TELCO CUSTOMER CHURN: IBM SAMPLE DATASET

	customerID	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	\
0	7590-VHVEG	Female	0	Yes	No	1	No	
1	5575-GNVDE	Male	0	No	No	34	Yes	
2	3668-QPYBK	Male	0	No	No	2	Yes	
3	7795-CFOCW	Male	0	No	No	45	No	
4	9237-HQITU	Female	0	No	No	2	Yes	

	MultipleLines	InternetService	OnlineSecurity	...	DeviceProtection	\
0	No phone service	DSL	No	...	No	
1	No	DSL	Yes	...	Yes	
2	No	DSL	Yes	...	No	
3	No phone service	DSL	Yes	...	Yes	
4	No	Fiber optic	No	...	No	

	TechSupport	StreamingTV	StreamingMovies	Contract	PaperlessBilling	\
0	No	No	No	Month-to-month	Yes	
1	No	No	No	One year	No	
2	No	No	No	Month-to-month	Yes	
3	Yes	No	No	One year	No	
4	No	No	No	Month-to-month	Yes	

	PaymentMethod	MonthlyCharges	TotalCharges	Churn
0	Electronic check	29.85	29.85	No
1	Mailed check	56.95	1889.5	No
2	Mailed check	53.85	108.15	Yes
3	Bank transfer (automatic)	42.30	1840.75	No
4	Electronic check	70.70	151.65	Yes

[5 rows x 21 columns]

```
CHECK FOR COLUMN DATATYPES:
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 7043 entries, 0 to 7042
Data columns (total 21 columns):
 #   Column            Non-Null Count  Dtype
---  ------            --------------  -----
 0   customerID        7043 non-null   object
 1   gender            7043 non-null   object
 2   SeniorCitizen     7043 non-null   int64
 3   Partner           7043 non-null   object
 4   Dependents        7043 non-null   object
 5   tenure            7043 non-null   int64
 6   PhoneService      7043 non-null   object
 7   MultipleLines     7043 non-null   object
 8   InternetService   7043 non-null   object
 9   OnlineSecurity    7043 non-null   object
 10  OnlineBackup      7043 non-null   object
 11  DeviceProtection  7043 non-null   object
 12  TechSupport       7043 non-null   object
 13  StreamingTV       7043 non-null   object
 14  StreamingMovies   7043 non-null   object
 15  Contract          7043 non-null   object
 16  PaperlessBilling  7043 non-null   object
 17  PaymentMethod     7043 non-null   object
 18  MonthlyCharges    7043 non-null   float64
 19  TotalCharges      7043 non-null   object
 20  Churn             7043 non-null   object
dtypes: float64(1), int64(2), object(18)
memory usage: 1.1+ MB


'TotalCharges' data type is string, which is weird.
Blank strings might be the reason why it cannot be converted to float.
--------------------------------------------------
```

```
CHECK FOR DATAFRAME TOTAL NULL VALUES:
customerID          0
gender              0
SeniorCitizen       0
Partner             0
Dependents          0
tenure              0
PhoneService        0
MultipleLines       0
InternetService     0
OnlineSecurity      0
OnlineBackup        0
DeviceProtection    0
TechSupport         0
StreamingTV         0
StreamingMovies     0
Contract            0
PaperlessBilling    0
PaymentMethod       0
MonthlyCharges      0
TotalCharges        0
Churn               0
dtype: int64

NOTE: Blank strings can be classified as not null.
--------------------------------------------------
```

```
Blank strings in 'TotalCharges' are replaced with NaN

CHECK FOR DATAFRAME TOTAL NULL VALUES:
customerID           0
gender               0
SeniorCitizen        0
Partner              0
Dependents           0
tenure               0
PhoneService         0
MultipleLines        0
InternetService      0
OnlineSecurity       0
OnlineBackup         0
DeviceProtection     0
TechSupport          0
StreamingTV          0
StreamingMovies      0
Contract             0
PaperlessBilling     0
PaymentMethod        0
MonthlyCharges       0
TotalCharges        11
Churn                0
dtype: int64
Missing TotalCharges: 11 (less missing data are safe to drop)
--------------------------------------------------------------
```

```
'TotalCharges' datatype is converted to float

CHECK FOR COLUMN DATATYPES:
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 7043 entries, 0 to 7042
Data columns (total 21 columns):
 #   Column            Non-Null Count  Dtype
---  ------            --------------  -----
 0   customerID        7043 non-null   object
 1   gender            7043 non-null   object
 2   SeniorCitizen     7043 non-null   int64
 3   Partner           7043 non-null   object
 4   Dependents        7043 non-null   object
 5   tenure            7043 non-null   int64
 6   PhoneService      7043 non-null   object
 7   MultipleLines     7043 non-null   object
 8   InternetService   7043 non-null   object
 9   OnlineSecurity    7043 non-null   object
 10  OnlineBackup      7043 non-null   object
 11  DeviceProtection  7043 non-null   object
 12  TechSupport       7043 non-null   object
 13  StreamingTV       7043 non-null   object
 14  StreamingMovies   7043 non-null   object
 15  Contract          7043 non-null   object
 16  PaperlessBilling  7043 non-null   object
 17  PaymentMethod     7043 non-null   object
 18  MonthlyCharges    7043 non-null   float64
 19  TotalCharges      7032 non-null   float64
 20  Churn             7043 non-null   object
dtypes: float64(2), int64(2), object(17)
memory usage: 1.1+ MB
--------------------------------------------------
```

