Analysis of Bank Telemarketing Data

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Understanding the Data

Client

Age

Job

Marital Status

Education

Credit in Default?

Housing Loan?

Personal Loan?

Last Contact

Mode of Communication

Call duration

Day, Month

Socio-Economic Factors

Quarterly Employment Variation Rate

Monthly Consumer Price Index

Monthly Consumer Confidence Index

Number of Employees

Euribor 3-month rate

Other

Outcome of previous campaign

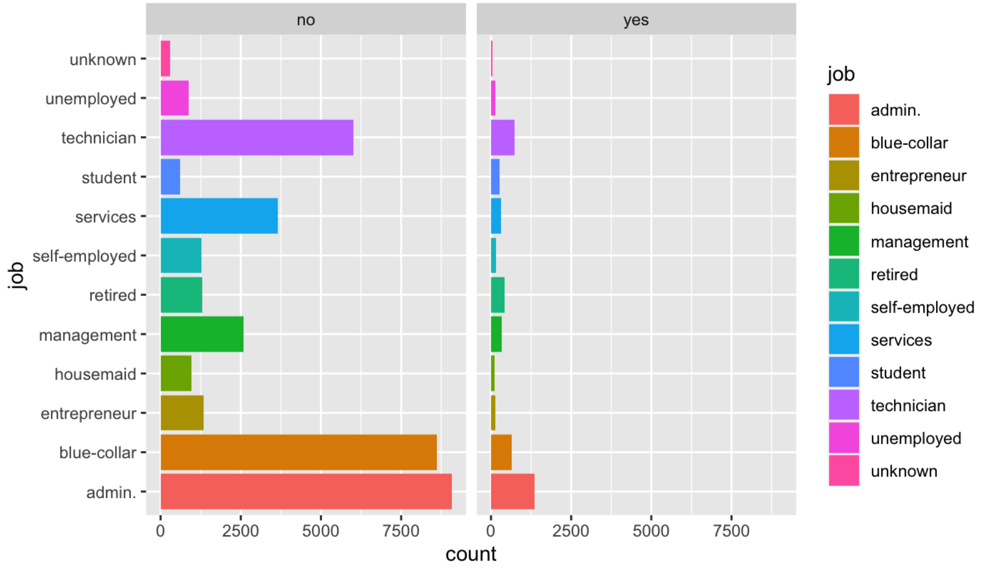
No of previous contacts in the current campaign

GOAL : The goal of the project is to build a classification model to predict if a client is going to subscribe to a term deposit

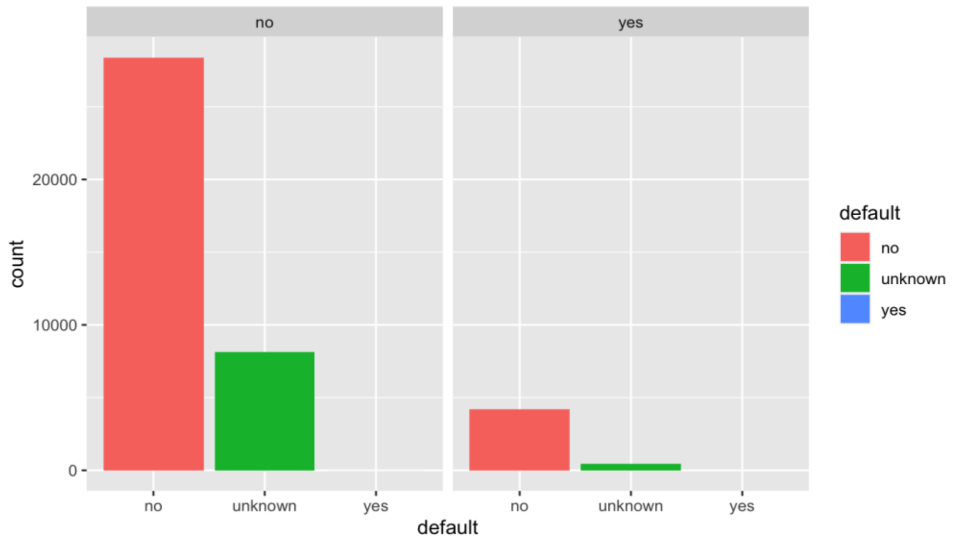
INDUSTRY RELEVANCE : The analysis is helpful in designing strategies to target prospective clients

