In [1]:

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import scipy.stats as stats
import warnings
import statsmodels.api as sm
from sklearn.linear_model import LinearRegression
from sklearn.linear_model import Ridge
from sklearn.linear_model import Lasso
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import minmax_scale
from sklearn.preprocessing import StandardScaler
from sklearn.metrics import r2_score,accuracy_score,classification_report,precision_recall_curve,roc_auc_score,roc_curve,precision_recall_
from sklearn import metrics
from statsmodels.stats.outliers_influence import variance_inflation_factor
from sklearn.model_selection import GridSearchCV
from category_encoders import TargetEncoder
from sklearn.linear_model import LogisticRegression
from sklearn.impute import KNNImputer
from imblearn.over_sampling import SMOTE
from sklearn.ensemble import RandomForestClassifier as RFC
from sklearn.model_selection import RandomizedSearchCV
from sklearn.ensemble import GradientBoostingClassifier as GBC
from sklearn.tree import DecisionTreeClassifier as DTC
```

Import Dataset

In [2]:

```
df = pd.read_csv('ola_driver_scaler.csv')
```

In [3]:

```
df.head()
```

Out[3]:

	Unnamed: 0	MMM-YY	Driver_ID	Age	Gender	City	Education_Level	Income	Dateofjoining	LastWorkingDate	Joining Designation	Grade	Total Business Value	Quarterly Rating
0	0	01/01/19	1	28.0	0.0	C23	2	57387	24/12/18	NaN	1	1	2381060	2
1	1	02/01/19	1	28.0	0.0	C23	2	57387	24/12/18	NaN	1	1	-665480	2
2	2	03/01/19	1	28.0	0.0	C23	2	57387	24/12/18	03/11/19	1	1	0	2
3	3	11/01/20	2	31.0	0.0	C7	2	67016	11/06/20	NaN	2	2	0	1
4	4	12/01/20	2	31.0	0.0	C7	2	67016	11/06/20	NaN	2	2	0	1

In [4]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 19104 entries, 0 to 19103
Data columns (total 14 columns):
 #   Column                Non-Null Count  Dtype  
---  ------                --------------  -----  
 0   Unnamed: 0            19104 non-null  int64  
 1   MMM-YY                19104 non-null  object 
 2   Driver_ID             19104 non-null  int64  
 3   Age                   19043 non-null  float64
 4   Gender                19052 non-null  float64
 5   City                  19104 non-null  object 
 6   Education_Level       19104 non-null  int64  
 7   Income                19104 non-null  int64  
 8   Dateofjoining         19104 non-null  object 
 9   LastWorkingDate       1616 non-null   object 
 10  Joining Designation   19104 non-null  int64  
 11  Grade                 19104 non-null  int64  
 12  Total Business Value  19104 non-null  int64  
 13  Quarterly Rating      19104 non-null  int64  
dtypes: float64(2), int64(8), object(4)
memory usage: 2.0+ MB
```

In [5]:

```
df.describe().T
```

Out[5]:

	count	mean	std	min	25%	50%	75%	max
Unnamed: 0	19104.0	9551.500000	5.514994e+03	0.0	4775.75	9551.5	14327.25	19103.0
Driver_ID	19104.0	1415.591133	8.107053e+02	1.0	710.00	1417.0	2137.00	2788.0
Age	19043.0	34.668435	6.257912e+00	21.0	30.00	34.0	39.00	58.0
Gender	19052.0	0.418749	4.933670e-01	0.0	0.00	0.0	1.00	1.0
Education_Level	19104.0	1.021671	8.001671e-01	0.0	0.00	1.0	2.00	2.0
Income	19104.0	65652.025126	3.091452e+04	10747.0	42383.00	60087.0	83969.00	188418.0
Joining Designation	19104.0	1.690536	8.369837e-01	1.0	1.00	1.0	2.00	5.0
Grade	19104.0	2.252670	1.026512e+00	1.0	1.00	2.0	3.00	5.0
Total Business Value	19104.0	571662.074958	1.128312e+06	-6000000.0	0.00	250000.0	699700.00	33747720.0
Quarterly Rating	19104.0	2.008899	1.009832e+00	1.0	1.00	2.0	3.00	4.0

```
Unique values in each feaure
```

In [6]:

```
for i in df.columns:
    print(i,df[i].nunique())
```

```
Unnamed: 0 19104
MMM-YY 24
Driver_ID 2381
Age 36
Gender 2
City 29
Education_Level 3
Income 2383
Dateofjoining 869
LastWorkingDate 493
Joining Designation 5
Grade 5
Total Business Value 10181
Quarterly Rating 4
```

```
dropping useless feature
```

In [7]:

```
df.drop(['Unnamed: 0'],axis = 1, inplace = True)
```

In [8]:

```
df.head(10)
```

Out[8]:

	MMM-YY	Driver_ID	Age	Gender	City	Education_Level	Income	Dateofjoining	LastWorkingDate	Joining Designation	Grade	Total Business Value	Quarterly Rating
0	01/01/19	1	28.0	0.0	C23	2	57387	24/12/18	NaN	1	1	2381060	2
1	02/01/19	1	28.0	0.0	C23	2	57387	24/12/18	NaN	1	1	-665480	2
2	03/01/19	1	28.0	0.0	C23	2	57387	24/12/18	03/11/19	1	1	0	2
3	11/01/20	2	31.0	0.0	C7	2	67016	11/06/20	NaN	2	2	0	1
4	12/01/20	2	31.0	0.0	C7	2	67016	11/06/20	NaN	2	2	0	1
5	12/01/19	4	43.0	0.0	C13	2	65603	12/07/19	NaN	2	2	0	1
6	01/01/20	4	43.0	0.0	C13	2	65603	12/07/19	NaN	2	2	0	1
7	02/01/20	4	43.0	0.0	C13	2	65603	12/07/19	NaN	2	2	0	1
8	03/01/20	4	43.0	0.0	C13	2	65603	12/07/19	NaN	2	2	350000	1
9	04/01/20	4	43.0	0.0	C13	2	65603	12/07/19	27/04/20	2	2	0	1

```
Interpreting the target feature
```

In [9]:

```
df['churn'] = df['LastWorkingDate'].fillna(0)
```

In [10]:

```
df['churn'] =[1 if x != 0 else x for x in df['churn']]
```

In [11]:

```
df.head()
```

Out[11]:

	MMM-YY	Driver_ID	Age	Gender	City	Education_Level	Income	Dateofjoining	LastWorkingDate	Joining Designation	Grade	Total Business Value	Quarterly Rating	churn
0	01/01/19	1	28.0	0.0	C23	2	57387	24/12/18	NaN	1	1	2381060	2	0
1	02/01/19	1	28.0	0.0	C23	2	57387	24/12/18	NaN	1	1	-665480	2	0
2	03/01/19	1	28.0	0.0	C23	2	57387	24/12/18	03/11/19	1	1	0	2	1
3	11/01/20	2	31.0	0.0	C7	2	67016	11/06/20	NaN	2	2	0	1	0
4	12/01/20	2	31.0	0.0	C7	2	67016	11/06/20	NaN	2	2	0	1	0

Categorical columns

In [12]:

```
cat_col =[]
con_col =[]
for i in df.columns:
    if df[i].nunique() < 40:
        cat_col.append(i)
    else:
        con_col.append(i)
```

In [13]:

```
cat_col
```

Out[13]:

```
['MMM-YY',
 'Age',
 'Gender',
 'City',
 'Education_Level',
 'Joining Designation',
 'Grade',
 'Quarterly Rating',
 'churn']
```

In [14]:

```
for i in df.columns:
    print(i,df[i].nunique())
```

```
MMM-YY 24
Driver_ID 2381
Age 36
Gender 2
City 29
Education_Level 3
Income 2383
Dateofjoining 869
LastWorkingDate 493
Joining Designation 5
Grade 5
Total Business Value 10181
Quarterly Rating 4
churn 2
```

Converting the datatypes

In [15]:

```
df['MMM-YY']=df['MMM-YY'].astype('datetime64[ns]')
```

In [16]:

```
df['Dateofjoining'] = df['Dateofjoining'].astype('datetime64[ns]')
df['LastWorkingDate'] = df['LastWorkingDate'].astype('datetime64[ns]')
```

