In [ ]:

```

```

In [1]:

```
!pip install lightgbm
```

```
Requirement already satisfied: lightgbm in /opt/conda/lib/python3.7/site-packages (2.3.1)
Requirement already satisfied: scipy in /opt/conda/lib/python3.7/site-packages (from lightgbm)
(1.4.1)
Requirement already satisfied: numpy in /opt/conda/lib/python3.7/site-packages (from lightgbm)
(1.18.3)
Requirement already satisfied: scikit-learn in /opt/conda/lib/python3.7/site-packages (from
lightgbm) (0.22.2.post1)
Requirement already satisfied: joblib>=0.11 in /opt/conda/lib/python3.7/site-packages (from
scikit-learn->lightgbm) (0.14.1)
```

In [2]:

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import lightgbm as lgb
from sklearn.model_selection import KFold
import warnings
import gc
import time
import sys
import datetime
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.metrics import mean_squared_error
warnings.simplefilter(action='ignore', category=FutureWarning)
pd.set_option('display.max_columns', 500)
```

In [3]:

```
#Saving the latest copy which has all the data in to csv format
#train_gf.to_csv('train_gf.csv')
#import dask.dataframe as dd
elo_train=pd.read_csv('hist_df.csv')
#print('Number of data points : ', elo_train.shape[0])
print('Number of data points : ', elo_train.shape[0])
print('Number of features : ', elo_train.shape[1])
print('Features : ', elo_train.columns.values)
#train_data.head()
```

```
Number of data points :  8685556
Number of features :  20
Features :  ['Unnamed: 0' 'first_active_month' 'card_id' 'feature_1' 'feature_2'
 'feature_3' 'target' 'authorized_flag' 'city_id' 'category_1'
 'installments' 'category_3' 'merchant_category_id' 'merchant_id'
 'month_lag' 'purchase_amount' 'purchase_date' 'category_2' 'state_id'
 'subsector_id']
```

In [4]:

```
#Removing 'unnamed' column from dataframe
#https://stackoverflow.com/questions/43983622/remove-unnamed-columns-in-pandas-dataframe
elo_train = elo_train.loc[:, ~elo_train.columns.str.contains('^Unnamed')]
print('Number of features : ', elo_train.shape[1])
```

```
Number of features :  19
```

-first active month seems like not important as it doesn't contribute much to the transaction

-first active month seems like not important as it doesn't contribute much to the transaction.

-authorised flag seems not important in deciding the feature almost majority of transactions are 'approved'

In [5]:

```
del elo_train['authorized_flag']
del elo_train['first_active_month']
```

In [6]:

```
print('Number of features : ', elo_train.shape[1])
```

```
Number of features :  17
```

In [7]:

```
elo_train.to_csv("elo_train.csv")
```

Train Test split

In [3]:

```
p_d=pd.read_csv('elo_train.csv')
#print('Number of data points : ', elo_train.shape[0])
print('Number of data points : ', p_d.shape[0])
print('Number of features : ', p_d.shape[1])
print('Features : ', p_d.columns.values)
```

```
Number of data points :  8685556
Number of features :  18
Features :  ['Unnamed: 0' 'card_id' 'feature_1' 'feature_2' 'feature_3' 'target'
 'city_id' 'category_1' 'installments' 'category_3' 'merchant_category_id'
 'merchant_id' 'month_lag' 'purchase_amount' 'purchase_date' 'category_2'
 'state_id' 'subsector_id']
```

In [4]:

```
#Removing 'unnamed' column from dataframe
#https://stackoverflow.com/questions/43983622/remove-unnamed-columns-in-pandas-dataframe
p_d = p_d.loc[:, ~p_d.columns.str.contains('^Unnamed')]
print('Number of features : ', p_d.shape[1])
```

```
Number of features :  17
```

In [5]:

```
from sklearn.utils import resample
elo_trn = resample(p_d,n_samples = 400000)
```

In [6]:

```
elo_trn.shape
```

Out[6]:

```
(400000, 17)
```

In [7]:

```
#https://stackoverflow.com/questions/40531255/how-to-replace-empty-cells-with-0-and-change-strings
-to-integers-where-possible/40531388
def recode_empty_cells(dataframe, list_of_columns):

    for column in list_of_columns:
      dataframe[column] = dataframe[column].replace(r'\s+', np.nan, regex=True)
      dataframe[column] = dataframe[column].fillna(0)
    return dataframe
```

In [8]:

```
recode_empty_cells(elo_trn, list(elo_trn.columns.values))
```

```
/opt/conda/lib/python3.7/site-packages/ipykernel_launcher.py:5: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  """
/opt/conda/lib/python3.7/site-packages/ipykernel_launcher.py:6: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
```

Out[8]:

	card_id	feature_1	feature_2	feature_3	target	city_id	category_1	installments	category_3	merchant_category_
1680165	C_ID_6e40c6d1d7	4.0	1.0	0.0	0.790527	14.0	N	1.0	B	842
3145610	C_ID_7889b6f868	3.0	1.0	1.0	-0.902832	-1.0	Y	1.0	B	879
693405	C_ID_9fac55761f	2.0	3.0	0.0	-1.042969	19.0	N	1.0	B	507
8682929	C_ID_35bf19ef29	0.0	0.0	0.0	0.000000	-1.0	Y	3.0	C	210
2487093	C_ID_e8ad14c005	2.0	1.0	0.0	0.394287	256.0	N	1.0	B	560
...	...	...	...	...	...	...	...	...	...	
2171045	C_ID_36347cd128	2.0	1.0	0.0	-0.371338	199.0	N	1.0	B	307
767202	C_ID_b706dae817	5.0	1.0	1.0	1.161133	150.0	N	1.0	B	705
5066186	C_ID_ead4c6a1c7	5.0	1.0	1.0	-0.263916	-1.0	Y	1.0	B	879
3816591	C_ID_e11116d6d1	2.0	3.0	0.0	-0.875000	233.0	N	1.0	B	367
5645888	C_ID_8d2895a550	5.0	1.0	1.0	3.398438	88.0	N	1.0	B	206

400000 rows × 17 columns

In [9]:

```
#https://thispointer.com/pandas-change-data-type-of-single-or-multiple-columns-of-dataframe-in-pyt
hon/
elo_trn['merchant_category_id']=elo_trn['merchant_category_id'].astype('int16')
elo_trn['feature_1']=elo_trn['feature_1'].astype('int16')
elo_trn['feature_2']=elo_trn['feature_2'].astype('int16')
elo_trn['feature_3']=elo_trn['feature_3'].astype('int16')
#elo_trn['authorized_flag']=elo_trn['authorized_flag'].astype('int16')
elo_trn['installments']=elo_trn['installments'].astype('int16')
#elo_trn['category_3']=elo_trn['category_3'].astype('float32')
#elo_trn['category_2']=elo_trn['category_2'].astype('float32')
# Convert first_active_month to datetime
#p_d['first_active_month'] = pd.to_datetime(p_d['first_active_month'],
                                             #format='%Y-%m')
```

```
/opt/conda/lib/python3.7/site-packages/ipykernel_launcher.py:2: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
```

```
/opt/conda/lib/python3.7/site-packages/ipykernel_launcher.py:3: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  This is separate from the ipykernel package so we can avoid doing imports until
/opt/conda/lib/python3.7/site-packages/ipykernel_launcher.py:4: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  after removing the cwd from sys.path.
/opt/conda/lib/python3.7/site-packages/ipykernel_launcher.py:5: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  """
/opt/conda/lib/python3.7/site-packages/ipykernel_launcher.py:7: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  import sys
```

In [10]:

```
y = elo_trn["target"].values
X = elo_trn.drop("target",axis = 1)
```

In [11]:

```
# train test split
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=1/3, random_state=85)
```

In [12]:

```
X_train.head(3)
```

Out[12]:

	card_id	feature_1	feature_2	feature_3	city_id	category_1	installments	category_3	merchant_category_id	m
1950195	C_ID_82d92e06f8	5	1	1	223.0	N	1	B	307	M_ID_7
2009749	C_ID_4f500e4e9e	4	2	0	19.0	N	1	B	307	M_ID_
1076201	C_ID_9f6052e4bb	2	2	0	251.0	N	1	B	813	M_ID_8

Root Mean Square Error

We'll be using the root mean squared error as our evaluation metric:
$$ RMSE(y, \hat{y}) = \sqrt{ \frac{1}{N} \sum_{i=1}^N (y_i - \hat{y}_i)^2 } $$

In [13]:

```
def root_mean_squared_error(y_true, y_pred):
    """Root mean squared error regression loss"""
    return np.sqrt(np.mean(np.square(y_true-y_pred)))
```

In [14]:

```
root_mean_squared_error(np.mean(y_train), y_train)
```

Out[14]:

```
1.2788985542843374
```

OK, so our models should for sure be getting RMSE values lower than 1.28

We have also checked with 8 million data points and found out that more or less both the RMSE looks same.

So, we condidering with 4 Million data points for better computation.

To apply model on top of it ... Let us convert all the features either in to Numerical

In [95]:

```
elo_trn.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 400000 entries, 700654 to 91880
Data columns (total 17 columns):
 #   Column               Non-Null Count   Dtype  
---  ------               --------------   -----  
 0   card_id              400000 non-null  object 
 1   feature_1            400000 non-null  int16  
 2   feature_2            400000 non-null  int16  
 3   feature_3            400000 non-null  int16  
 4   target               400000 non-null  float64
 5   city_id              400000 non-null  float64
 6   category_1           400000 non-null  float64
 7   installments         400000 non-null  int16  
 8   category_3           400000 non-null  float32
 9   merchant_category_id 400000 non-null  int16  
 10  merchant_id          400000 non-null  object 
 11  month_lag            400000 non-null  float64
 12  purchase_amount      400000 non-null  float64
 13  purchase_date        400000 non-null  float64
 14  category_2           400000 non-null  float32
 15  state_id             400000 non-null  float64
 16  subsector_id         400000 non-null  float64
dtypes: float32(2), float64(8), int16(5), object(2)
memory usage: 40.4+ MB
```

Most of the datatypes to be changed accordingly to the problem. Since, we are converting the most of the featureds

first active month needs to be converted in to Numerical.

'card_id' needs to be converted in to Numerical.

Data pre-processing

The 'card_id's always start with C*ID*.

In [15]:

```
#https://stackoverflow.com/questions/51102205/how-to-know-the-labels-assigned-by-astypecategory-ca
t-codes
elo_trn['card_id'].apply(len).unique()
```

Out[15]:

```
array([15])
```

In [16]:

```
#https://www.geeksforgeeks.org/python-pandas-series-str-slice/
elo_trn['card_id'].str.slice(5, 15).sample(10)
```

Out[16]:

```
239539     0e04880b40
```

```
7747528    35a963b6a2
4943362    5d363b9bcf
6327733    91e8e78f76
2796519    50efa6942b
4921010    182ce31cf6
6568441    6cd9169601
4918952    a2ebd032e7
533326     b16d7133af
6877993    276c915fb2
Name: card_id, dtype: object
```

Since, C*ID* is a common part for all the line items in card_id, we are removing it just because it is not necessary to be retained in the model.

-if we remove the C*ID* part from the card_id almost the remaining set of numbers looks in the range of 0-9,a-f.

In [17]:

```
(elo_trn['card_id']
 .str.slice(5, 15)
 .apply(lambda x: all(f in '0123456789abcdef' for f in x))
 .all())
```

Out[17]:

```
True
```

In [18]:

```
#https://stackoverflow.com/questions/51102205/how-to-know-the-labels-assigned-by-astypecategory-ca
t-codes
card_id_map = dict(zip(
    elo_trn['card_id'].values,
    elo_trn['card_id'].astype('category').cat.codes.values
))
```

In [19]:

```
# Map the values
elo_trn['card_id'] = elo_trn['card_id'].map(card_id_map).astype('uint32')
```

```
/opt/conda/lib/python3.7/site-packages/ipykernel_launcher.py:2: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
```

In [20]:

```
# Map the values
X_train['card_id'] = X_train['card_id'].map(card_id_map).astype('uint32')
X_test['card_id'] = X_test['card_id'].map(card_id_map).astype('uint32')
```

```
/opt/conda/lib/python3.7/site-packages/ipykernel_launcher.py:2: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy

/opt/conda/lib/python3.7/site-packages/ipykernel_launcher.py:3: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  This is separate from the ipykernel package so we can avoid doing imports until
```

Now, converting 'Merchant_id' in the same way as 'card_id'

The 'merchant_id' always start with M*ID*.

In [21]:

```
#https://stackoverflow.com/questions/51102205/how-to-know-the-labels-assigned-by-astypecategory-ca
t-codes
elo_trn['merchant_id'].apply(len).unique()
```

Out[21]:

```
array([15])
```

In [22]:

```
#https://stackoverflow.com/questions/51102205/how-to-know-the-labels-assigned-by-astypecategory-ca
t-codes
merchant_id_map = dict(zip(
    elo_trn['merchant_id'].values,
    elo_trn['merchant_id'].astype('category').cat.codes.values
))
```

In [23]:

```
# Map the values
elo_trn['merchant_id'] = elo_trn['merchant_id'].map(merchant_id_map).astype('uint32')
```

```
/opt/conda/lib/python3.7/site-packages/ipykernel_launcher.py:2: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
```

In [24]:

```
# Map the values
X_train['merchant_id'] = X_train['merchant_id'].map(merchant_id_map).astype('uint32')
X_test['merchant_id'] = X_test['merchant_id'].map(merchant_id_map).astype('uint32')
```

```
/opt/conda/lib/python3.7/site-packages/ipykernel_launcher.py:2: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy

/opt/conda/lib/python3.7/site-packages/ipykernel_launcher.py:3: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  This is separate from the ipykernel package so we can avoid doing imports until
```

In [25]:

```
elo_trn.head()
```

Out[25]:

	card_id	feature_1	feature_2	feature_3	target	city_id	category_1	installments	category_3	merchant_category_id	merch
1680165	39413	4	1	0	0.790527	14.0	N	1	B	842	
3145610	43022	3	1	1	-0.902832	-1.0	Y	1	B	879	
693405	56963	2	3	0	-	19.0	N	1	B	507	

	card_id	feature_1	feature_2	feature_3	target	city_id	category_1	installments	category_3	merchant_category_id	merch
693405	56963	2	3	0	1.042969	19.0	N	1	B	507	
8682929	19303	0	0	0	0.000000	-1.0	Y	3	C	210	
2487093	82755	2	1	0	0.394287	256.0	N	1	B	560	

In [26]:

```
X_train.head()
```

Out[26]:

	card_id	feature_1	feature_2	feature_3	city_id	category_1	installments	category_3	merchant_category_id	merchant_id	m
1950195	46674	5	1	1	223.0	N	1	B	307	44809	
2009749	28476	4	2	0	19.0	N	1	B	307	87061	
1076201	56851	2	2	0	251.0	N	1	B	813	48736	
882404	82193	2	1	0	12.0	N	1	B	360	51763	
4827284	14255	4	1	0	283.0	N	1	B	884	75568	

Converting Boolean in to Numerical

In [27]:

```
#converting boolean features in to Numerical
#https://datascience.stackexchange.com/questions/42465/do-i-need-to-convert-booleans-to-ints-to-en
ter-them-in-a-machine-learning-algori
#hist_f['authorized_flag'] = hist_f['authorized_flag'].map({'Y': 1, 'N': 0})
elo_trn['category_1'] = elo_trn['category_1'].map({'Y': 1, 'N': 0})
X_train['category_1'] = X_train['category_1'].map({'Y': 1, 'N': 0})
X_test['category_1'] = X_test['category_1'].map({'Y': 1, 'N': 0})
```

```
/opt/conda/lib/python3.7/site-packages/ipykernel_launcher.py:4: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  after removing the cwd from sys.path.
/opt/conda/lib/python3.7/site-packages/ipykernel_launcher.py:5: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  """
/opt/conda/lib/python3.7/site-packages/ipykernel_launcher.py:6: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
```

In [28]:

```
#converting boolean features in to Numerical
#https://datascience.stackexchange.com/questions/42465/do-i-need-to-convert-booleans-to-ints-to-en
ter-them-in-a-machine-learning-algori
#hist_f['authorized_flag'] = hist_f['authorized_flag'].map({'Y': 1, 'N': 0})
elo_trn['category_3'] = elo_trn['category_3'].map({'A':0, 'B':1, 'C':2})
X_train['category_3'] = X_train['category_3'].map({'A':0, 'B':1, 'C':2})
X_test['category_3'] = X_test['category_3'].map({'A':0, 'B':1, 'C':2})
```