Exploratory Data Analysis: Client Data

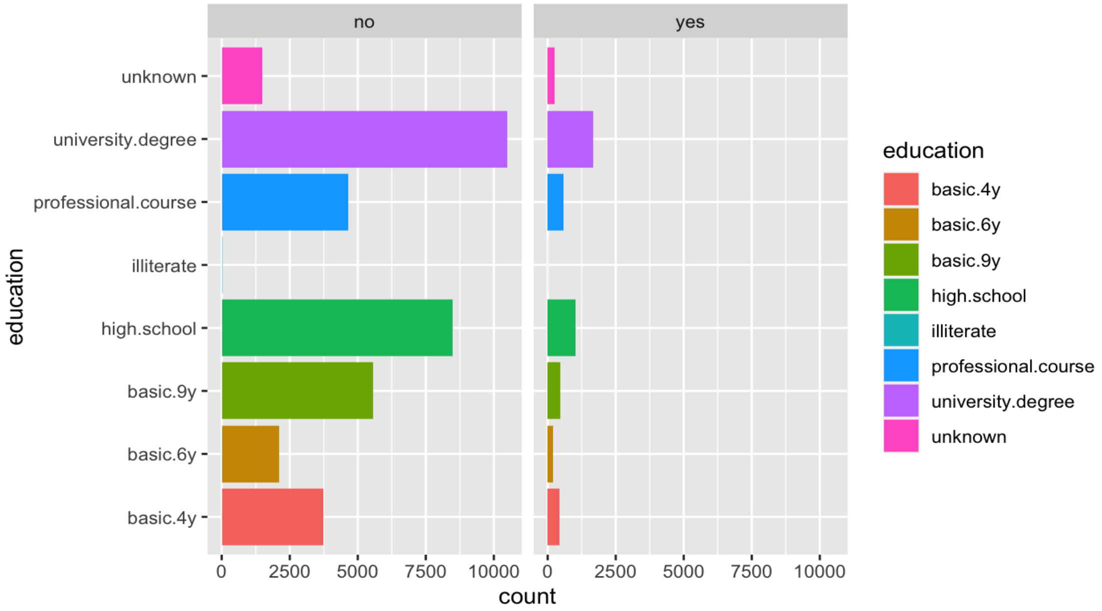
Distribution of jobs



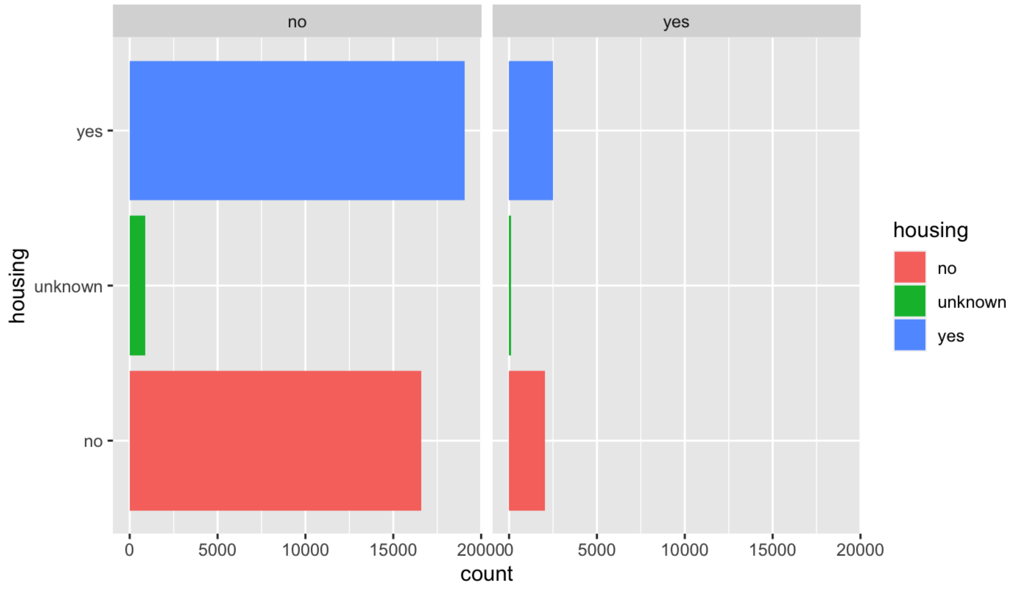
Distribution of defaulters



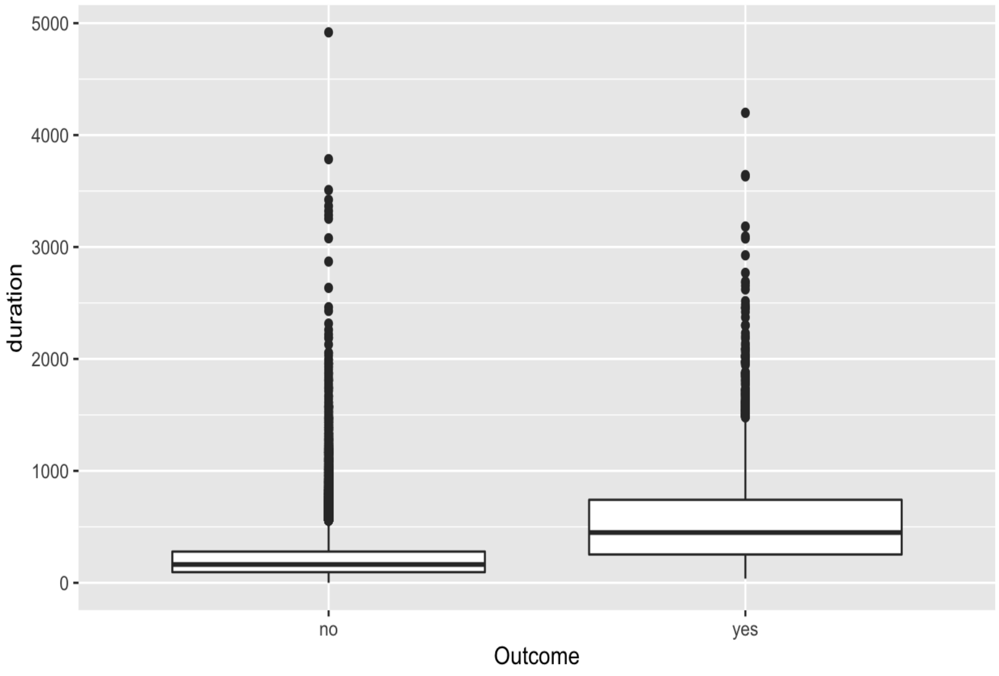
Distribution of education

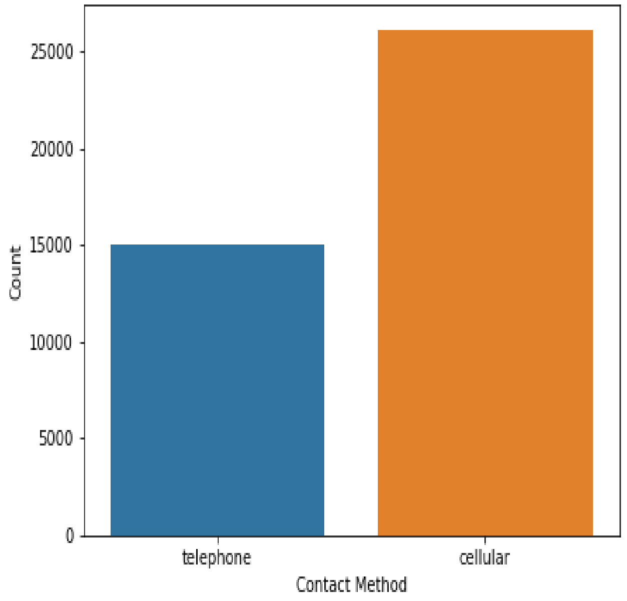


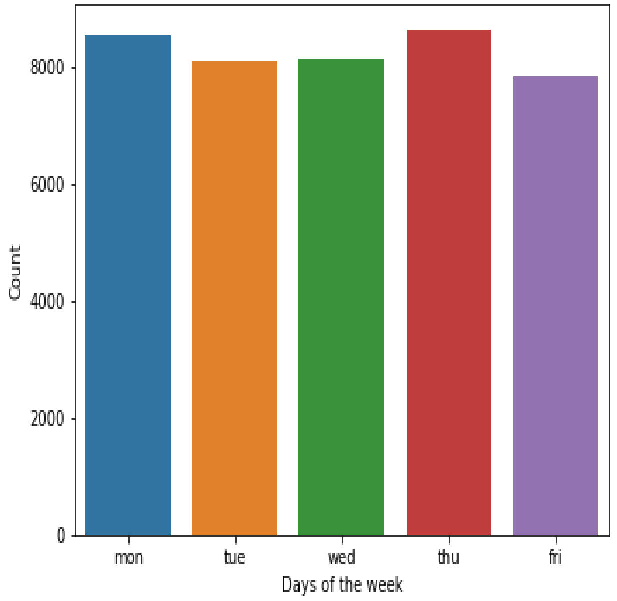
Distribution of clients with housing loans



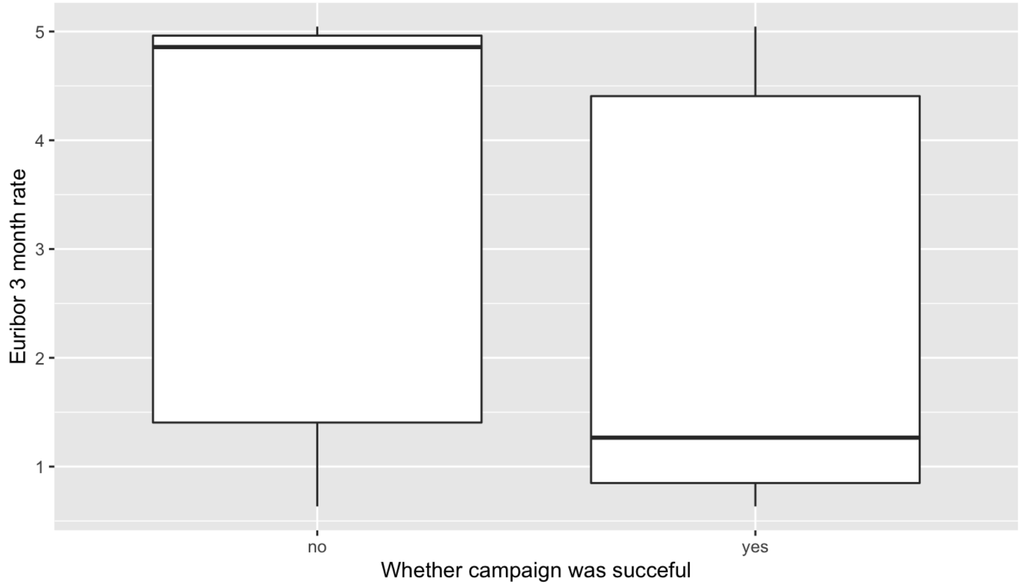
Exploratory Data Analysis: Last Contact Data