In [17]:

```
df['MMM-YY'].nunique()
```

Out[17]:

```
24
```

In [18]:

```
df['month'] = df['MMM-YY'].dt.month
```

In [19]:

```
df['year'] = df['MMM-YY'].dt.year
```

In [20]:

```
df.head()
```

Out[20]:

	MMM-YY	Driver_ID	Age	Gender	City	Education_Level	Income	Dateofjoining	LastWorkingDate	Joining Designation	Grade	Total Business Value	Quarterly Rating	churn	montl
0	2019-01-01	1	28.0	0.0	C23	2	57387	2018-12-24	NaT	1	1	2381060	2	0	
1	2019-02-01	1	28.0	0.0	C23	2	57387	2018-12-24	NaT	1	1	-665480	2	0	2
2	2019-03-01	1	28.0	0.0	C23	2	57387	2018-12-24	2019-03-11	1	1	0	2	1	3
3	2020-11-01	2	31.0	0.0	C7	2	67016	2020-11-06	NaT	2	2	0	1	0	1
4	2020-12-01	2	31.0	0.0	C7	2	67016	2020-11-06	NaT	2	2	0	1	0	1

Imputation for missing values using target encoding

In [21]:

```
te = TargetEncoder()
```

```
C:\ProgramData\Anaconda3\lib\site-packages\category_encoders\target_encoder.py:92: FutureWarning: Default parameter min_sam
ples_leaf will change in version 2.6.See https://github.com/scikit-learn-contrib/category_encoders/issues/327 (https://gith
ub.com/scikit-learn-contrib/category_encoders/issues/327)
  warnings.warn("Default parameter min_samples_leaf will change in version 2.6."
C:\ProgramData\Anaconda3\lib\site-packages\category_encoders\target_encoder.py:97: FutureWarning: Default parameter smoothi
ng will change in version 2.6.See https://github.com/scikit-learn-contrib/category_encoders/issues/327 (https://github.com/
scikit-learn-contrib/category_encoders/issues/327)
  warnings.warn("Default parameter smoothing will change in version 2.6."
```

In [22]:

```
te.fit(df['City'],df['churn'])
df['City']=te.transform(df['City'])
```

In [23]:

```
df.head()
```

Out[23]:

	MMM-YY	Driver_ID	Age	Gender	City	Education_Level	Income	Dateofjoining	LastWorkingDate	Joining Designation	Grade	Total Business Value	Quarterly Rating	churn	r
0	2019-01-01	1	28.0	0.0	0.105948	2	57387	2018-12-24	NaT	1	1	2381060	2	0	
1	2019-02-01	1	28.0	0.0	0.105948	2	57387	2018-12-24	NaT	1	1	-665480	2	0	
2	2019-03-01	1	28.0	0.0	0.105948	2	57387	2018-12-24	2019-03-11	1	1	0	2	1	
3	2020-11-01	2	31.0	0.0	0.085386	2	67016	2020-11-06	NaT	2	2	0	1	0	
4	2020-12-01	2	31.0	0.0	0.085386	2	67016	2020-11-06	NaT	2	2	0	1	0	

In [24]:

```
# df.drop('MMM-YY',axis = 1,inplace = True)
```

In [25]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 19104 entries, 0 to 19103
Data columns (total 16 columns):
 #   Column                Non-Null Count  Dtype         
---  ------                --------------  -----         
 0   MMM-YY                19104 non-null  datetime64[ns]
 1   Driver_ID             19104 non-null  int64         
 2   Age                   19043 non-null  float64       
 3   Gender                19052 non-null  float64       
 4   City                  19104 non-null  float64       
 5   Education_Level       19104 non-null  int64         
 6   Income                19104 non-null  int64         
 7   Dateofjoining         19104 non-null  datetime64[ns]
 8   LastWorkingDate       1616 non-null   datetime64[ns]
 9   Joining Designation   19104 non-null  int64         
 10  Grade                 19104 non-null  int64         
 11  Total Business Value  19104 non-null  int64         
 12  Quarterly Rating      19104 non-null  int64         
 13  churn                 19104 non-null  int64         
 14  month                 19104 non-null  int64         
 15  year                  19104 non-null  int64         
dtypes: datetime64[ns](3), float64(3), int64(10)
memory usage: 2.3 MB
```

In [26]:

```
knnImputer = KNNImputer(n_neighbors=3)
```

In [27]:

```
x=np.array(df['Age']).reshape(-1,1)
```

In [28]:

```
x=knnImputer.fit_transform(x)
```

In [29]:

```
x=pd.DataFrame(x)
x.isna().sum()
```

Out[29]:

```
0    0
dtype: int64
```

In [30]:

```
# df = df.drop('Age',inplace = True,axis =1)
```

In [31]:

```
type(x)
```

Out[31]:

```
pandas.core.frame.DataFrame
```

In [32]:

```
df['Age']=x[0]
```

In [33]:

```
df
```

Out[33]:

	MMM-YY	Driver_ID	Age	Gender	City	Education_Level	Income	Dateofjoining	LastWorkingDate	Joining Designation	Grade	Total Business Value	Quarterly Rating	chu
0	2019-01-01	1	28.0	0.0	0.105948	2	57387	2018-12-24	NaT	1	1	2381060	2	
1	2019-02-01	1	28.0	0.0	0.105948	2	57387	2018-12-24	NaT	1	1	-665480	2	
2	2019-03-01	1	28.0	0.0	0.105948	2	57387	2018-12-24	2019-03-11	1	1	0	2	
3	2020-11-01	2	31.0	0.0	0.085386	2	67016	2020-11-06	NaT	2	2	0	1	
4	2020-12-01	2	31.0	0.0	0.085386	2	67016	2020-11-06	NaT	2	2	0	1	
...	...	...	...	...	...	...	...	...	...	...	...	...	...	
19099	2020-08-01	2788	30.0	0.0	0.076336	2	70254	2020-06-08	NaT	2	2	740280	3	
19100	2020-09-01	2788	30.0	0.0	0.076336	2	70254	2020-06-08	NaT	2	2	448370	3	
19101	2020-10-01	2788	30.0	0.0	0.076336	2	70254	2020-06-08	NaT	2	2	0	2	
19102	2020-11-01	2788	30.0	0.0	0.076336	2	70254	2020-06-08	NaT	2	2	200420	2	
19103	2020-12-01	2788	30.0	0.0	0.076336	2	70254	2020-06-08	NaT	2	2	411480	2	

19104 rows × 16 columns

Checking for null values

In [34]:

```
np.round(df.isna().sum()/len(df)*100,2)
```

Out[34]:

```
MMM-YY                  0.00
Driver_ID               0.00
Age                     0.00
Gender                  0.27
City                    0.00
Education_Level         0.00
Income                  0.00
Dateofjoining           0.00
LastWorkingDate        91.54
Joining Designation     0.00
Grade                   0.00
Total Business Value    0.00
Quarterly Rating        0.00
churn                   0.00
month                   0.00
year                    0.00
dtype: float64
```

In [35]:

```
df.shape
```

Out[35]:

```
(19104, 16)
```

dropping missing values for gender

In [36]:

```
df['Gender'].dropna(inplace=True,axis = 0)
```

In [37]:

```
df = df[df['Gender'].notna()]
```

In [38]:

```
df.shape
```

Out[38]:

```
(19052, 16)
```

In [39]:

