

```
# Basic imports
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
# ML imports
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from imblearn.over_sampling import SMOTE
from sklearn.linear_model import LogisticRegression
from sklearn.ensemble import RandomForestClassifier
from xgboost import XGBClassifier
from sklearn.metrics import accuracy_score, precision_score, recall_score, f1_score, roc_auc_score, confusion_matrix
import joblib
import warnings
warnings.filterwarnings("ignore")

RND = 42 # random state for reproducibility
```

```
from google.colab import files
uploaded = files.upload()
```

No file chosen Upload widget is only available when the cell has been executed in the current browser session. Please rerun this cell to enable.

Saving support_data.csv to support_data.csv
 Saving usage_data.csv to usage_data.csv
 Saving customer_profile.csv to customer_profile.csv
 Saving churn_label.csv to churn_label.csv
 Saving billing_data.csv to billing_data.csv

```
# Load CSVs
profile = pd.read_csv('customer_profile.csv')
usage = pd.read_csv('usage_data.csv')
billing = pd.read_csv('billing_data.csv')
support = pd.read_csv('support_data.csv')
churn = pd.read_csv('churn_label.csv')
```

```
# Merge step-by-step
df = profile.merge(usage, on='customer_id', how='left') \
    .merge(billing, on='customer_id', how='left') \
    .merge(support, on='customer_id', how='left') \
    .merge(churn, on='customer_id', how='left')
```

```
# Keeping customer_id separately for final results
customer_ids = df['customer_id'].copy()
```

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1000 entries, 0 to 999
Data columns (total 24 columns):
 #   Column           Non-Null Count  Dtype  
 ---  -- 
 0   customer_id     1000 non-null   object  
 1   join_date       1000 non-null   datetime64[ns]
 2   age              1000 non-null   int64  
 3   gender           1000 non-null   object  
 4   region           1000 non-null   object  
 5   plan_type        1000 non-null   object  
 6   device_type      1000 non-null   object  
 7   avg_monthly_sessions 1000 non-null   int64  
 8   last_30_day_sessions 1000 non-null   int64  
 9   last_7_day_sessions 1000 non-null   int64  
 10  feature_usage_score 1000 non-null   float64 
 11  inactivity_days 1000 non-null   int64  
 12  engagement_drop_pct 1000 non-null   float64 
 13  tenure_months   1000 non-null   int64  
 14  renewal_status   1000 non-null   object  
 15  last_payment_date 1000 non-null   datetime64[ns]
 16  payment_failed_count 1000 non-null   int64  
 17  plan_changes     1000 non-null   int64  
 18  monthly_revenue   1000 non-null   int64  
 19  complaint_count   1000 non-null   int64  
 20  avg_resolution_time 1000 non-null   float64 
 21  negative_sentiment_score 1000 non-null   float64
```

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22 last_complaint_category    717 non-null   object
23 churn                      1000 non-null  int64
dtypes: datetime64[ns](2), float64(4), int64(11), object(7)
memory usage: 187.6+ KB

```

Cleaning and handling missing values

```

# Convert dates to datetime
df['join_date'] = pd.to_datetime(df['join_date'], errors='coerce')
df['last_payment_date'] = pd.to_datetime(df['last_payment_date'], errors='coerce')

# Fill numeric NaNs with median
num_cols = df.select_dtypes(include=['int64','float64']).columns
df[num_cols] = df[num_cols].fillna(df[num_cols].median())

# Fill categorical NaNs with 'Unknown'
cat_cols = df.select_dtypes(include=['object']).columns.drop('customer_id')
df[cat_cols] = df[cat_cols].fillna('Unknown')