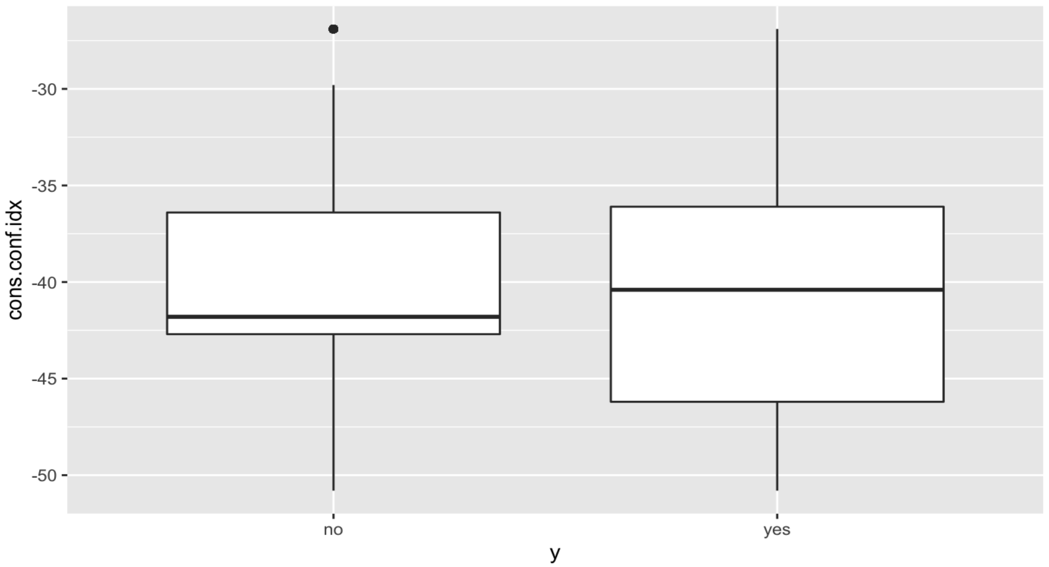

Call duration is higher for positive outcomes

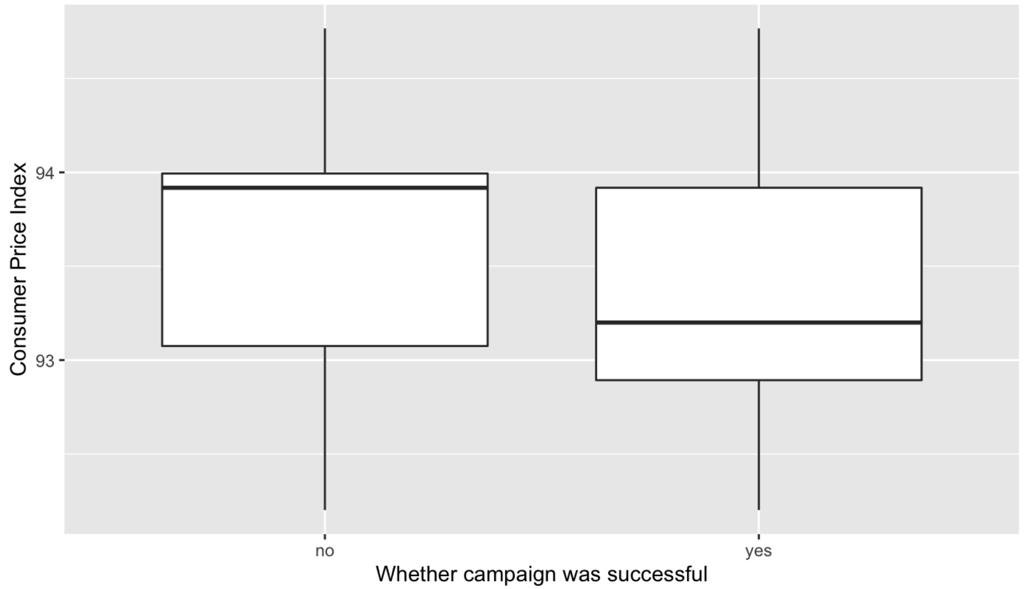

Count of Contact Methods

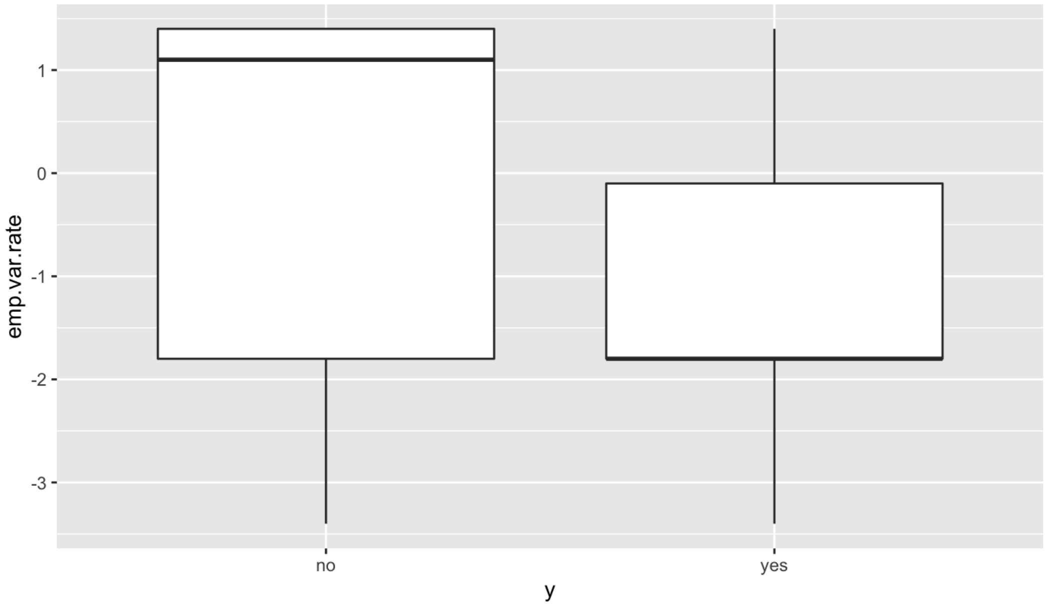

Count of Calls made on Days of the week

Exploratory Data Analysis: Socio-Economic Factors


Outcome is highly dependent on Euribor 3 month rate


Outcome might be dependent on Consumer confidence index


Outcome is dependent on Consumer price index

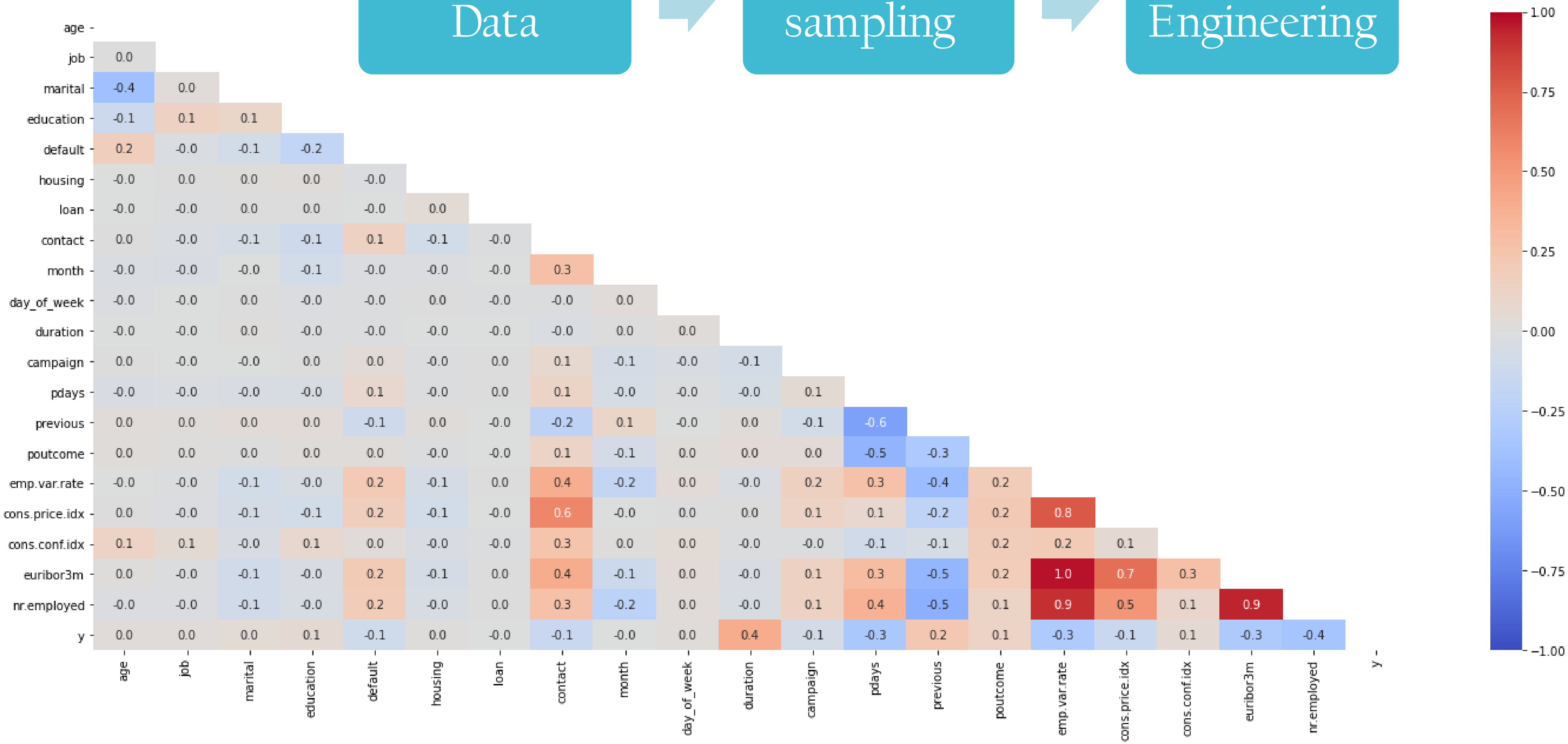

Outcome is highly dependent on Employment Variation Rate