```
df.head()
```

Out[39]:

	MMM-YY	Driver_ID	Age	Gender	City	Education_Level	Income	Dateofjoining	LastWorkingDate	Joining Designation	Grade	Total Business Value	Quarterly Rating	churn	m
0	2019-01-01	1	28.0	0.0	0.105948	2	57387	2018-12-24	NaT	1	1	2381060	2	0	
1	2019-02-01	1	28.0	0.0	0.105948	2	57387	2018-12-24	NaT	1	1	-665480	2	0	
2	2019-03-01	1	28.0	0.0	0.105948	2	57387	2018-12-24	2019-03-11	1	1	0	2	1	
3	2020-11-01	2	31.0	0.0	0.085386	2	67016	2020-11-06	NaT	2	2	0	1	0	
4	2020-12-01	2	31.0	0.0	0.085386	2	67016	2020-11-06	NaT	2	2	0	1	0	

In [40]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 19052 entries, 0 to 19103
Data columns (total 16 columns):
 #   Column                Non-Null Count  Dtype         
---  ------                --------------  -----         
 0   MMM-YY                19052 non-null  datetime64[ns]
 1   Driver_ID             19052 non-null  int64         
 2   Age                   19052 non-null  float64       
 3   Gender                19052 non-null  float64       
 4   City                  19052 non-null  float64       
 5   Education_Level       19052 non-null  int64         
 6   Income                19052 non-null  int64         
 7   Dateofjoining         19052 non-null  datetime64[ns]
 8   LastWorkingDate       1611 non-null   datetime64[ns]
 9   Joining Designation   19052 non-null  int64         
 10  Grade                 19052 non-null  int64         
 11  Total Business Value  19052 non-null  int64         
 12  Quarterly Rating      19052 non-null  int64         
 13  churn                 19052 non-null  int64         
 14  month                 19052 non-null  int64         
 15  year                  19052 non-null  int64         
dtypes: datetime64[ns](3), float64(3), int64(10)
memory usage: 2.5 MB
```

In [41]:

```
df.columns
```

Out[41]:

```
Index(['MMM-YY', 'Driver_ID', 'Age', 'Gender', 'City', 'Education_Level',
       'Income', 'Dateofjoining', 'LastWorkingDate', 'Joining Designation',
       'Grade', 'Total Business Value', 'Quarterly Rating', 'churn', 'month',
       'year'],
      dtype='object')
```

In [42]:

```
grouped_df = df.groupby('Driver_ID').agg(reporting_start_date = ('MMM-YY','min'),
                                         reporting_end_date = ('MMM-YY','max'),
                                         age = ('Age','max'),
                                         gender = ('Gender','max'),
                                         city = ('City','max'),
                                         education = ('Education_Level','max'),
                                         joining_income = ('Income','min'),
                                         current_income =('Income','max'),
                                         joining_date = ('Dateofjoining','min'),
                                         exit_date=('LastWorkingDate','max'),
                                         designation = ('Joining Designation','min'),
                                         initial_grade = ('Grade','min'),
                                         current_grade = ('Grade','max'),
                                         total_bussiness = ('Total Business Value','sum'),
                                         initial_rating = ('Quarterly Rating','min'),
                                         current_rating = ('Quarterly Rating','max'))
```

In [43]:

```
grouped_df['quarterly_rating'] = grouped_df['current_rating']-grouped_df['initial_rating']
```

In [44]:

```
grouped_df['quarterly_rating'] = grouped_df['quarterly_rating'].apply(lambda x: 1 if x>0 else 0)
```

In [45]:

```
grouped_df['income_change'] = grouped_df['current_income']-grouped_df['joining_income']
```

In [46]:

```
grouped_df['income_change'] = grouped_df['income_change'].apply(lambda x: 1 if x>0 else 0)
```

In [47]:

```
grouped_df['income_change'].value_counts()
```

Out[47]:

```
0    2337
1      44
Name: income_change, dtype: int64
```

In [48]:

```
grouped_df['quarterly_rating'].value_counts()
```

Out[48]:

```
0    1278
1    1103
Name: quarterly_rating, dtype: int64
```

In [49]:

```
grouped_df['churn'] = (grouped_df['exit_date']-grouped_df['joining_date']).dt.days
```

In [50]:

```
grouped_df['churn']=np.round(grouped_df['churn']/30,2)
```

In [51]:

```
grouped_df['churn'] = grouped_df['churn'].fillna('0')
```

In [52]:

```
grouped_df['churn'].head()
```

Out[52]:

```
Driver_ID
1    2.57
2       0
4    4.73
5     1.9
6       0
Name: churn, dtype: object
```

In [53]:

```
grouped_df.head()
```

Out[53]:

Driver_ID	reporting_start_date	reporting_end_date	age	gender	city	education	joining_income	current_income	joining_date	exit_date	designation
1	2019-01-01	2019-03-01	28.0	0.0	0.105948	2	57387	57387	2018-12-24	2019-03-11	1
2	2020-11-01	2020-12-01	31.0	0.0	0.085386	2	67016	67016	2020-11-06	NaT	2
4	2019-12-01	2020-04-01	43.0	0.0	0.101933	2	65603	65603	2019-12-07	2020-04-27	2
5	2019-01-01	2019-03-01	29.0	0.0	0.101923	0	46368	46368	2019-01-09	2019-03-07	1
6	2020-08-01	2020-12-01	31.0	1.0	0.096154	1	78728	78728	2020-07-31	NaT	3

In [54]:

```
grouped_df['churn'] = [0 if x is '0' else 1 for x in grouped_df['churn']]
```

```
<>:1: SyntaxWarning: "is" with a literal. Did you mean "=="?
<>:1: SyntaxWarning: "is" with a literal. Did you mean "=="?
C:\Users\Ashok kumar\AppData\Local\Temp\ipykernel_14516\2957724929.py:1: SyntaxWarning: "is" with a literal. Did you mean
"=="?
  grouped_df['churn'] = [0 if x is '0' else 1 for x in grouped_df['churn']]
```

In [55]:

```
grouped_df['churn'].value_counts()
```

Out[55]:

```
1    1611
0     770
Name: churn, dtype: int64
```

In [56]:

```
grouped_df.head(20)
```

Out[56]:

Driver_ID	reporting_start_date	reporting_end_date	age	gender	city	education	joining_income	current_income	joining_date	exit_date	desig
1	2019-01-01	2019-03-01	28.000000	0.0	0.105948	2	57387	57387	2018-12-24	2019-03-11	
2	2020-11-01	2020-12-01	31.000000	0.0	0.085386	2	67016	67016	2020-11-06	NaT	
4	2019-12-01	2020-04-01	43.000000	0.0	0.101933	2	65603	65603	2019-12-07	2020-04-27	
5	2019-01-01	2019-03-01	29.000000	0.0	0.101923	0	46368	46368	2019-01-09	2019-03-07	
6	2020-08-01	2020-12-01	31.000000	1.0	0.096154	1	78728	78728	2020-07-31	NaT	
8	2020-09-01	2020-11-01	34.000000	0.0	0.116525	0	70656	70656	2020-09-19	2020-11-15	
11	2020-12-01	2020-12-01	28.000000	1.0	0.070812	2	42172	42172	2020-12-07	NaT	
12	2019-07-01	2019-12-01	35.000000	0.0	0.105948	2	28116	28116	2019-06-29	2019-12-21	
13	2019-01-01	2020-11-01	31.000000	0.0	0.070812	2	119227	119227	2015-05-28	2020-11-25	
14	2020-10-01	2020-12-01	39.000000	1.0	0.074799	0	19734	19734	2020-10-16	NaT	
16	2019-01-01	2019-02-01	30.000000	1.0	0.105948	0	52963	52963	2018-11-30	2019-02-22	
17	2019-01-01	2019-07-01	43.000000	0.0	0.110119	2	51099	51099	2018-03-06	2019-07-20	
18	2019-01-01	2019-05-01	27.000000	1.0	0.125000	1	31631	31631	2019-01-09	2019-04-30	
20	2019-10-01	2020-03-01	34.668435	1.0	0.070812	0	40342	40342	2019-10-25	2020-03-01	
21	2019-01-01	2020-02-01	34.000000	1.0	0.056667	1	22755	22755	2018-05-12	2020-02-17	
22	2019-01-01	2020-04-01	41.000000	0.0	0.081989	2	31224	31224	2018-05-25	2020-04-26	
24	2019-01-01	2019-10-01	34.668435	0.0	0.083062	2	76308	76308	2018-05-25	2019-10-27	
25	2019-01-01	2020-12-01	31.000000	0.0	0.083062	1	102077	102077	2017-10-30	NaT	
26	2019-01-01	2020-12-01	43.000000	0.0	0.089506	2	121529	132577	2018-05-07	NaT	
29	2019-01-01	2019-05-01	30.000000	0.0	0.101933	2	30312	30312	2018-05-20	2019-05-23	