```

```
df.info()
```

```

<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1000 entries, 0 to 999
Data columns (total 24 columns):
 #   Column            Non-Null Count  Dtype  
--- 
 0   customer_id      1000 non-null   object  
 1   join_date        1000 non-null   datetime64[ns]
 2   age              1000 non-null   int64   
 3   gender           1000 non-null   object  
 4   region           1000 non-null   object  
 5   plan_type        1000 non-null   object  
 6   device_type      1000 non-null   object  
 7   avg_monthly_sessions 1000 non-null  int64   
 8   last_30_day_sessions 1000 non-null  int64   
 9   last_7_day_sessions 1000 non-null  int64   
 10  feature_usage_score 1000 non-null  float64 
 11  inactivity_days 1000 non-null   int64   
 12  engagement_drop_pct 1000 non-null  float64 
 13  tenure_months   1000 non-null   int64   
 14  renewal_status   1000 non-null   object  
 15  last_payment_date 1000 non-null   datetime64[ns]
 16  payment_failed_count 1000 non-null  int64   
 17  plan_changes     1000 non-null   int64   
 18  monthly_revenue  1000 non-null   int64   
 19  complaint_count  1000 non-null   int64   
 20  avg_resolution_time 1000 non-null  float64 
 21  negative_sentiment_score 1000 non-null  float64 
 22  last_complaint_category 1000 non-null   object  
 23  churn            1000 non-null   int64  
dtypes: datetime64[ns](2), float64(4), int64(11), object(7)
memory usage: 187.6+ KB

```

```
#encode categorical values
categorical_cols = ['gender','region','plan_type','device_type','renewal_status','last_complaint_category']
df = pd.get_dummies(df, columns=[c for c in categorical_cols if c in df.columns], drop_first=True)
```

```
df.info()
```

```

<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1000 entries, 0 to 999
Data columns (total 31 columns):
 #   Column            Non-Null Count  Dtype  
--- 
 0   customer_id      1000 non-null   object  
 1   join_date        1000 non-null   datetime64[ns]
 2   age              1000 non-null   int64   
 3   avg_monthly_sessions 1000 non-null  int64   
 4   last_30_day_sessions 1000 non-null  int64   
 5   last_7_day_sessions 1000 non-null  int64   
 6   feature_usage_score 1000 non-null  float64 
 7   inactivity_days 1000 non-null   int64   
 8   engagement_drop_pct 1000 non-null  float64 
 9   tenure_months   1000 non-null   int64   
 10  last_payment_date 1000 non-null   datetime64[ns]
 11  payment_failed_count 1000 non-null  int64   
 12  plan_changes     1000 non-null   int64  
 13  gender_Female    1000 non-null   object  
 14  gender_Male      1000 non-null   object  
 15  region_Central   1000 non-null   object  
 16  region_East      1000 non-null   object  
 17  region_North     1000 non-null   object  
 18  region_South     1000 non-null   object  
 19  plan_type_Mobile 1000 non-null   object  
 20  plan_type_Smart 1000 non-null   object  
 21  device_type_Laptop 1000 non-null   object  
 22  device_type_Tablet 1000 non-null   object  
 23  renewal_status_Active 1000 non-null  int64  
 24  renewal_status_Inactive 1000 non-null  int64  
 25  last_complaint_category_0 1000 non-null  object  
 26  last_complaint_category_1 1000 non-null  object  
 27  churn_No         1000 non-null   object  
 28  churn_Yes        1000 non-null   object  

```

```

13 monthly_revenue           1000 non-null   int64
14 complaint_count          1000 non-null   int64
15 avg_resolution_time      1000 non-null   float64
16 negative_sentiment_score 1000 non-null   float64
17 churn                     1000 non-null   int64
18 gender_Male               1000 non-null   bool
19 gender_Other              1000 non-null   bool
20 region_North              1000 non-null   bool
21 region_South              1000 non-null   bool
22 region_West               1000 non-null   bool
23 plan_type_Premium         1000 non-null   bool
24 plan_type_Standard        1000 non-null   bool
25 device_type_Mobile        1000 non-null   bool
26 device_type_Tablet        1000 non-null   bool
27 renewal_status_Manual    1000 non-null   bool
28 last_complaint_category_Service 1000 non-null   bool
29 last_complaint_category_Technical 1000 non-null   bool
30 last_complaint_category_Unknown 1000 non-null   bool
dtypes: bool(13), datetime64[ns](2), float64(4), int64(11), object(1)
memory usage: 153.4+ KB

```

Feature Engineering

```

today = pd.Timestamp.today()

# Days since join / last payment
df['days_since_join'] = (today - df['join_date']).dt.days
df['days_since_payment'] = (today - df['last_payment_date']).dt.days

# Engagement & session features
df['sessions_7_to_30_ratio'] = df['last_7_day_sessions'] / (df['last_30_day_sessions'] + 1)
df['session_change_pct'] = ((df['last_7_day_sessions'] - df['avg_monthly_sessions']) / (df['avg_monthly_sessions'] + 1)) * 100
df['inactivity_proportion'] = df['inactivity_days'] / 30
df['feature_use_per_session'] = df['feature_usage_score'] / (df['avg_monthly_sessions'] + 1)