Conclusions drawn from EDA

- Socio-economic factors highly influence the outcome. There might be possible correlation between these variables that needs to be checked.
- Client Data like education, job, marital status etc. does not influence the outcome.
- Call duration influences the outcome. The duration is higher for people who subscribed to the term deposit.

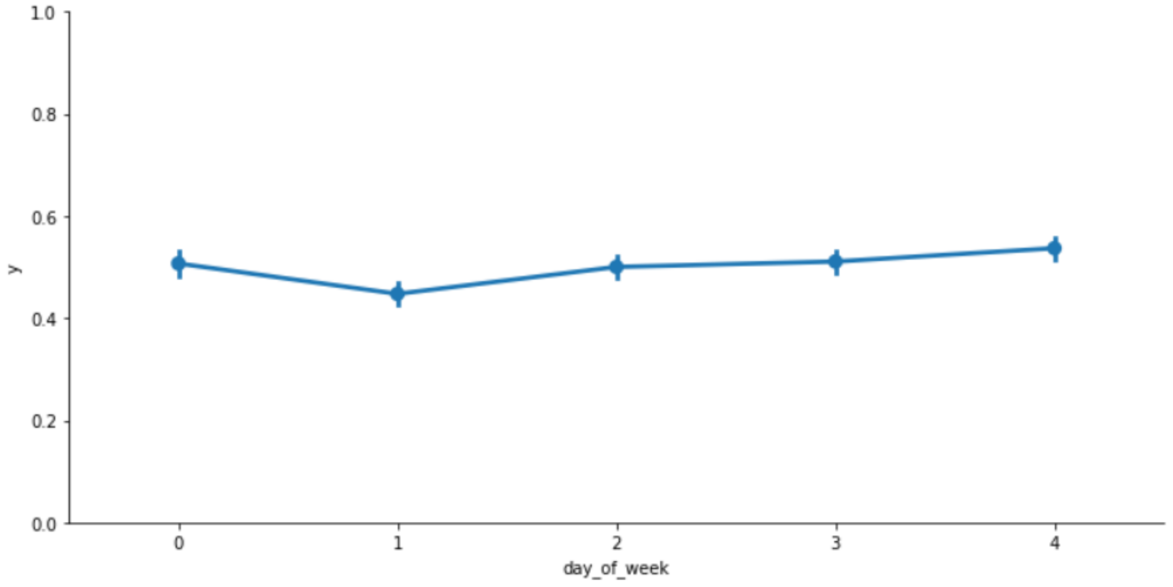
Feature Engineering

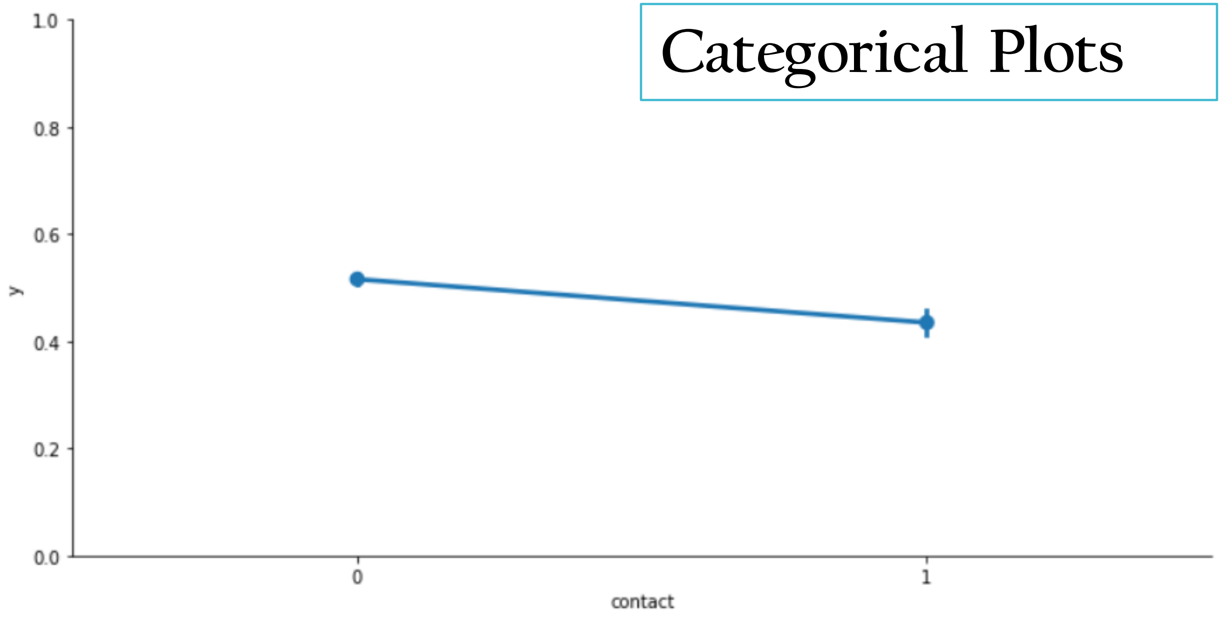
Imbalanced Data → Under-sampling → Feature Engineering