In [57]:

```
for i in grouped_df.columns:
    print(i,grouped_df[i].nunique())
```

```
reporting_start_date 24
reporting_end_date 24
age 37
gender 2
city 29
education 3
joining_income 2339
current_income 2339
joining_date 869
exit_date 493
designation 5
initial_grade 5
current_grade 5
total_bussiness 1626
initial_rating 4
current_rating 4
quarterly_rating 2
income_change 2
churn 2
```

In [58]:

```
grouped_df['age'] =grouped_df['age'].round(2)
```

In [59]:

```
grouped_df['age'].replace(34.67,34,inplace=True)
```

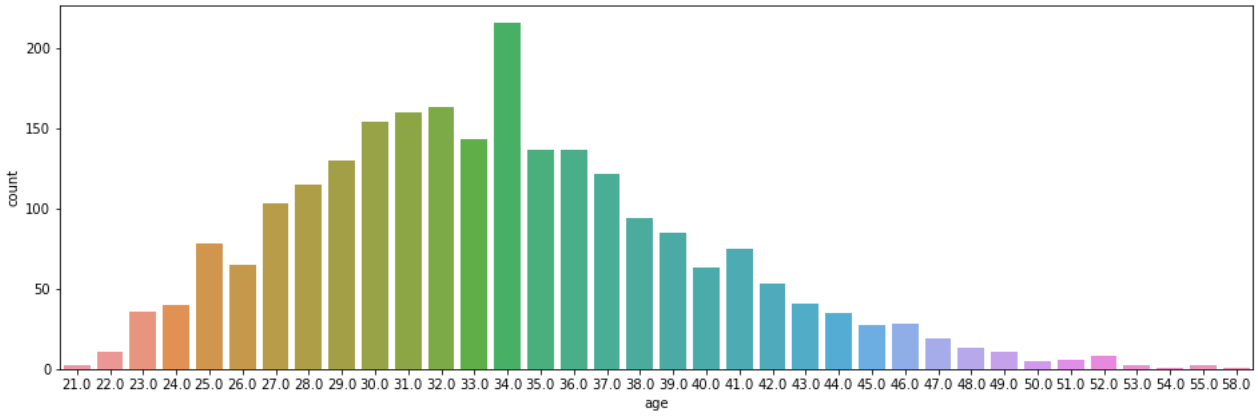
In [60]:

```
plt.figure(figsize=(16,5))
sns.countplot(grouped_df['age'])
```

```
C:\ProgramData\Anaconda3\lib\site-packages\seaborn\_decorators.py:36: FutureWarning: Pass the following variable as a keywo
rd arg: x. From version 0.12, the only valid positional argument will be `data`, and passing other arguments without an exp
licit keyword will result in an error or misinterpretation.
  warnings.warn(
```

Out[60]:

```
<AxesSubplot:xlabel='age', ylabel='count'>
```

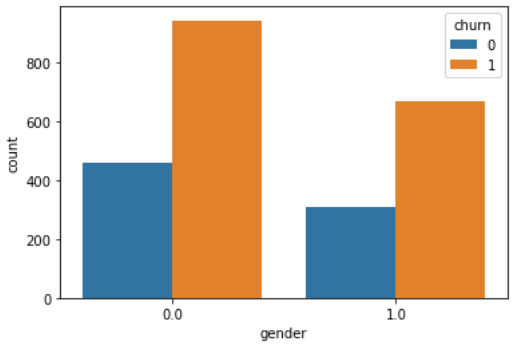


In [61]:

```
sns.countplot(x=grouped_df['gender'],hue=grouped_df['churn'])
```

Out[61]:

```
<AxesSubplot:xlabel='gender', ylabel='count'>
```



In [62]:

```
grouped_df['education'].value_counts()
```

Out[62]:

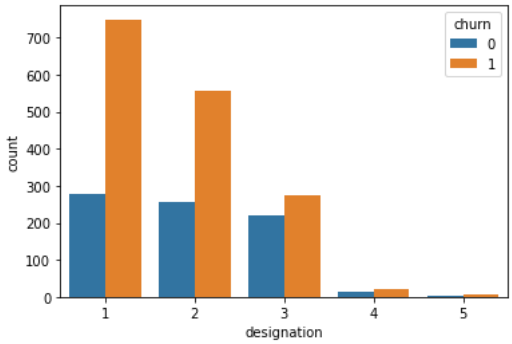
```
2    802
1    795
0    784
Name: education, dtype: int64
```

In [63]:

```
sns.countplot(x=grouped_df['designation'],hue = grouped_df['churn'])
```

Out[63]:

```
<AxesSubplot:xlabel='designation', ylabel='count'>
```



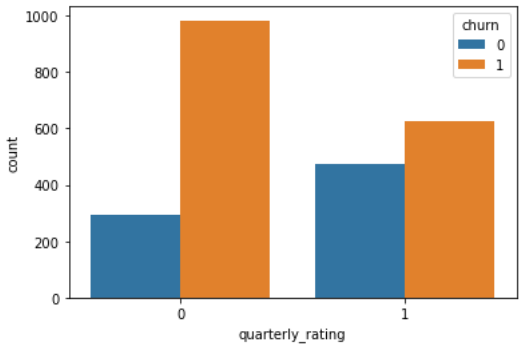
In [64]:

```
sns.countplot(grouped_df['quarterly_rating'],hue = grouped_df['churn'])
```

```
C:\ProgramData\Anaconda3\lib\site-packages\seaborn\_decorators.py:36: FutureWarning: Pass the following variable as a keywo
rd arg: x. From version 0.12, the only valid positional argument will be `data`, and passing other arguments without an exp
licit keyword will result in an error or misinterpretation.
  warnings.warn(
```

Out[64]:

```
<AxesSubplot:xlabel='quarterly_rating', ylabel='count'>
```



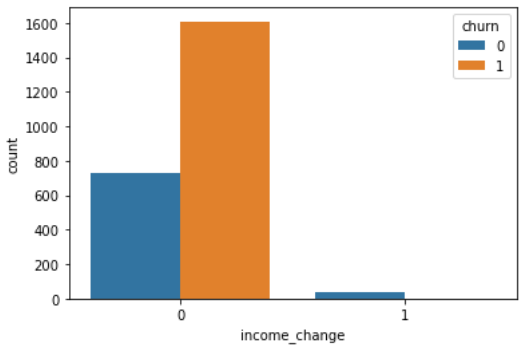
In [65]:

```
sns.countplot(grouped_df['income_change'],hue = grouped_df['churn'])
```

```
C:\ProgramData\Anaconda3\lib\site-packages\seaborn\_decorators.py:36: FutureWarning: Pass the following variable as a keywo
rd arg: x. From version 0.12, the only valid positional argument will be `data`, and passing other arguments without an exp
licit keyword will result in an error or misinterpretation.
  warnings.warn(
```

Out[65]:

```
<AxesSubplot:xlabel='income_change', ylabel='count'>
```



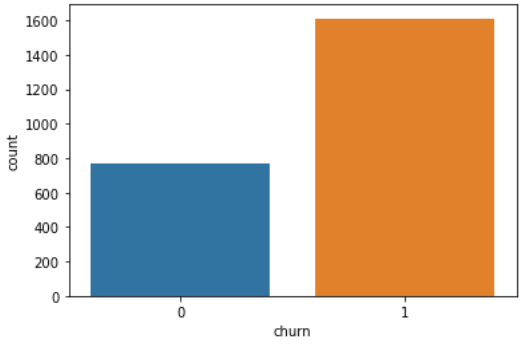
In [66]:

```
sns.countplot(grouped_df['churn'])
```

```
C:\ProgramData\Anaconda3\lib\site-packages\seaborn\_decorators.py:36: FutureWarning: Pass the following variable as a keywo
rd arg: x. From version 0.12, the only valid positional argument will be `data`, and passing other arguments without an exp
licit keyword will result in an error or misinterpretation.
  warnings.warn(
```

Out[66]:

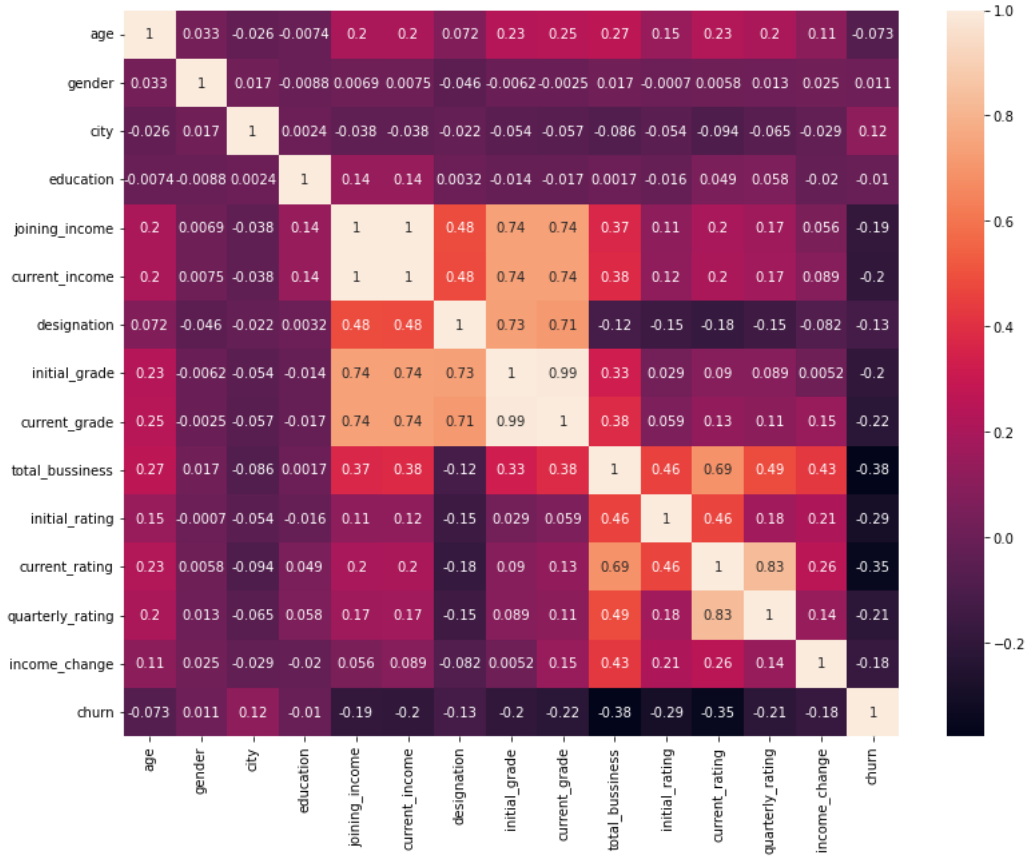
```
<AxesSubplot:xlabel='churn', ylabel='count'>
```




```
--> Most of the drivers are of age 34
--> Male drivers are more compared to female
--> About 50% of the drivers churn in both male and female
--> People with less designation churn more and gradually decreases w.r.t designation
--> Drivers whose quarterly rating change they are less likely to churn.
--> Same like quarterly rating change if there is an income change then the drivers are less likely to churn
```

In [67]:

```
plt.figure(figsize=(13,10))
sns.heatmap(grouped_df.corr(),annot=True)
plt.show()
```



In [68]:

```
for i in grouped_df.columns:
    print(i,grouped_df[i].nunique())
```

```
reporting_start_date 24
reporting_end_date 24
age 36
gender 2
city 29
education 3
joining_income 2339
current_income 2339
joining_date 869
exit_date 493
designation 5
initial_grade 5
current_grade 5
total_bussiness 1626
initial_rating 4
current_rating 4
quarterly_rating 2
income_change 2
churn 2
```

Dropping useless features

In [69]:

```
grouped_df.drop(['initial_rating','current_rating','initial_grade','joining_date','exit_date','joining_date'],
                inplace = True,axis=1)
```

In [70]:

```
for i in grouped_df.columns:
    print(i,grouped_df[i].nunique())
```

```
reporting_start_date 24
reporting_end_date 24
age 36
gender 2
city 29
education 3
joining_income 2339
current_income 2339
designation 5
current_grade 5
total_bussiness 1626
quarterly_rating 2
income_change 2
churn 2
```

In [71]:

```
grouped_df.head()
```

Out[71]:

Driver_ID	reporting_start_date	reporting_end_date	age	gender	city	education	joining_income	current_income	designation	current_grade	total_b
1	2019-01-01	2019-03-01	28.0	0.0	0.105948	2	57387	57387	1	1	
2	2020-11-01	2020-12-01	31.0	0.0	0.085386	2	67016	67016	2	2	
4	2019-12-01	2020-04-01	43.0	0.0	0.101933	2	65603	65603	2	2	
5	2019-01-01	2019-03-01	29.0	0.0	0.101923	0	46368	46368	1	1	
6	2020-08-01	2020-12-01	31.0	1.0	0.096154	1	78728	78728	3	3	

One-hot encoding for education feature as it is having only 3 unique values

In [72]:

```
edu=pd.get_dummies(grouped_df['education'],prefix='education',drop_first=True)
grouped_df=pd.concat([grouped_df,edu],axis=1)
```

In [73]:

```
grouped_df.head()
```

Out[73]:

Driver_ID	reporting_start_date	reporting_end_date	age	gender	city	education	joining_income	current_income	designation	current_grade	total_b
1	2019-01-01	2019-03-01	28.0	0.0	0.105948	2	57387	57387	1	1	
2	2020-11-01	2020-12-01	31.0	0.0	0.085386	2	67016	67016	2	2	
4	2019-12-01	2020-04-01	43.0	0.0	0.101933	2	65603	65603	2	2	
5	2019-01-01	2019-03-01	29.0	0.0	0.101923	0	46368	46368	1	1	
6	2020-08-01	2020-12-01	31.0	1.0	0.096154	1	78728	78728	3	3	

In [74]:

```
grouped_df = grouped_df.reset_index()
```

In [75]:

```
grouped_df.head()
```

Out[75]:

	Driver_ID	reporting_start_date	reporting_end_date	age	gender	city	education	joining_income	current_income	designation	current_grade	tota
0	1	2019-01-01	2019-03-01	28.0	0.0	0.105948	2	57387	57387	1	1	
1	2	2020-11-01	2020-12-01	31.0	0.0	0.085386	2	67016	67016	2	2	
2	4	2019-12-01	2020-04-01	43.0	0.0	0.101933	2	65603	65603	2	2	
3	5	2019-01-01	2019-03-01	29.0	0.0	0.101923	0	46368	46368	1	1	
4	6	2020-08-01	2020-12-01	31.0	1.0	0.096154	1	78728	78728	3	3	

In [76]:

```
grouped_df.drop(['reporting_start_date','reporting_end_date'],axis = 1,inplace = True)
```

In [77]:

```
grouped_df.columns
```

Out[77]:

```
Index(['Driver_ID', 'age', 'gender', 'city', 'education', 'joining_income',
       'current_income', 'designation', 'current_grade', 'total_bussiness',
       'quarterly_rating', 'income_change', 'churn', 'education_1',
       'education_2'],
      dtype='object')
```

Outliers

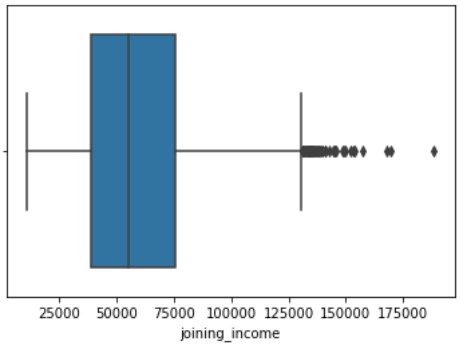
In [78]:

```
sns.boxplot(grouped_df['joining_income'])
```

```
C:\ProgramData\Anaconda3\lib\site-packages\seaborn\_decorators.py:36: FutureWarning: Pass the following variable as a keywo
rd arg: x. From version 0.12, the only valid positional argument will be `data`, and passing other arguments without an exp
licit keyword will result in an error or misinterpretation.
  warnings.warn(
```