```

```

# Billing / risk features
df['payment_risk'] = df['payment_failed_count'] / (df['tenure_months'] + 1)
df['revenue_engagement_gap'] = df['monthly_revenue'] / (df['avg_monthly_sessions'] + 1)
df['complaints_per_month'] = df['complaint_count'] / (df['tenure_months'] + 1)
df['sentiment_adjusted_complaints'] = df['complaint_count'] * df['negative_sentiment_score']
df['support_pain_score'] = df['avg_resolution_time'] * df['negative_sentiment_score']
df['tenure_risk'] = 1 / (df['tenure_months'] + 1)
df['price_sensitivity'] = df['plan_changes'] / (df['tenure_months'] + 1)

```

```

# Drop raw date columns
df.drop(['join_date', 'last_payment_date'], axis=1, inplace=True)

```

```
df.info()
```

```

<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1000 entries, 0 to 999
Data columns (total 42 columns):
 #   Column           Non-Null Count  Dtype  
--- 
 0   customer_id     1000 non-null   object 
 1   age              1000 non-null   int64  
 2   avg_monthly_sessions 1000 non-null   int64  
 3   last_30_day_sessions 1000 non-null   int64  
 4   last_7_day_sessions 1000 non-null   int64  
 5   feature_usage_score 1000 non-null   float64
 6   inactivity_days   1000 non-null   int64  
 7   engagement_drop_pct 1000 non-null   float64
 8   tenure_months     1000 non-null   int64  
 9   payment_failed_count 1000 non-null   int64  
 10  plan_changes      1000 non-null   int64  
 11  monthly_revenue   1000 non-null   int64  
 12  complaint_count   1000 non-null   int64  
 13  avg_resolution_time 1000 non-null   float64
 14  negative_sentiment_score 1000 non-null   float64
 15  churn             1000 non-null   int64  
 16  gender_Male       1000 non-null   bool  
 17  gender_Other      1000 non-null   bool  
 18  region_North      1000 non-null   bool  
 19  region_South      1000 non-null   bool  
 20  region_West       1000 non-null   bool  
 21  plan_type_Premium 1000 non-null   bool  
 22  plan_type_Standard 1000 non-null   bool 

```

```

23 device_type_Mobile           1000 non-null  bool
24 device_type_Tablet          1000 non-null  bool
25 renewal_status_Manual       1000 non-null  bool
26 last_complaint_category_Service 1000 non-null  bool
27 last_complaint_category_Technical 1000 non-null  bool
28 last_complaint_category_Unknown 1000 non-null  bool
29 days_since_join             1000 non-null  int64
30 days_since_payment          1000 non-null  int64
31 sessions_7_to_30_ratio      1000 non-null  float64
32 session_change_pct          1000 non-null  float64
33 inactivity_proportion       1000 non-null  float64
34 feature_use_per_session    1000 non-null  float64
35 payment_risk                1000 non-null  float64
36 revenue_engagement_gap     1000 non-null  float64
37 complaints_per_month        1000 non-null  float64
38 sentiment_adjusted_complaints 1000 non-null  float64
39 support_pain_score          1000 non-null  float64
40 tenure_risk                 1000 non-null  float64
41 price_sensitivity           1000 non-null  float64
dtypes: bool(13), float64(15), int64(13), object(1)
memory usage: 239.4+ KB

```

```

# Features and target
X = df.drop(['churn','customer_id']) if 'customer_id' in df.columns else ['churn'], axis=1)
y = df['churn'].astype(int)

```

Train-Test Split

```

X_train, X_test, y_train, y_test, cid_train, cid_test = train_test_split(
    X, y, customer_ids, test_size=0.2, stratify=y, random_state=RND
)

scaler = StandardScaler()
X_train_scaled = scaler.fit_transform(X_train)
X_test_scaled = scaler.transform(X_test)

#handling class imbalance with SMOTE
sm = SMOTE(random_state=RND)
X_train_bal, y_train_bal = sm.fit_resample(X_train_scaled, y_train)

