	0.4185	0.6113	0.5306
Logistic Regression SMOTE	0.8087	0.4172	0.6135	0.5299
Logistic Regression SMOTETomek	0.8059	0.4159	0.6193	0.5296
Logistic Regression SMOTETomek PCA	0.7871	0.3961	0.6258	0.5589
Random Forest TomekLinks	0.8780	0.3770	0.3307	1.5218
Random Forest SMOTETomek PCA	0.8347	0.3614	0.4191	1.8288
Random Forest SMOTETomek	0.8572	0.3590	0.3582	1.6882
Random Forest SMOTE	0.8611	0.3554	0.3430	1.7068
Random Forest	0.8787	0.3457	0.2872	1.0826
Logistic Regression TomekLinks	0.8948	0.3428	0.2458	0.2860
Random Forest under Sample	0.7215	0.3348	0.6280	1.8183
Logistic Regression	0.8954	0.2798	0.1820	0.2855

Conclusion:

- SVC model is the best results. As we can see in table, this method has the highest F-score. We receive F1-score about 0.45.
- SVC without resample works better than with resample.

## 2 Summary

During creating of this analysis, we could discover information about correlation, affect to output and thanks to this we could do our model. Now, we may use our model to predict if client has subscribe term deposit base on delivered informations. It helps to bank to reduce number of employees that contact with people (greater precision in selecting customers). Our model is based on SVC. Below, one more time we can see our results for this model.

```
[132]: Classifier  Accuracy  F-score  Recall  Log_loss  
SVC          0.84    0.4531  0.5939    0.2892
```