Out[78]:

```
<AxesSubplot:xlabel='joining_income'>
```



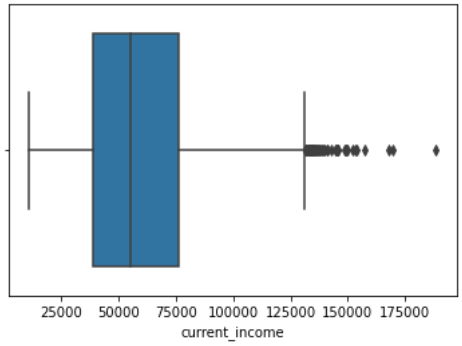
In [79]:

```
sns.boxplot(grouped_df['current_income'])
```

```
C:\ProgramData\Anaconda3\lib\site-packages\seaborn\_decorators.py:36: FutureWarning: Pass the following variable as a keywo
rd arg: x. From version 0.12, the only valid positional argument will be `data`, and passing other arguments without an exp
licit keyword will result in an error or misinterpretation.
  warnings.warn(
```

Out[79]:

```
<AxesSubplot:xlabel='current_income'>
```



In [80]:

```
grouped_df.describe().T
```

Out[80]:

	count	mean	std	min	25%	50%	75%	max
Driver_ID	2381.0	1.397559e+03	8.061616e+02	1.000000e+00	695.000000	1400.000000	2.100000e+03	2.788000e+03
age	2381.0	3.378958e+01	5.908034e+00	2.100000e+01	30.000000	33.000000	3.700000e+01	5.800000e+01
gender	2381.0	4.103318e-01	4.919972e-01	0.000000e+00	0.000000	0.000000	1.000000e+00	1.000000e+00
city	2381.0	8.606014e-02	1.561639e-02	5.666667e-02	0.074799	0.083062	9.246575e-02	1.250000e-01
education	2381.0	1.007560e+00	8.162900e-01	0.000000e+00	0.000000	1.000000	2.000000e+00	2.000000e+00
joining_income	2381.0	5.920906e+04	2.827590e+04	1.074700e+04	39104.000000	55276.000000	7.576500e+04	1.884180e+05
current_income	2381.0	5.933616e+04	2.838301e+04	1.074700e+04	39104.000000	55315.000000	7.598600e+04	1.884180e+05
designation	2381.0	1.820244e+00	8.414334e-01	1.000000e+00	1.000000	2.000000	2.000000e+00	5.000000e+00
current_grade	2381.0	2.097018e+00	9.417017e-01	1.000000e+00	1.000000	2.000000	3.000000e+00	5.000000e+00
total_bussiness	2381.0	4.579832e+06	9.119725e+06	-1.385530e+06	0.000000	807040.000000	4.169060e+06	9.533106e+07
quarterly_rating	2381.0	4.632507e-01	4.987524e-01	0.000000e+00	0.000000	0.000000	1.000000e+00	1.000000e+00
income_change	2381.0	1.847963e-02	1.347062e-01	0.000000e+00	0.000000	0.000000	0.000000e+00	1.000000e+00
churn	2381.0	6.766065e-01	4.678697e-01	0.000000e+00	0.000000	1.000000	1.000000e+00	1.000000e+00
education_1	2381.0	3.338933e-01	4.717012e-01	0.000000e+00	0.000000	0.000000	1.000000e+00	1.000000e+00
education_2	2381.0	3.368333e-01	4.727266e-01	0.000000e+00	0.000000	0.000000	1.000000e+00	1.000000e+00

In [81]:

```
grouped_df.shape
```

Out[81]:

```
(2381, 15)
```

In [82]:

```
grouped_df.quantile([0.05,0.1,0.5,0.7,0.8,0.9,0.95,0.97,0.98,0.99,1]).T
```

Out[82]:

	0.05	0.10	0.50	0.70	0.80	0.90	0.95	0.97	0.98	
Driver_ID	141.000000	284.000000	1400.000000	1.959000e+03	2.233000e+03	2.509000e+03	2.648000e+03	2.705600e+03	2.730400e+03	2.7592(
age	25.000000	27.000000	33.000000	3.600000e+01	3.800000e+01	4.200000e+01	4.500000e+01	4.600000e+01	4.800000e+01	5.0000(
gender	0.000000	0.000000	0.000000	1.000000e+00	1.000000e+00	1.000000e+00	1.000000e+00	1.000000e+00	1.000000e+00	1.0000(
city	0.061805	0.070522	0.083062	9.067017e-02	1.019231e-01	1.101190e-01	1.165254e-01	1.165254e-01	1.250000e-01	1.2500
education	0.000000	0.000000	1.000000	2.000000e+00	2.000000e+00	2.000000e+00	2.000000e+00	2.000000e+00	2.000000e+00	2.0000(
joining_income	20170.000000	25459.000000	55276.000000	7.008800e+04	8.128800e+04	9.930000e+04	1.138070e+05	1.233784e+05	1.307636e+05	1.3698
current_income	20170.000000	25459.000000	55315.000000	7.033900e+04	8.156100e+04	9.941500e+04	1.138070e+05	1.237416e+05	1.312396e+05	1.3715
designation	1.000000	1.000000	2.000000	2.000000e+00	3.000000e+00	3.000000e+00	3.000000e+00	3.000000e+00	3.000000e+00	4.0000(
current_grade	1.000000	1.000000	2.000000	3.000000e+00	3.000000e+00	3.000000e+00	4.000000e+00	4.000000e+00	4.000000e+00	4.2000(
total_bussiness	0.000000	0.000000	807040.000000	2.945540e+06	5.958340e+06	1.497077e+07	2.347103e+07	3.014097e+07	3.478996e+07	4.3135(
quarterly_rating	0.000000	0.000000	0.000000	1.000000e+00	1.000000e+00	1.000000e+00	1.000000e+00	1.000000e+00	1.000000e+00	1.0000(
income_change	0.000000	0.000000	0.000000	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00	1.0000(
churn	0.000000	0.000000	1.000000	1.000000e+00	1.000000e+00	1.000000e+00	1.000000e+00	1.000000e+00	1.000000e+00	1.0000(
education_1	0.000000	0.000000	0.000000	1.000000e+00	1.000000e+00	1.000000e+00	1.000000e+00	1.000000e+00	1.000000e+00	1.0000(
education_2	0.000000	0.000000	0.000000	1.000000e+00	1.000000e+00	1.000000e+00	1.000000e+00	1.000000e+00	1.000000e+00	1.0000(

removing rows based on the outliers

In [83]:

```
grouped_df = grouped_df[grouped_df['joining_income']<grouped_df['joining_income'].quantile(0.98)]
```

In [84]:

```
grouped_df.shape
```

Out[84]:

```
(2333, 15)
```

In [85]:

```
print(f'Percentage of rows removed is', np.round(100 - (2333/2381)*100,2))
```

```
Percentage of rows removed is 2.02
```

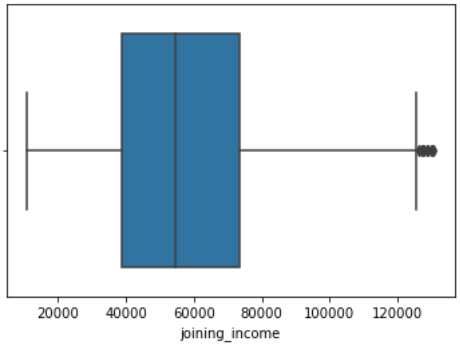
In [86]:

```
sns.boxplot(grouped_df['joining_income'])
```

```
C:\ProgramData\Anaconda3\lib\site-packages\seaborn\_decorators.py:36: FutureWarning: Pass the following variable as a keywo
rd arg: x. From version 0.12, the only valid positional argument will be `data`, and passing other arguments without an exp
licit keyword will result in an error or misinterpretation.
  warnings.warn(
```