```
/opt/conda/lib/python3.7/site-packages/ipykernel_launcher.py:4: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
```

```
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  after removing the cwd from sys.path.
/opt/conda/lib/python3.7/site-packages/ipykernel_launcher.py:5: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  """
/opt/conda/lib/python3.7/site-packages/ipykernel_launcher.py:6: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
```

Applying Machine Learning models

1) Xbgoost Model

Hyperparameter Tuning

In [31]:

```
from sklearn.model_selection import RandomizedSearchCV
import xgboost as xgb
parameters2 = {'n_estimators': [5,10,50,100,200,500,1000] ,
             'max_depth' :  [2,3,4,5,6,7,8,9,10]}


XGB_rg = xgb.XGBRegressor(random_state=11,class_weight='balanced')

XGB_rg2=RandomizedSearchCV(XGB_rg ,param_distributions = parameters2,
scoring="neg_mean_squared_error", cv=5)
XGB_rg2.fit(X_train,y_train)
```

Out[31]:

```
RandomizedSearchCV(cv=5, error_score=nan,
                   estimator=XGBRegressor(base_score=None, booster=None,
                                          class_weight='balanced',
                                          colsample_bylevel=None,
                                          colsample_bynode=None,
                                          colsample_bytree=None, gamma=None,
                                          gpu_id=None, importance_type='gain',
                                          interaction_constraints=None,
                                          learning_rate=None,
                                          max_delta_step=None, max_depth=None,
                                          min_child_weight=None, missing=nan,
                                          mono...
                                          scale_pos_weight=None, subsample=None,
                                          tree_method=None,
                                          validate_parameters=False,
                                          verbosity=None),
                   iid='deprecated', n_iter=10, n_jobs=None,
                   param_distributions={'max_depth': [2, 3, 4, 5, 6, 7, 8, 9,
                                                      10],
                                        'n_estimators': [5, 10, 50, 100, 200,
                                                         500, 1000]},
                   pre_dispatch='2*n_jobs', random_state=None, refit=True,
                   return_train_score=False, scoring='neg_mean_squared_error',
                   verbose=0)
```

In [32]:

```
#https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
a2=XGB_rg2.best_params_['n_estimators']
p2 = XGB_rg2.best_params_['max_depth']
print(XGB_rg2.best_score_)
print(a2)
print(a2)
print(p2)
```

```
-1.2954496745193524
1000
6
```

In [33]:

```
#Calculating y_train_pred and y_test_pred
y_train_pred = XGB_rg2.predict(X_train)
y_test_pred = XGB_rg2.predict(X_test)
```

In [34]:

```
#Calculating rsme and mape scores by using the utility function
rmse_train = root_mean_squared_error(np.mean(y_train), y_train_pred)
rmse_test = root_mean_squared_error(np.mean(y_test), y_test_pred)
```

In [35]:

```
print('Train RMSE : ', rmse_train)
print('\n'+'-'*45)
print('Test RMSE : ', rmse_test)
```

```
Train RMSE :  0.57682365

---------------------------------------------
Test RMSE :  0.48889488
```

-There is a quite difference between Train and Test RMSE values, seems like an overfitting.

In [36]:

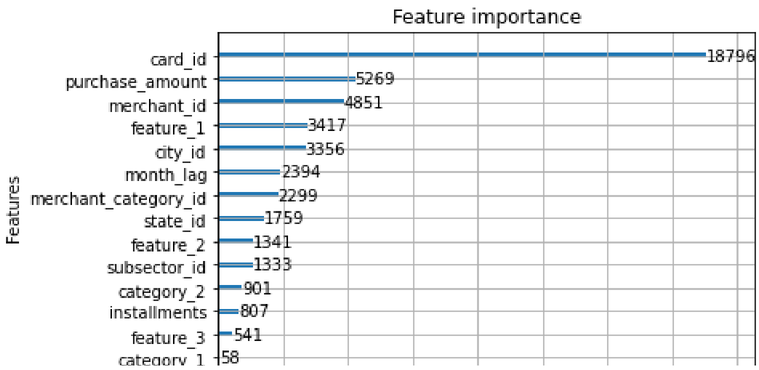
```
# initialize Our first XGBoost model...
first_xgb = xgb.XGBRegressor(silent=False, n_jobs=13, random_state=15, n_estimators=a2, max_depth=p
2)
first_xgb.fit(X_train,y_train)
```

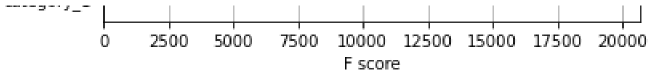
Out[36]:

```
XGBRegressor(base_score=0.5, booster=None, colsample_bylevel=1,
             colsample_bynode=1, colsample_bytree=1, gamma=0, gpu_id=-1,
             importance_type='gain', interaction_constraints=None,
             learning_rate=0.300000012, max_delta_step=0, max_depth=6,
             min_child_weight=1, missing=nan, monotone_constraints=None,
             n_estimators=1000, n_jobs=13, num_parallel_tree=1,
             objective='reg:squarederror', random_state=15, reg_alpha=0,
             reg_lambda=1, scale_pos_weight=1, silent=False, subsample=1,
             tree_method=None, validate_parameters=False, verbosity=None)
```

In [37]:

```
xgb.plot_importance(first_xgb)
plt.show()
```





2) Random Forest

Hyperparameter Tuning

In [39]:

```
pip install -U scikit-learn
```

```
Requirement already up-to-date: scikit-learn in /opt/conda/lib/python3.7/site-packages
(0.22.2.post1)
Requirement already satisfied, skipping upgrade: joblib>=0.11 in /opt/conda/lib/python3.7/site-pac
kages (from scikit-learn) (0.14.1)
Requirement already satisfied, skipping upgrade: scipy>=0.17.0 in /opt/conda/lib/python3.7/site-pa
ckages (from scikit-learn) (1.4.1)
Requirement already satisfied, skipping upgrade: numpy>=1.11.0 in /opt/conda/lib/python3.7/site-pa
ckages (from scikit-learn) (1.18.3)
Note: you may need to restart the kernel to use updated packages.
```

In [ ]:

```
#from sklearn.ensemble import RandomForestClassifier
from sklearn.ensemble import RandomForestRegressor
from sklearn.model_selection import RandomizedSearchCV


parameters = {'n_estimators': [5,10,50,100,200,500,1000] ,
             'max_depth' :  [2,3,4,5,6,7,8,9,10]}


clf_rf = RandomForestRegressor(random_state=11)

clf=RandomizedSearchCV(clf_rf ,param_distributions = parameters, scoring="neg_mean_squared_error",
cv=10)
clf.fit(X_train,y_train)
```

In [30]:

```
#https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
a=clf.best_params_['n_estimators']
p = clf.best_params_['max_depth']
print(clf.best_score_)
print(a)
print(p)
```

```
-1.613220463986368
100
10
```

In [31]:

```
#Calculating y_train_pred and y_test_pred
y_train_pred = clf.predict(X_train)
y_test_pred = clf.predict(X_test)
```

In [32]:

```
#Calculating rsme and mape scores by using the utility function
rmse_train = root_mean_squared_error(np.mean(y_train), y_train_pred)
rmse_test = root_mean_squared_error(np.mean(y_test), y_test_pred)
```

In [33]:

```
print('Train RMSE : ', rmse_train)
print('\n'+'-'*45)
print('\n'+'-'*45)
print('Test RMSE : ', rmse_test)
```

```
Train RMSE :  0.09853955273915958

---------------------------------------------
Test RMSE :  0.088096504311728
```

In [34]:

```
# initialize Our first XGBoost model...
first_rf=RandomForestRegressor(random_state=11,max_depth=p, n_estimators=a)
first_rf.fit(X_train,y_train)
```

Out[34]:

```
RandomForestRegressor(bootstrap=True, ccp_alpha=0.0, criterion='mse',
                      max_depth=10, max_features='auto', max_leaf_nodes=None,
                      max_samples=None, min_impurity_decrease=0.0,
                      min_impurity_split=None, min_samples_leaf=1,
                      min_samples_split=2, min_weight_fraction_leaf=0.0,
                      n_estimators=100, n_jobs=None, oob_score=False,
                      random_state=11, verbose=0, warm_start=False)
```

In [35]:

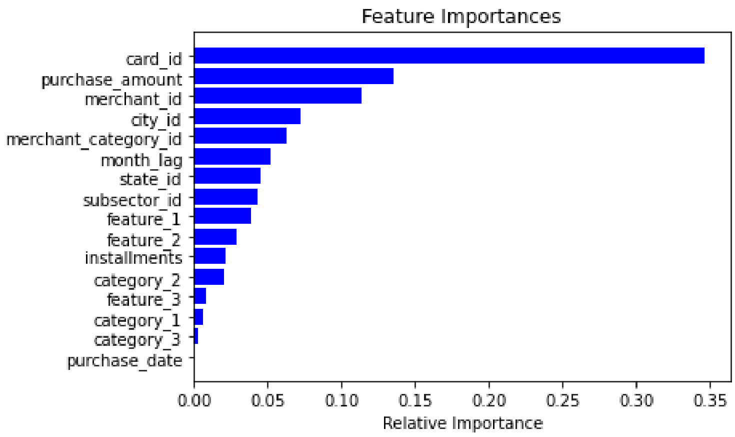
```
# display the relative importance of each attribute
importances = first_rf.feature_importances_
#Sort it
print ("Sorted Feature Importance:")
sorted_feature_importance = sorted(zip(importances, list(X_train)), reverse=True)
print (sorted_feature_importance)
```

```
Sorted Feature Importance:
[(0.34665109585490045, 'card_id'), (0.13576402615497096, 'purchase_amount'), (0.11408330014067478,
'merchant_id'), (0.07297851646716934, 'city_id'), (0.06315624630846088, 'merchant_category_id'), (
0.05175112937741567, 'month_lag'), (0.04550159577712224, 'state_id'), (0.04330655716908893,
'subsector_id'), (0.03898770904210475, 'feature_1'), (0.02853309125031698, 'feature_2'),
(0.021640896024411282, 'installments'), (0.020650079553432087, 'category_2'),
(0.008067049901486534, 'feature_3'), (0.006164689892738173, 'category_1'), (0.002764017085706982,
'category_3'), (0.0, 'purchase_date')]
```

In [36]:

```
features = list(X_train)
importances = first_rf.feature_importances_
indices = np.argsort(importances)

plt.title('Feature Importances')
plt.barh(range(len(indices)), importances[indices], color='b', align='center')
plt.yticks(range(len(indices)), [features[i] for i in indices])
plt.xlabel('Relative Importance')
plt.show()
```



3) LightGBM

Hyperparameter Tuning

In [29]:

```
from lightgbm import LGBMRegressor
from sklearn.model_selection import RandomizedSearchCV
param = {'n_estimators':  [5,10,50,100,200,500,1000] ,
             'max_depth' :  [2,3,4,5,6,7,8,9,10] ,
             'reg_lambda':  [0.05,0.5,0,1,2] ,
             'reg_alpha' :  [0.05,0.5,0,1,2] ,
             'learning_rate':  [0.005,0.05,0.5,0.1]}


estimator = lgb.LGBMRegressor()
clf= RandomizedSearchCV(estimator, param_distributions=param, scoring='neg_mean_squared_error', cv=
5, verbose=1)
#clf.fit(X_train,y_train)
#clf.best_params_, clf.best_score_
```

In [30]:

```
clf.fit(X_train, y_train)
print('Best score reached: {} with params: {} '.format(clf.best_score_, clf.best_params_))
```

```
Fitting 5 folds for each of 10 candidates, totalling 50 fits
```

```
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done  50 out of  50 | elapsed:  2.8min finished
```

```
Best score reached: -1.6064828551920822 with params: {'reg_lambda': 1, 'reg_alpha': 0.05,
'n_estimators': 500, 'max_depth': 8, 'learning_rate': 0.1}
```

In [31]:

```
#https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
a=clf.best_params_['n_estimators']
p = clf.best_params_['max_depth']
q = clf.best_params_['reg_lambda']
r = clf.best_params_['reg_alpha']
s = clf.best_params_['learning_rate']
print(clf.best_score_)
print(a)
print(p)
print(q)
print(r)
print(s)
```

```
-1.6064828551920822
500
8
1
0.05
0.1
```

In [32]:

```
#Calculating y_train_pred and y_test_pred
y_train_pred = clf.predict(X_train)
y_test_pred = clf.predict(X_test)
```

In [33]:

```
#Calculating rsme and mape scores by using the utility function
rmse_train = root_mean_squared_error(np.mean(y_train), y_train_pred)
rmse_test = root_mean_squared_error(np.mean(y_test), y_test_pred)
```

In [34]:

```
print('Train RMSE : ', rmse_train)
print('\n'+'-'*45)
print('Test RMSE : ', rmse_test)
```

```
Train RMSE :  0.19503661136870817

---------------------------------------------
Test RMSE :  0.18523077930954995
```

In [35]:

```
# Train new model
first_LG = LGBMRegressor(max_depth=p, n_estimators=a, learning_rate = s, reg_lambda = q, reg_alpha
= r, class_weight='balanced')
first_LG.fit(X_train,y_train)
```

Out[35]:

```
LGBMRegressor(boosting_type='gbdt', class_weight='balanced',
              colsample_bytree=1.0, importance_type='split', learning_rate=0.1,
              max_depth=8, min_child_samples=20, min_child_weight=0.001,
              min_split_gain=0.0, n_estimators=500, n_jobs=-1, num_leaves=31,
              objective=None, random_state=None, reg_alpha=0.05, reg_lambda=1,
              silent=True, subsample=1.0, subsample_for_bin=200000,
              subsample_freq=0)
```

In [37]:

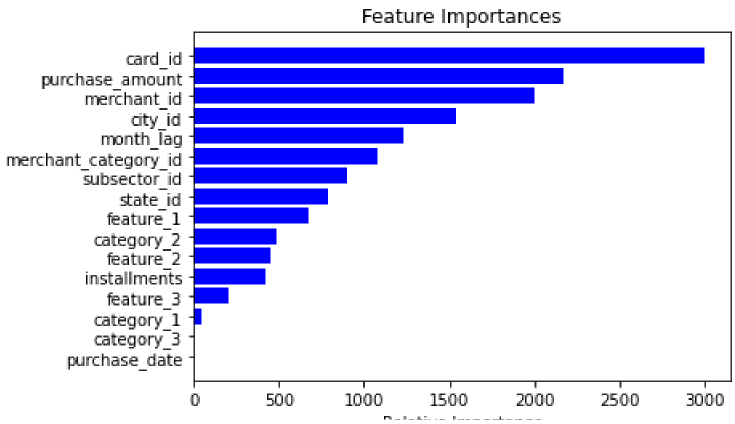
```
# display the relative importance of each attribute
importances = first_LG.feature_importances_
#Sort it
print ("Sorted Feature Importance:")
sorted_feature_importance = sorted(zip(importances, list(X_train)), reverse=True)
print (sorted_feature_importance)
```

```
Sorted Feature Importance:
[(3004, 'card_id'), (2174, 'purchase_amount'), (2008, 'merchant_id'), (1546, 'city_id'), (1231, 'm
onth_lag'), (1077, 'merchant_category_id'), (904, 'subsector_id'), (785, 'state_id'), (674,
'feature_1'), (484, 'category_2'), (447, 'feature_2'), (418, 'installments'), (200, 'feature_3'),
(47, 'category_1'), (1, 'category_3'), (0, 'purchase_date')]
```

In [38]:

```
features = list(X_train)
importances = first_LG.feature_importances_
indices = np.argsort(importances)

plt.title('Feature Importances')
plt.barh(range(len(indices)), importances[indices], color='b', align='center')
plt.yticks(range(len(indices)), [features[i] for i in indices])
plt.xlabel('Relative Importance')
plt.show()
```



Relative Importance

In [37]:

```
from prettytable import PrettyTable

tb = PrettyTable()
tb.field_names= ("Model", "Test- MSE")
tb.add_row(["Randomised Model", "1.283"])
tb.add_row(["Random Forest", "0.088"])
tb.add_row(["XGBoost", "0.488",])
tb.add_row(["LightGBM", "0.185"])
print(tb.get_string(titles = "Regression Models- Observations"))
#print(tb)
```

```
+------------------+-----------+
|      Model       | Test- MSE |
+------------------+-----------+
| Randomised Model |   1.283   |
|  Random Forest   |   0.088   |
|     XGBoost      |   0.488   |
|     LightGBM     |   0.185   |
+------------------+-----------+
```