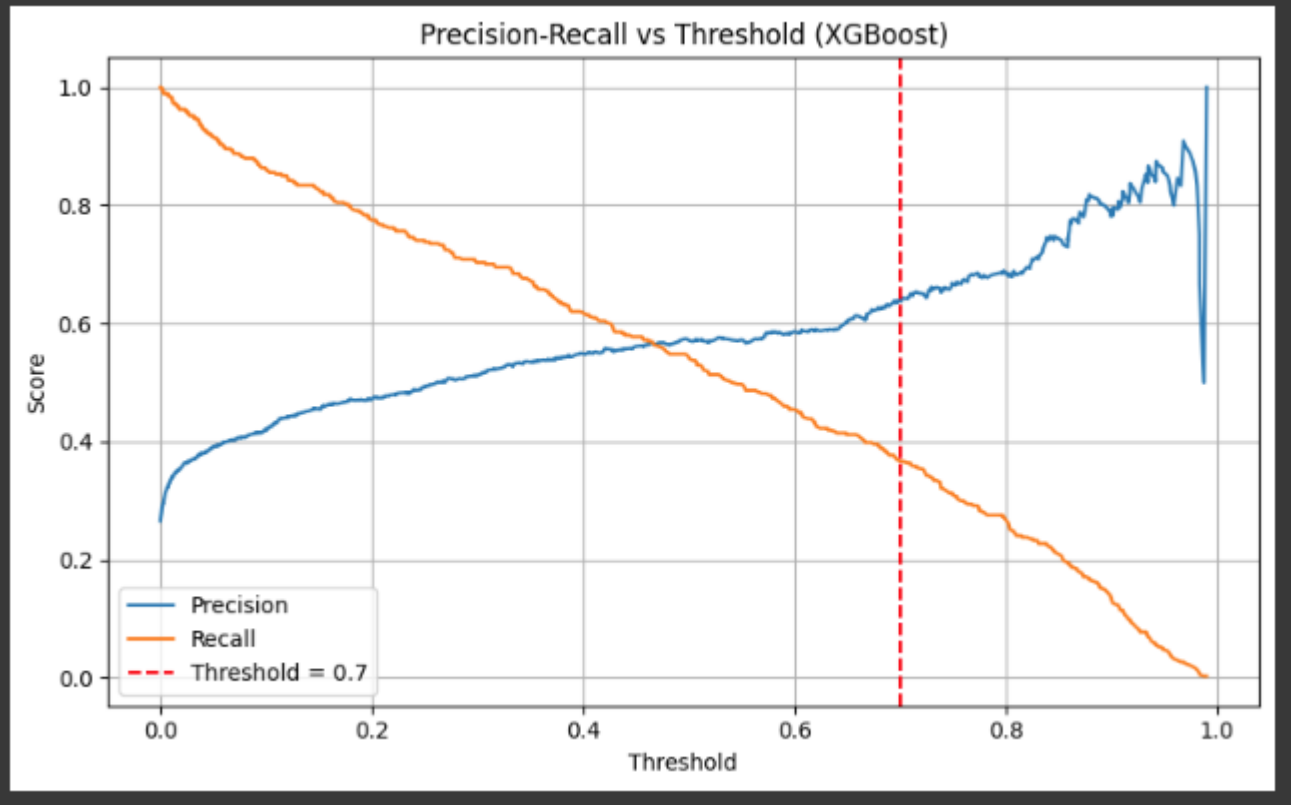
```
CHECK FOR DATAFRAME TOTAL NULL VALUES:
customerID          0
gender              0
SeniorCitizen       0
Partner             0
Dependents          0
tenure              0
PhoneService        0
MultipleLines       0
InternetService     0
OnlineSecurity      0
OnlineBackup        0
DeviceProtection    0
TechSupport         0
StreamingTV         0
StreamingMovies     0
Contract            0
PaperlessBilling    0
PaymentMethod       0
MonthlyCharges      0
TotalCharges        0
Churn               0
dtype: int64

 No Null values found
--------------------------------------------------
```

```
'customerID' dropped
----------------------------------------------------------

Redundancy reworked:
'MultipleLines': 'No phone service' is set to 'No'
'OnlineSecurity': 'No internet service' is set to 'No'
'OnlineBackup': 'No internet service' is set to 'No'
'DeviceProtection': 'No internet service' is set to 'No'
'TechSupport': 'No internet service' is set to 'No'
'StreamingTV': 'No internet service' is set to 'No'
'StreamingMovies': 'No internet service' is set to 'No'
'PaymentMethod': 'Bank transfer (automatic)' is set to 'Bank Transfer'
'Credit card (automatic)' is set to 'Credit Card'
'Contract': 'Month-to-month' is set to 'Month-To-Month',
'Contract': 'One year' is set to 'One Year',
'Contract': 'Two year' is set to 'Two Year'

----------------------------------------------------------
```