Out[86]:

```
<AxesSubplot:xlabel='joining_income'>
```



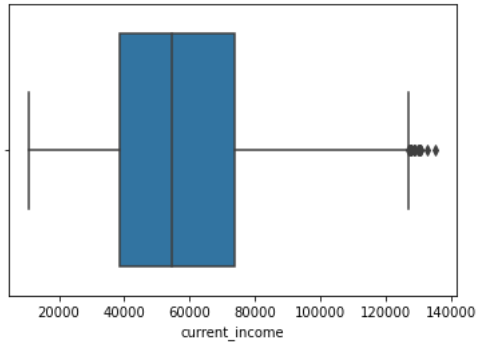
In [87]:

```
sns.boxplot(grouped_df['current_income'])
```

```
C:\ProgramData\Anaconda3\lib\site-packages\seaborn\_decorators.py:36: FutureWarning: Pass the following variable as a keywo
rd arg: x. From version 0.12, the only valid positional argument will be `data`, and passing other arguments without an exp
licit keyword will result in an error or misinterpretation.
  warnings.warn(
```

Out[87]:

```
<AxesSubplot:xlabel='current_income'>
```



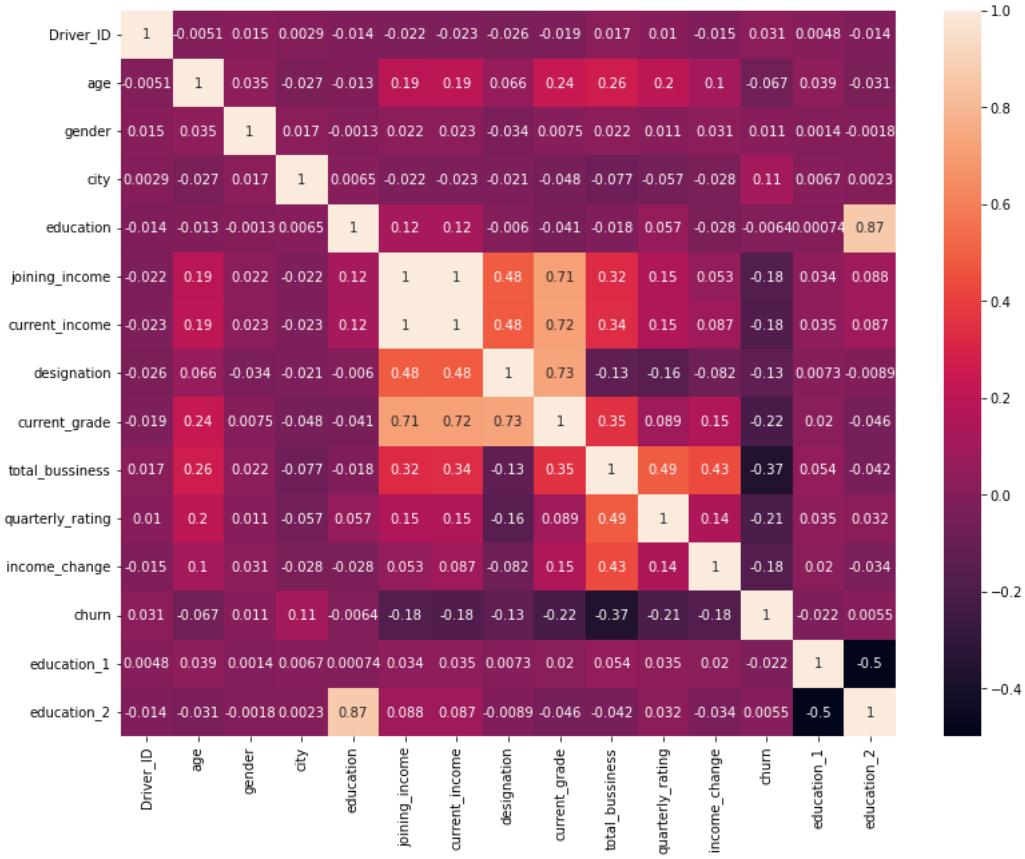
Heatmap

In [88]:

```
plt.figure(figsize=(13,10))
sns.heatmap(grouped_df.corr(),annot=True)
```

Out[88]:

```
<AxesSubplot:>
```



In [89]:

```
grouped_df.columns
```

Out[89]:

```
Index(['Driver_ID', 'age', 'gender', 'city', 'education', 'joining_income',
       'current_income', 'designation', 'current_grade', 'total_bussiness',
       'quarterly_rating', 'income_change', 'churn', 'education_1',
       'education_2'],
      dtype='object')
```

Removing the columns which are highly correlated

In [90]:

```
grouped_df.drop(['education','joining_income','current_grade'],inplace=True,axis=1)
```

In [91]:

```
plt.figure(figsize=(13,10))
sns.heatmap(grouped_df.corr(),annot=True)
```

Out[91]:

```
<AxesSubplot:>
```

In [92]:

```
grouped_df.columns
```

Out[92]:

```
Index(['Driver_ID', 'age', 'gender', 'city', 'current_income', 'designation',
       'total_bussiness', 'quarterly_rating', 'income_change', 'churn',
       'education_1', 'education_2'],
      dtype='object')
```

Target column

In [93]:

```
y = grouped_df['churn']
```

In [94]:

```
grouped_df.drop(['churn'],inplace = True, axis = 1)
```

In [95]:

```
columns = grouped_df.columns
```

Standardiszation

In [96]:

```
scaler = StandardScaler()
grouped_df = scaler.fit_transform(grouped_df)
```

In [97]:

```
grouped_df = pd.DataFrame(grouped_df,columns=columns)
```

In [98]:

```
grouped_df.head()
```

Out[98]:

	Driver_ID	age	gender	city	current_income	designation	total_bussiness	quarterly_rating	income_change	education_1	education_2
0	-1.734914	-0.972352	-0.837662	1.266088	-0.009970	-0.980752	-0.300427	-0.917255	-0.135398	-0.708016	1.416490
1	-1.733671	-0.462577	-0.837662	-0.048920	0.359957	0.240868	-0.499117	-0.917255	-0.135398	-0.708016	1.416490
2	-1.731185	1.576521	-0.837662	1.009333	0.305673	0.240868	-0.458582	-0.917255	-0.135398	-0.708016	1.416490
3	-1.729942	-0.802427	-0.837662	1.008684	-0.433297	-0.980752	-0.485177	-0.917255	-0.135398	-0.708016	-0.705971
4	-1.728699	-0.462577	1.193799	0.639725	0.809909	1.462488	-0.352611	1.090209	-0.135398	1.412397	-0.705971

In [99]:

```
#dropping driverID as it is not useful churn
grouped_df.drop(['Driver_ID'],inplace=True,axis = 1)
```

In [100]:

```
grouped_df.head()
```

Out[100]:

	age	gender	city	current_income	designation	total_bussiness	quarterly_rating	income_change	education_1	education_2
0	-0.972352	-0.837662	1.266088	-0.009970	-0.980752	-0.300427	-0.917255	-0.135398	-0.708016	1.416490
1	-0.462577	-0.837662	-0.048920	0.359957	0.240868	-0.499117	-0.917255	-0.135398	-0.708016	1.416490
2	1.576521	-0.837662	1.009333	0.305673	0.240868	-0.458582	-0.917255	-0.135398	-0.708016	1.416490
3	-0.802427	-0.837662	1.008684	-0.433297	-0.980752	-0.485177	-0.917255	-0.135398	-0.708016	-0.705971
4	-0.462577	1.193799	0.639725	0.809909	1.462488	-0.352611	1.090209	-0.135398	1.412397	-0.705971

Train Test split

In [101]:

```
X_train,X_test,y_train,y_test = train_test_split(grouped_df,y,test_size=0.2,shuffle=True)
```

In [102]:

```
y_train.value_counts()
```

Out[102]:

```
1    1275
0     591
Name: churn, dtype: int64
```

As there is imbalance in the target variable lets perform SMOTE to balance the data