```

Train Models

```

# Logistic Regression
log_reg = LogisticRegression(max_iter=2000, class_weight='balanced', random_state=RND)
log_reg.fit(X_train_bal, y_train_bal)

```

```

* LogisticRegression
LogisticRegression(class_weight='balanced', max_iter=2000, random_state=42)

```

```

# Random Forest
rf = RandomForestClassifier(n_estimators=300, class_weight='balanced', random_state=RND)
rf.fit(X_train_bal, y_train_bal)

```

```

* RandomForestClassifier
RandomForestClassifier(class_weight='balanced', n_estimators=300,
random_state=42)

```

```

# XGBoost
xgb_final = XGBClassifier(
    n_estimators=300, learning_rate=0.05, max_depth=5,
    subsample=0.8, colsample_bytree=0.8,
    objective='binary:logistic', eval_metric='logloss',
    use_label_encoder=False, random_state=RND
)
xgb_final.fit(X_train_bal, y_train_bal)

```

```
XGBClassifier(base_score=None, booster=None, callbacks=None,
   colsample_bylevel=None, colsample_bynode=None,
   colsample_bytree=0.8, device=None, early_stopping_rounds=None,
   enable_categorical=False, eval_metric='logloss',
   feature_types=None, feature_weights=None, gamma=None,
   grow_policy=None, importance_type=None,
   interaction_constraints=None, learning_rate=0.05, max_bin=None,
   max_cat_threshold=None, max_cat_to_onehot=None,
   max_delta_step=None, max_depth=5, max_leaves=None,
   min_child_weight=None, missing=np.nan, monotone_constraints=None,
   multi_strategy=None, n_estimators=300, n_jobs=None,
   num_parallel_tree=None, ...)
```

```
#evaluating the models
def eval_report(y_true, y_pred, y_prob, model_name):
    print(f"\n== {model_name} ==")
    print("Accuracy:", round(accuracy_score(y_true, y_pred),4))
    print("Precision:", round(precision_score(y_true, y_pred),4))
    print("Recall:", round(recall_score(y_true, y_pred),4))
    print("F1 Score:", round(f1_score(y_true, y_pred),4))
    print("ROC-AUC:", round(roc_auc_score(y_true, y_prob),4))
    print("Confusion Matrix:\n", confusion_matrix(y_true, y_pred))
```

```
# Predictions
#logistic regression
y_pred_lr = log_reg.predict(X_test_scaled)
y_prob_lr = log_reg.predict_proba(X_test_scaled)[:,1]
```

```
#random forest
y_pred_rf = rf.predict(X_test_scaled)
y_prob_rf = rf.predict_proba(X_test_scaled)[:,1]
```

```
#XGBoost
y_pred_xgb = xgb_final.predict(X_test_scaled)
y_prob_xgb = xgb_final.predict_proba(X_test_scaled)[:,1]
```

```
#evaluate
eval_report(y_test, y_pred_lr, y_prob_lr, "Logistic Regression")
eval_report(y_test, y_pred_rf, y_prob_rf, "Random Forest")
eval_report(y_test, y_pred_xgb, y_prob_xgb, "XGBoost")
```