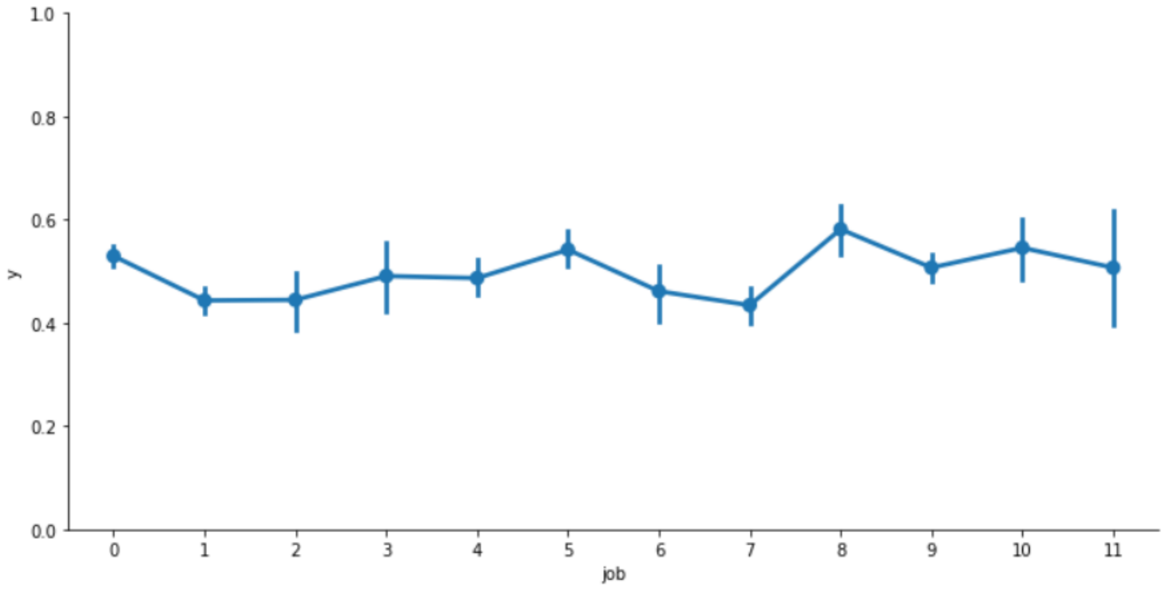


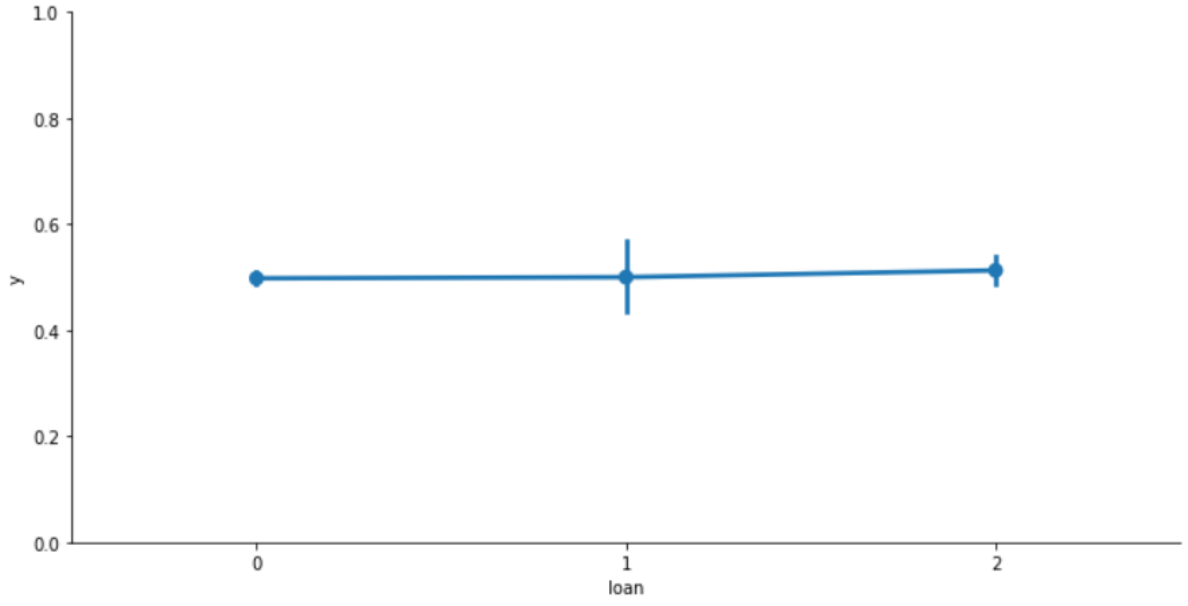
	age	job	marital	education	default	housing	loan	contact	month	day_of_week	duration	campaign	pdays	previous	poutcome	emp.var.rate	cons.price.idx	cons.conf.idx	euribor3m	nr.employed	y
age																					
job	0.0																				
marital	-0.4	0.0																			
education	-0.1	0.1	0.1																		
default	0.2	-0.0	-0.1	-0.2																	
housing	-0.0	0.0	0.0	0.0	-0.0																
loan	-0.0	-0.0	0.0	0.0	-0.0	0.0															
contact	0.0	-0.0	-0.1	-0.1	0.1	-0.1	-0.0														
month	-0.0	-0.0	-0.0	-0.1	-0.0	-0.0	-0.0	0.3													
day_of_week	-0.0	-0.0	0.0	-0.0	-0.0	0.0	-0.0	-0.0	0.0												
duration	-0.0	-0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0	0.0	0.0											
campaign	0.0	-0.0	-0.0	0.0	0.0	-0.0	0.0	0.1	-0.1	-0.0	-0.1										
pdays	-0.0	-0.0	-0.0	-0.0	0.1	-0.0	0.0	0.1	-0.0	-0.0	-0.0	0.1									
previous	0.0	0.0	0.0	0.0	-0.1	0.0	-0.0	-0.2	0.1	-0.0	0.0	-0.1	-0.6								
poutcome	0.0	0.0	0.0	0.0	0.0	-0.0	-0.0	0.1	-0.1	0.0	0.0	0.0	-0.5	-0.3							
emp.var.rate	-0.0	-0.0	-0.1	-0.0	0.2	-0.1	0.0	0.4	-0.2	0.0	-0.0	0.2	0.3	-0.4	0.2						
cons.price.idx	0.0	-0.0	-0.1	-0.1	0.2	-0.1	-0.0	0.6	-0.0	0.0	0.0	0.1	0.1	-0.2	0.2	0.8					
cons.conf.idx	0.1	0.1	-0.0	0.1	0.0	-0.0	-0.0	0.3	0.0	0.0	-0.0	-0.0	-0.1	-0.1	0.2	0.2	0.1				
euribor3m	0.0	-0.0	-0.1	-0.0	0.2	-0.1	0.0	0.4	-0.1	0.0	-0.0	0.1	0.3	-0.5	0.2	1.0	0.7	0.3			
nr.employed	-0.0	-0.0	-0.1	-0.0	0.2	-0.0	0.0	0.3	-0.2	0.0	-0.0	0.1	0.4	-0.5	0.1	0.9	0.5	0.1	0.9		
y	0.0	0.0	0.0	0.1	-0.1	0.0	-0.0	-0.1	-0.0	0.0	0.4	-0.1	-0.3	0.2	0.1	-0.3	-0.1	0.1	-0.3	-0.4	