In [103]:

```
sm = SMOTE()
x_sm,y_sm = sm.fit_resample(X_train,y_train)
```

In [104]:

```
y_train.shape
```

Out[104]:

```
(1866,)
```

In [105]:

```
x_sm.shape
```

Out[105]:

```
(2550, 10)
```

In [106]:

```
y_sm.value_counts()
```

Out[106]:

```
1    1275
0    1275
Name: churn, dtype: int64
```

In [107]:

```
grouped_df.describe()
```

Out[107]:

	age	gender	city	current_income	designation	total_bussiness	quarterly_rating	income_change	education_1	educa
count	2.333000e+03	2.333000e+03	2.333000e+03	2.333000e+03	2.333000e+03	2.333000e+03	2.333000e+03	2.333000e+03	2.333000e+03	2.3330
mean	4.192008e-16	-1.407171e-16	-7.105808e-16	-4.616015e-18	-4.618038e-16	1.479623e-16	1.888283e-16	-2.098621e-16	-2.232819e-16	-1.63
std	1.000214e+00	1.000214e+00	1.000214e+00	1.000214e+00	1.000214e+00	1.000214e+00	1.000214e+00	1.000214e+00	1.000214e+00	1.0002
min	-2.161826e+00	-8.376620e-01	-1.885600e+00	-1.801785e+00	-9.807517e-01	-6.595825e-01	-9.172554e-01	-1.353980e-01	-7.080162e-01	-7.05
25%	-6.325023e-01	-8.376620e-01	-7.260070e-01	-7.307679e-01	-9.807517e-01	-4.991170e-01	-9.172554e-01	-1.353980e-01	-7.080162e-01	-7.05
50%	-1.227276e-01	-8.376620e-01	-1.975458e-01	-1.170406e-01	2.408680e-01	-4.105218e-01	-9.172554e-01	-1.353980e-01	-7.080162e-01	-7.05
75%	5.569720e-01	1.193799e+00	4.038599e-01	6.256944e-01	2.408680e-01	-3.681955e-02	1.090209e+00	-1.353980e-01	1.412397e+00	1.4164
max	4.125395e+00	1.193799e+00	2.484524e+00	2.980640e+00	3.905727e+00	1.054167e+01	1.090209e+00	7.385636e+00	1.412397e+00	1.4164

In [ ]:

```
```

Bagging : Random Forest

In [108]:

```
params = {
    "n_estimators": [10,25,50,100,115,125,150],
    "max_depth" : [3, 5, 6,7,9],
    "max_leaf_nodes" : [15, 20, 25,30]
}

rfc = RFC(n_jobs = -1)
clf = RandomizedSearchCV(rfc, params, scoring = "accuracy", cv=3, n_jobs = -1, verbose = 1)

clf.fit(x_sm, y_sm)
```

```
Fitting 3 folds for each of 10 candidates, totalling 30 fits
```

Out[108]:

```
RandomizedSearchCV(cv=3, estimator=RandomForestClassifier(n_jobs=-1), n_jobs=-1,
                   param_distributions={'max_depth': [3, 5, 6, 7, 9],
                                        'max_leaf_nodes': [15, 20, 25, 30],
                                        'n_estimators': [10, 25, 50, 100, 115,
                                                         125, 150]},
                   scoring='accuracy', verbose=1)
```

In [109]:

```
res = clf.cv_results_

for i in range(len(res["params"])):
  print(f"Parameters:{res['params'][i]} Mean_score: {res['mean_test_score'][i]} Rank: {res['rank_test_score'][i]}")
```

```
Parameters:{'n_estimators': 150, 'max_leaf_nodes': 15, 'max_depth': 3} Mean_score: 0.7011764705882353 Rank: 8
Parameters:{'n_estimators': 10, 'max_leaf_nodes': 20, 'max_depth': 5} Mean_score: 0.7137254901960786 Rank: 7
Parameters:{'n_estimators': 150, 'max_leaf_nodes': 25, 'max_depth': 9} Mean_score: 0.7274509803921569 Rank: 1
Parameters:{'n_estimators': 150, 'max_leaf_nodes': 15, 'max_depth': 5} Mean_score: 0.7168627450980392 Rank: 6
Parameters:{'n_estimators': 150, 'max_leaf_nodes': 30, 'max_depth': 6} Mean_score: 0.7270588235294118 Rank: 3
Parameters:{'n_estimators': 25, 'max_leaf_nodes': 30, 'max_depth': 3} Mean_score: 0.6960784313725491 Rank: 9
Parameters:{'n_estimators': 25, 'max_leaf_nodes': 20, 'max_depth': 3} Mean_score: 0.6933333333333334 Rank: 10
Parameters:{'n_estimators': 115, 'max_leaf_nodes': 20, 'max_depth': 7} Mean_score: 0.7274509803921569 Rank: 1
Parameters:{'n_estimators': 115, 'max_leaf_nodes': 15, 'max_depth': 9} Mean_score: 0.7219607843137256 Rank: 5
Parameters:{'n_estimators': 50, 'max_leaf_nodes': 15, 'max_depth': 6} Mean_score: 0.7235294117647059 Rank: 4
```

In [110]:

```
print(clf.best_estimator_)
```

```
RandomForestClassifier(max_depth=9, max_leaf_nodes=25, n_estimators=150,
                       n_jobs=-1)
```

In [111]:

```
rf = clf.best_estimator_

rf.fit(x_sm, y_sm)

print("Model acc",rf.score(X_test, y_test))
```

```
Model acc 0.7002141327623126
```

In [112]:

```
y_pred = rf.predict(X_test)
```

In [113]:

```
metrics.confusion_matrix(y_test, y_pred)
```

Out[113]:

```
array([[ 83,  68],
       [ 72, 244]], dtype=int64)
```

In [114]:

```
print(classification_report(y_test,y_pred))
```

```
              precision    recall  f1-score   support

           0       0.54      0.55      0.54       151
           1       0.78      0.77      0.78       316

    accuracy                           0.70       467
   macro avg       0.66      0.66      0.66       467
weighted avg       0.70      0.70      0.70       467
```

```
-->The Random Forest method out of all predicted 0 the measure of correctly predicted is 57%, and for 1 it is
80%(Precision).
-->The Random Forest method out of all actual 0 the measure of correctly predicted is 59%, and for 1 it is 79%
(Recall).
```

Boosting : GBDT

In [115]:

```
gbc = GBC(n_estimators=300, learning_rate=0.25, max_depth=4, random_state=0, verbose = 1).fit(x_sm, y_sm)

print(f"Training accuracy:{gbc.score(x_sm, y_sm)}\nTest Accuracy: {gbc.score(X_test, y_test)}")
```

```
      Iter       Train Loss   Remaining Time
         1           1.2612            4.67s
         2           1.1840            2.33s
         3           1.1311            4.48s
         4           1.0856            3.35s
         5           1.0491            4.17s
         6           1.0227            3.86s
         7           1.0033            3.63s
         8           0.9874            3.75s
         9           0.9725            3.59s
        10           0.9467            3.22s
        20           0.8351            2.92s
        30           0.7569            2.74s
        40           0.6942            2.48s
        50           0.6503            2.43s
        60           0.6028            2.31s
        70           0.5593            2.16s
        80           0.5251            2.08s
        90           0.4955            1.99s
       100           0.4590            1.89s
       200           0.2601            0.93s
       300           0.1589            0.00s
Training accuracy:0.9968627450980392
Test Accuracy: 0.7301927194860813
```

In [116]:

```
y_pred = gbc.predict(X_test)
```

In [117]:

```
metrics.confusion_matrix(y_test, y_pred)
```

Out[117]:

```
array([[ 76,  75],
       [ 51, 265]], dtype=int64)
```

In [118]:

```
print(classification_report(y_test,y_pred))
```

```
              precision    recall  f1-score   support

           0       0.60      0.50      0.55       151
           1       0.78      0.84      0.81       316

    accuracy                           0.73       467
   macro avg       0.69      0.67      0.68       467
weighted avg       0.72      0.73      0.72       467
```

-->The Gradient Boost method out of all predicted 0 the measure of correctly predicted is 57%, and for 1 it is 77%(Precision).
-->The Random Forest method out of all actual 0 the measure of correctly predicted is 50%, and for 1 it is 82% (Recall).

Insights and Recommendations:

--> We observe that there is high precision, which leads to the relevant results
--> Change in income and quarterly rating has high effect on the driver to churn or not.
--> The total bussiness value that the driver has on the company has an effect.

--> Recognizing the driver efforts and provide them effective rating would prevent the driver from churning.