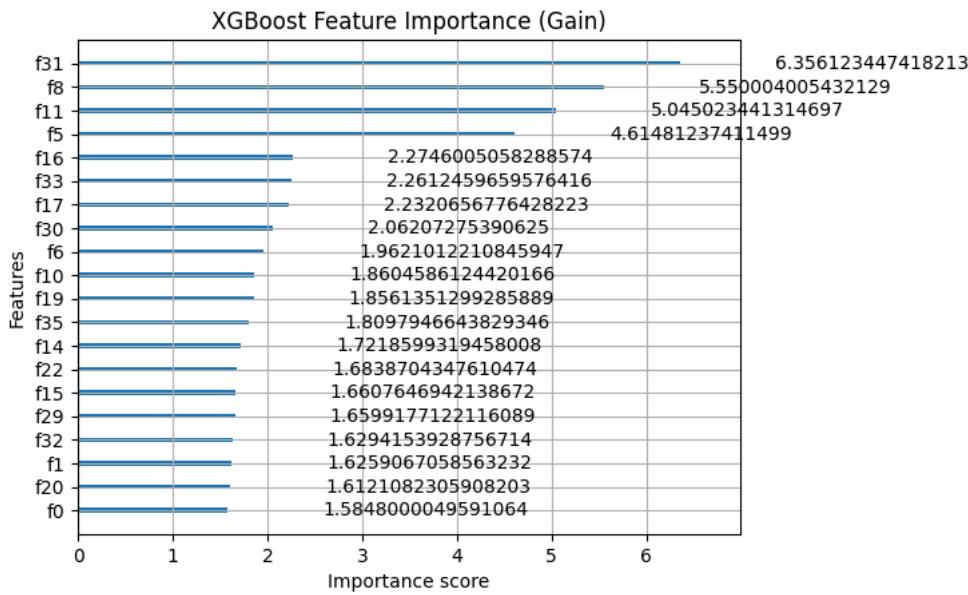
```
==== Logistic Regression ====
Accuracy: 0.735
Precision: 0.7946
Recall: 0.7479
F1 Score: 0.7706
ROC-AUC: 0.8079
Confusion Matrix:
[[58 23]
 [30 89]]
```

```
==== Random Forest ====
Accuracy: 0.77
Precision: 0.8288
Recall: 0.7731
F1 Score: 0.8
ROC-AUC: 0.8459
Confusion Matrix:
[[62 19]
 [27 92]]
```

```
==== XGBoost ====
Accuracy: 0.79
Precision: 0.8667
Recall: 0.7647
F1 Score: 0.8125
ROC-AUC: 0.858
Confusion Matrix:
[[67 14]
 [28 91]]
```

As per the above evaluation, we can see that XGBoost has the most accuracy and precision. So now we'll do feature importance for XGBoost

```
import xgboost as xgb
xgb.plot_importance(xgb_final, importance_type='gain', max_num_features=20)
plt.title("XGBoost Feature Importance (Gain)")
plt.show()
```



```
#prediction of top 20 customers who are most likely to churn
final_results = pd.DataFrame({
    'customer_id': cid_test.values,
    'actual_churn': y_test.values,
    'predicted_churn': y_pred_xgb,
    'churn_probability': y_prob_xgb
})
top_churners = final_results.sort_values(by='churn_probability', ascending=False).reset_index(drop=True)
top_churners.head(20)
```

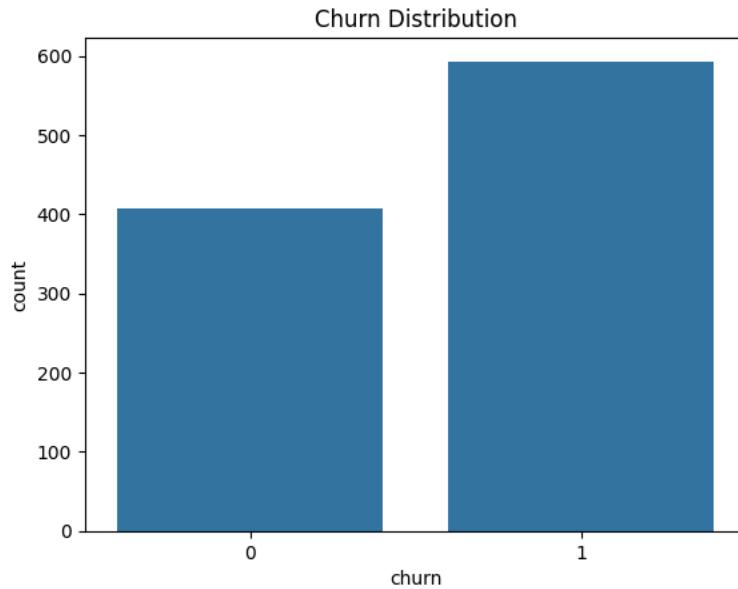
	customer_id	actual_churn	predicted_churn	churn_probability
0	C00978	1	1	0.998749
1	C00831	1	1	0.998031
2	C00874	1	1	0.997370
3	C00695	1	1	0.997316
4	C00604	1	1	0.997300
5	C00223	1	1	0.997279
6	C00188	1	1	0.996610
7	C00205	1	1	0.995920
8	C00854	1	1	0.995815
9	C00379	1	1	0.995759
10	C00576	1	1	0.995724
11	C00813	1	1	0.995177
12	C00340	1	1	0.993665
13	C00464	1	1	0.993460
14	C00380	1	1	0.993040
15	C00227	0	1	0.992648
16	C00433	1	1	0.992552
17	C00302	1	1	0.992124
18	C00289	1	1	0.990299
19	C00210	1	1	0.988677

```
#saving models and results
joblib.dump(log_reg, "log_reg_model.joblib")
joblib.dump(rf, "rf_model.joblib")
joblib.dump(xgb_final, "xgb_model.joblib")
joblib.dump(scaler, "scaler.joblib")
final_results.to_csv("final_churn_predictions.csv", index=False)
```

```
#saving into the system
from google.colab import files

files.download("log_reg_model.joblib")
files.download("rf_model.joblib")
files.download("xgb_model.joblib")
files.download("scaler.joblib")
files.download("final_churn_predictions.csv")
```

```
#churn distribution
sns.countplot(data=df, x='churn')
plt.title("Churn Distribution")
plt.show()
```