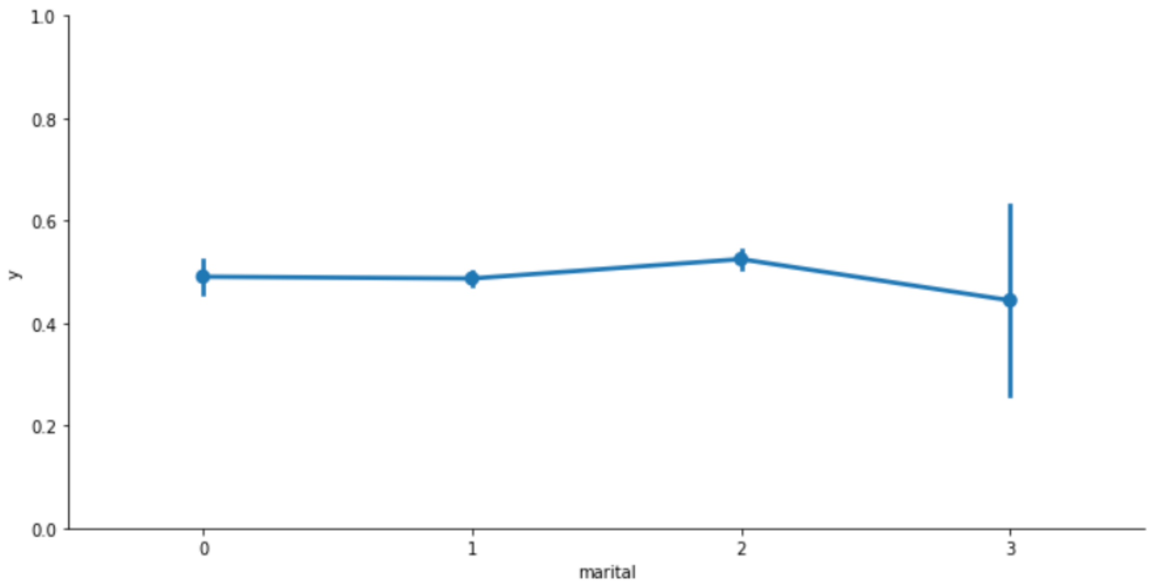
Categorical Plots

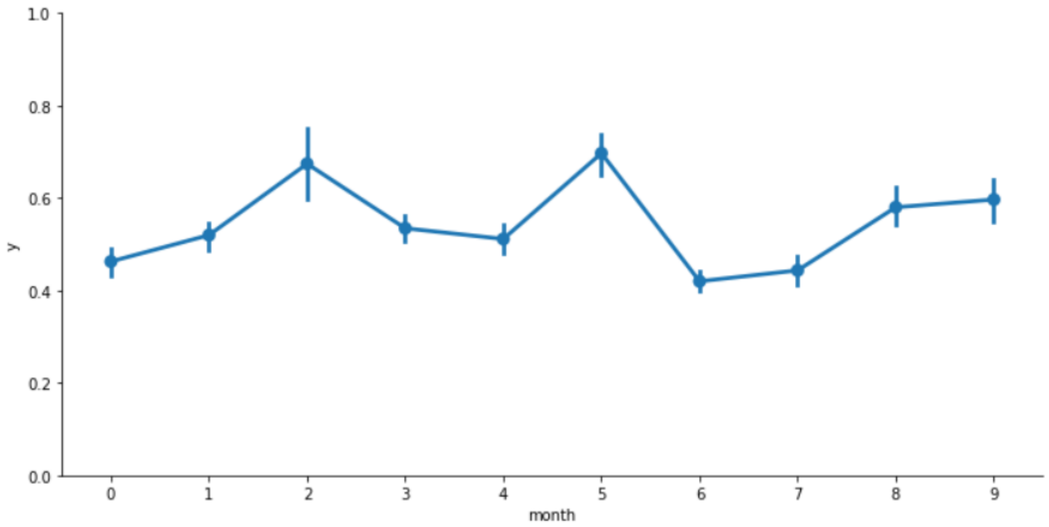


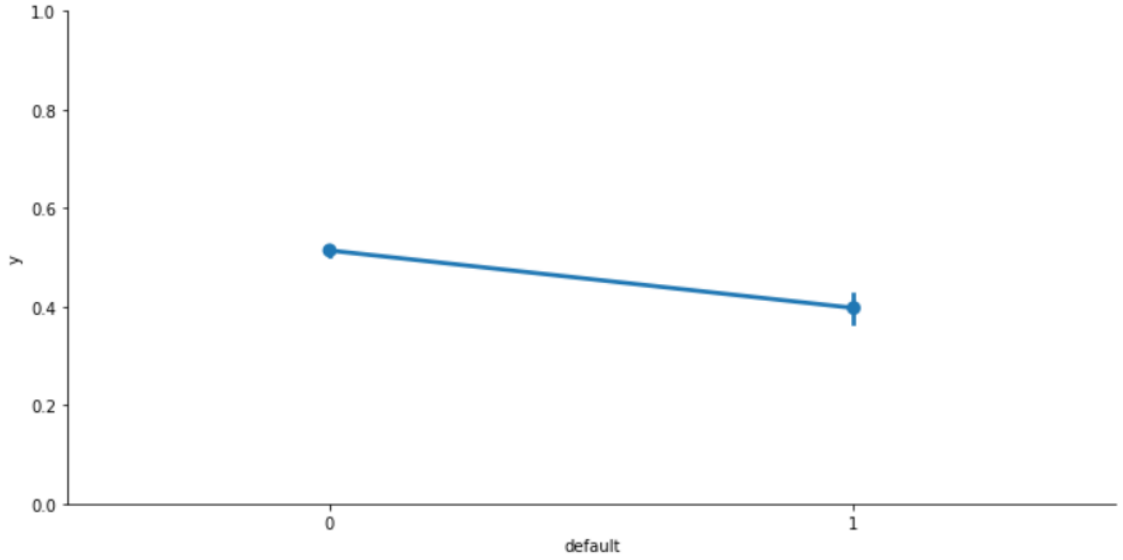


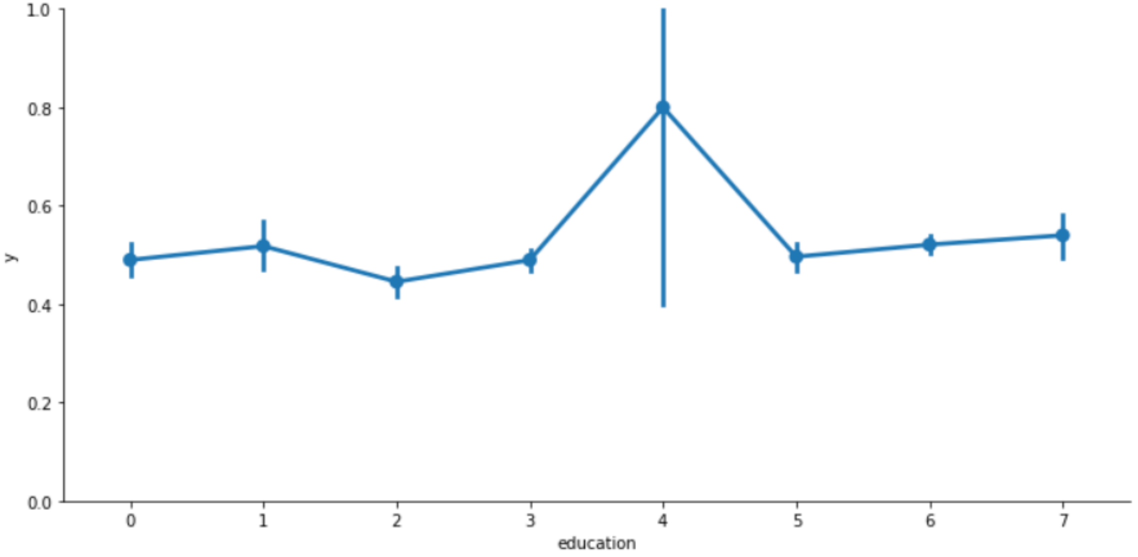





1.0
0.8
0.6
0.4
0.2
0.0
y
0
1
2
3
marital


1.0
0.8
0.6
0.4
0.2
0.0
y
0
1
2
3
4
5
6
7
8
9
month


1.0
0.8
0.6
0.4
0.2
0.0
y
0
1
default


1.0
0.8
0.6
0.4
0.2
0.0
y
0
1
2
3
4
5
6
7
education

Statistical Significance Test:

We performed Statistical significance test for every feature with the output to see if a feature is statistically significant with output.

Feature	P-Value
Age	0.551
Job	0.495
Marital	0.00604
Education	0.000896
Default	2.47e-13
Housing	0.719
Loan	0.319
Contact	6.08e-10
Month	0.839
Day of Week	0.000613
Duration	4.38e-19
Campaign	0.466
pdays	2.25e-66
previous	2.04e-19
poutcome	1.37e-56
Emp.var.rate	1.09e-10
Cons.price.idx	8.1e-05
Cons.conf.idx	1.83e-05
Euribor3m	1.24e-19
Nr.employed	3.27e-38

Conclusion After Feature Engineering

- **Duration, pdays, emp.var.rate, euribor3m and nr.employed** have good correlation with output therefore they might form a very good features compared to others.