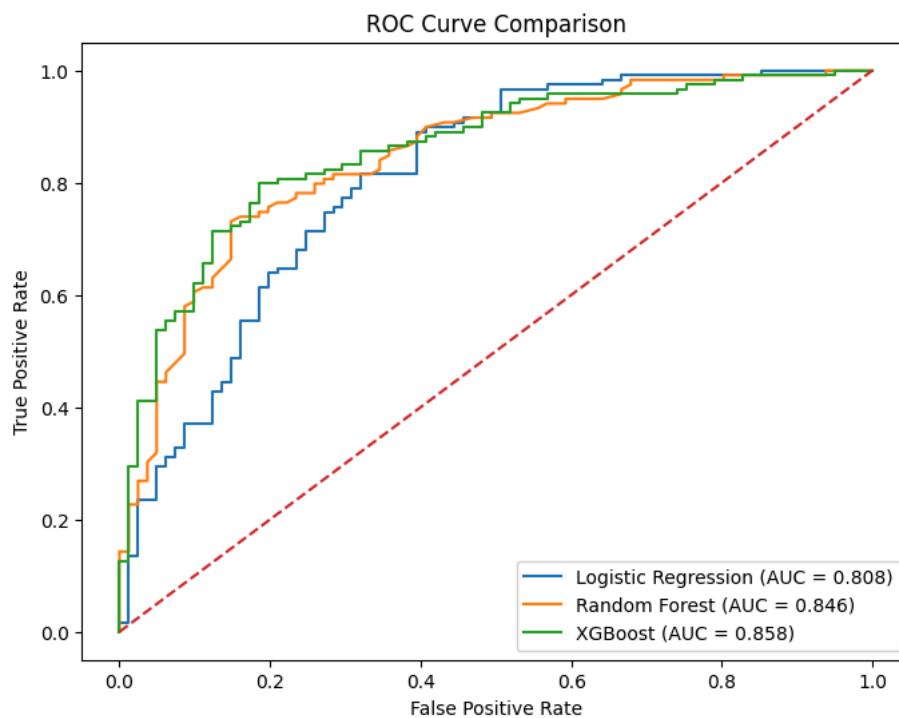
```
#ROC curve comparison
from sklearn.metrics import roc_curve, auc

models = {
    "Logistic Regression": (y_test, y_prob_lr),
    "Random Forest": (y_test, y_prob_rf),
    "XGBoost": (y_test, y_prob_xgb)
}

plt.figure(figsize=(8,6))

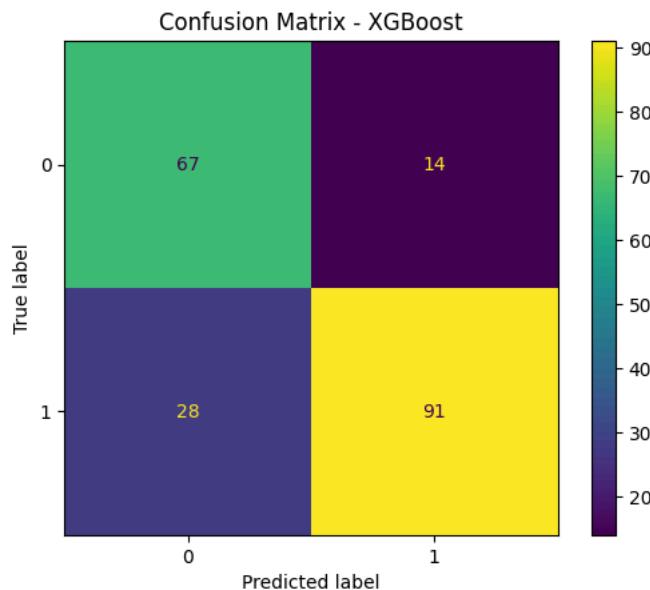
for model_name, (true, prob) in models.items():
    fpr, tpr, _ = roc_curve(true, prob)
    auc_score = auc(fpr, tpr)
    plt.plot(fpr, tpr, label=f"{model_name} (AUC = {auc_score:.3f})")

plt.plot([0,1],[0,1], '--')
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