- There is high correlation between the socio-economic variables.
- From categorical plot we can see that when value of **poutcome(Previous campaign outcome)** is success, there is 72.5% positive outcome.
- **Age, housing, month and campaign** have p-value greater than 0.05 therefore we can eliminate them as they fail to reject null hypothesis.

Models and Evaluation Metrics

Models Implemented:

Logistic Regression
Support Vector Classifier
K Nearest Neighbours
Random Forest Classifier

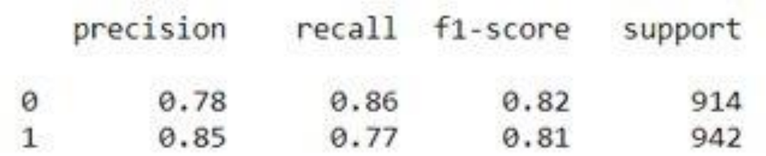
		True Class	
		Positive	Negative
Predicted Class	Positive	TP	FP
	Negative	FN	TN

Since the problem we are trying to solve is a classification problem, we generated a confusion matrix to calculate F1 score to compare models

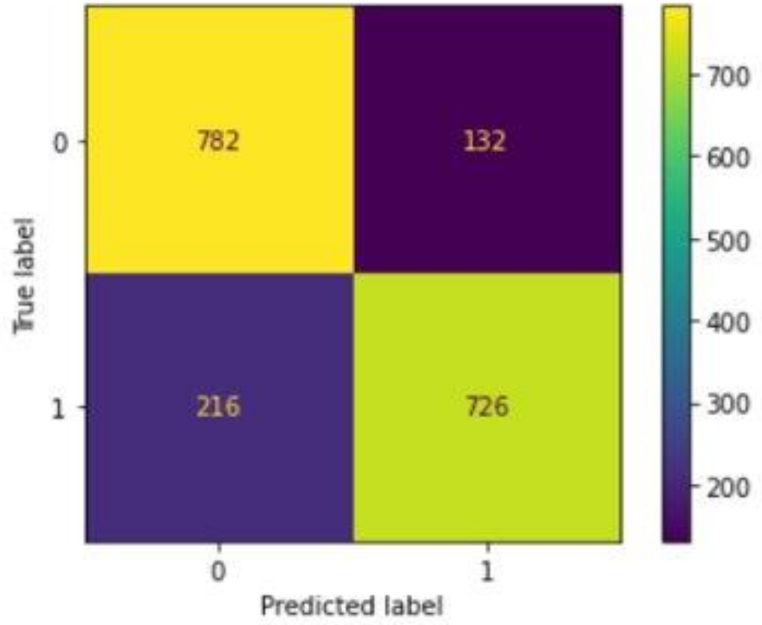
$$\text{F1 Score} = \frac{2 \text{ x (Precision x Recall)}}{\text{Precision + Recall}}$$

Logistic Regression

The accuracy for this model is: 81.25%

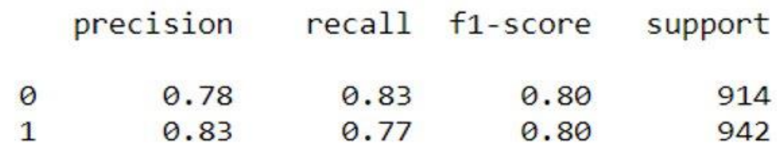


```
     precision    recall  f1-score   support

0         0.78      0.86      0.82       914
1         0.85      0.77      0.81       942
```