plt.title("ROC Curve Comparison")
plt.legend()
plt.show()
```



```
#XGBoost confusion matrix
from sklearn.metrics import ConfusionMatrixDisplay

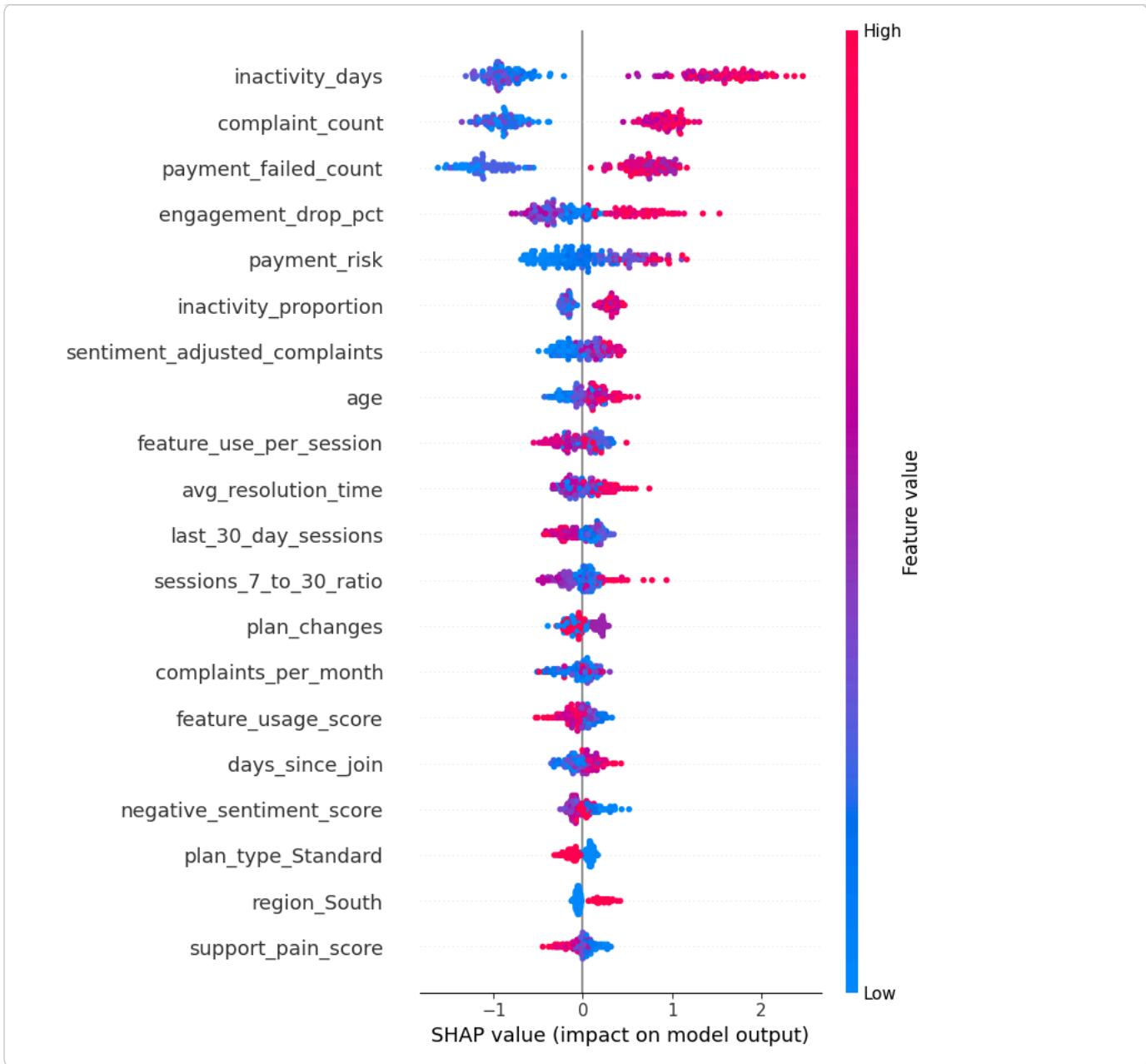
ConfusionMatrixDisplay.from_estimator(xgb_final, X_test_scaled, y_test)
plt.title("Confusion Matrix - XGBoost")
plt.show()
```



```
#shap summary plot
import shap

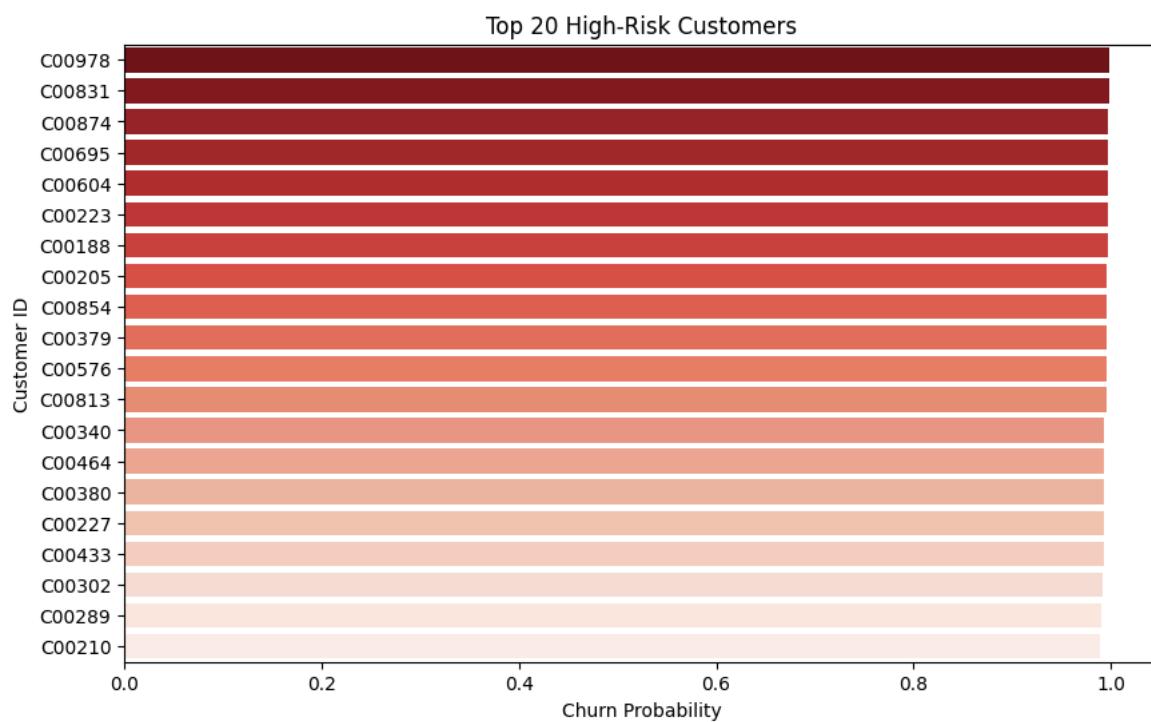
explainer = shap.TreeExplainer(xgb_final)
shap_values = explainer.shap_values(X_test_scaled)

shap.summary_plot(shap_values, X_test, plot_type="dot")
```



```
#top churners
top20 = final_results.sort_values(by="churn_probability", ascending=False).head(20)

plt.figure(figsize=(10,6))
sns.barplot(x="churn_probability", y="customer_id", data=top20, palette="Reds_r")
plt.title("Top 20 High-Risk Customers")
plt.xlabel("Churn Probability")
plt.ylabel("Customer ID")
plt.show()
```



```
# Export the full cleaned + feature engineered dataset  
df_with_id = df.copy() # your final DF with customer_id preserved  
df_with_id.to_csv("full_feature_dataset.csv", index=False)
```

```
final_results.to_csv("final_churn_predictions.csv", index=False)
```