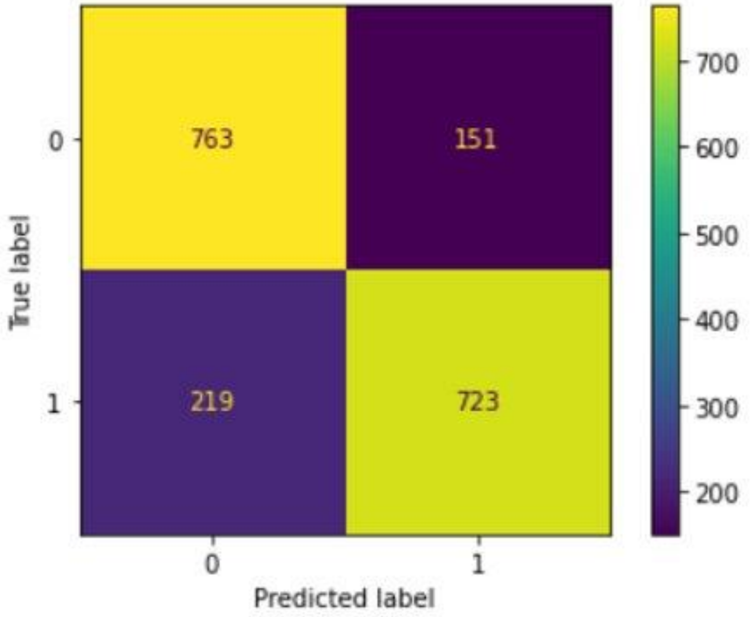


Support Vector Classifier

The accuracy for this model is: 80.06%

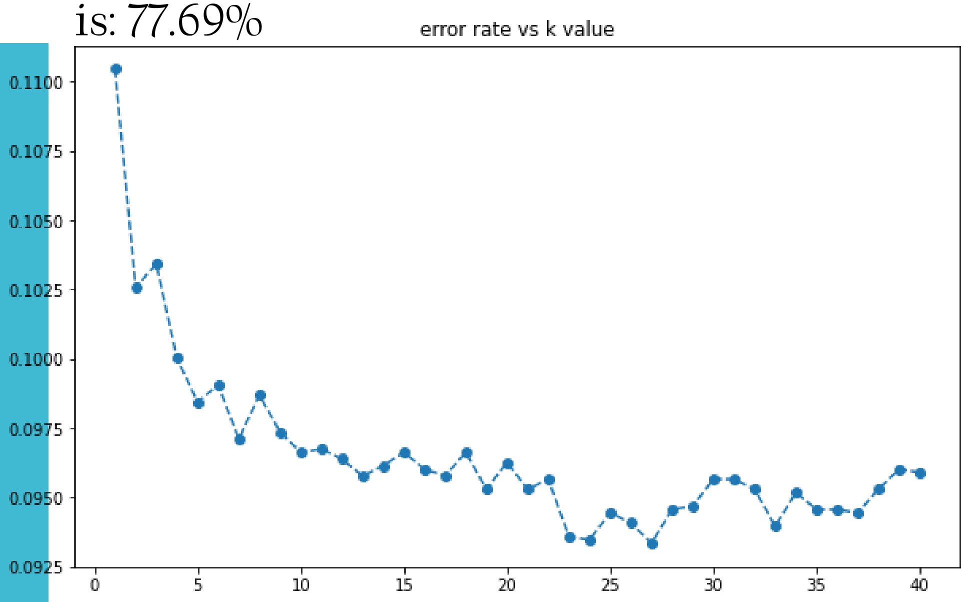


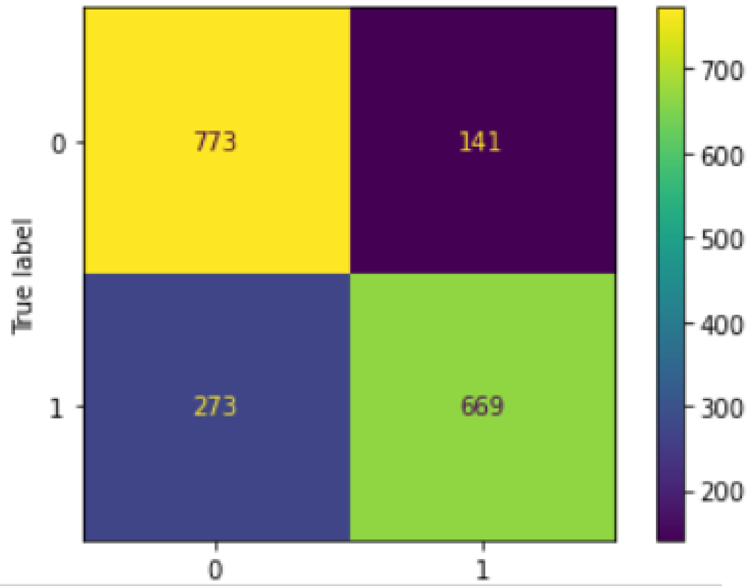
```
     precision    recall  f1-score   support

0         0.78      0.83      0.80       914
1         0.83      0.77      0.80       942
```

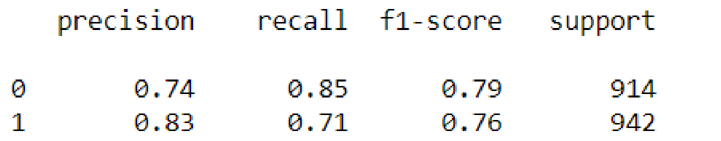


K- Nearest Neighbors (k=27)

The accuracy of this model is: 77.69%



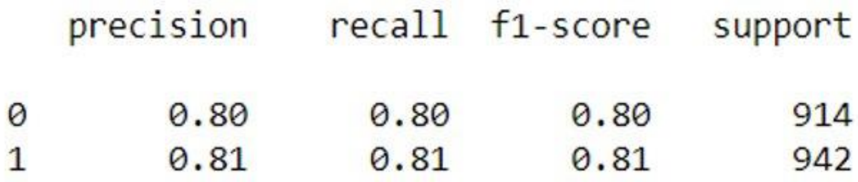




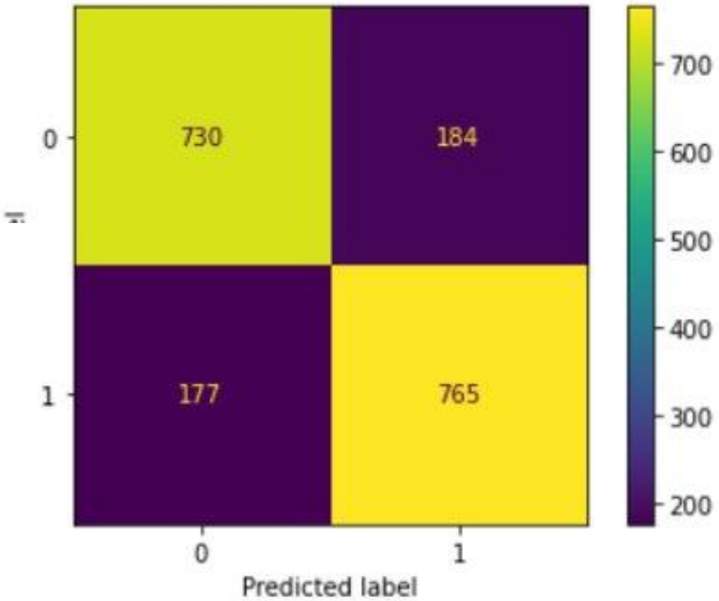
```
          precision    recall  f1-score   support

0              0.74      0.85      0.79       914
1              0.83      0.71      0.76       942
```

Random Forest Classifier

The accuracy for this model is: 80.54%



```
      precision    recall  f1-score    support

0          0.80      0.80      0.80        914
1          0.81      0.81      0.81        942
```



Conclusion after Machine Learning

- Using our evaluation metrics, we can conclude that the logistic regression model was the best fit model on our data set giving an overall F1 score of 0.82

- Questions?