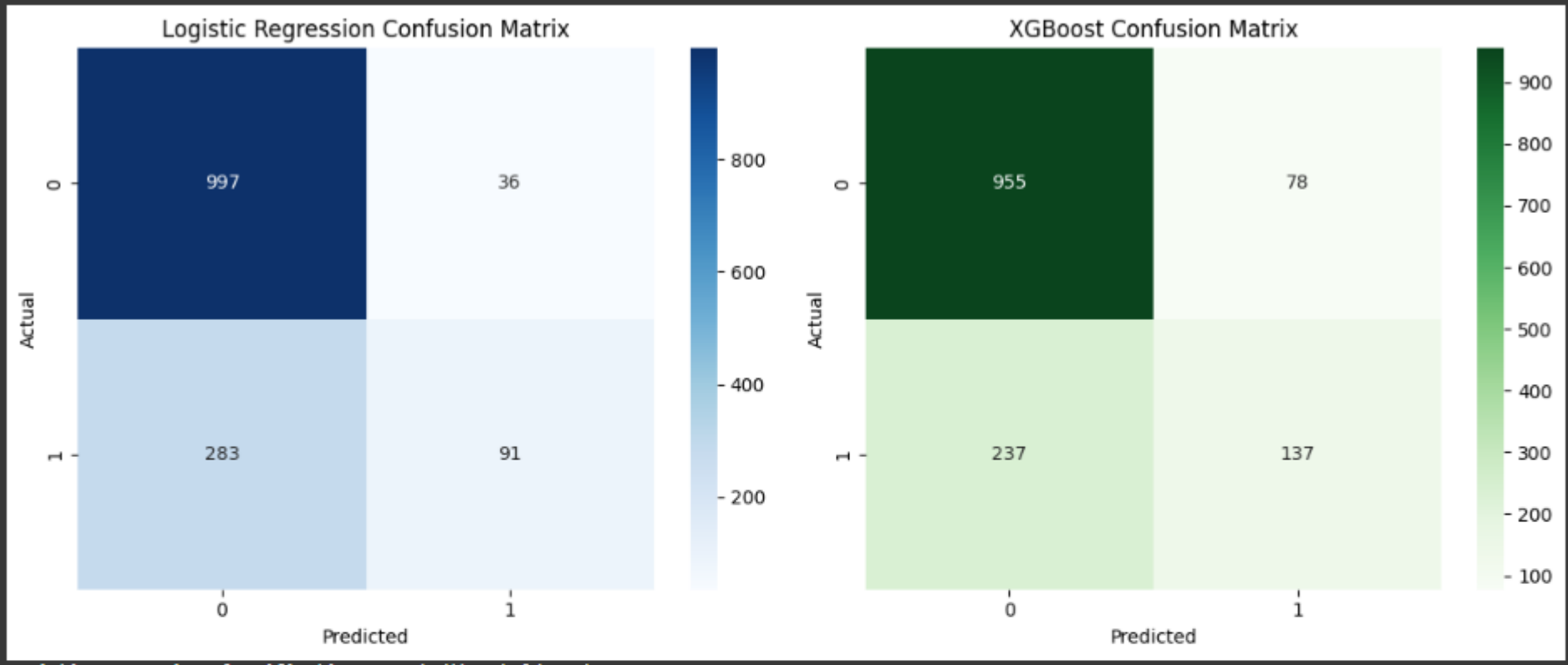
```
Before SMOTE:
 Churn
0    4130
1    1495
Name: count, dtype: int64
----------------------------------------------------------------------

Afer SMOTE:
 Churn
0    4130
1    4130
Name: count, dtype: int64
----------------------------------------------------------------------
```

XGBClassifier

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


Precision-Recall vs Threshold (XGBoost)
Score
Threshold
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0
Precision
Recall
Threshold = 0.7

```
XGBoost Accuracy:
 0.7761194029850746
------------------------------------------------------------
```




```
Logistic Regression Classification Report (threshold=0.7):
              precision    recall  f1-score   support

           0       0.78      0.97      0.86      1033
           1       0.72      0.24      0.36       374

    accuracy                           0.77      1407
   macro avg       0.75      0.60      0.61      1407
weighted avg       0.76      0.77      0.73      1407

------------------------------------------------------------

XGBoost Classification Report (threshold=0.7):
              precision    recall  f1-score   support

           0       0.80      0.92      0.86      1033
           1       0.64      0.37      0.47       374

    accuracy                           0.78      1407
   macro avg       0.72      0.65      0.66      1407
weighted avg       0.76      0.78      0.75      1407

------------------------------------------------------------
```

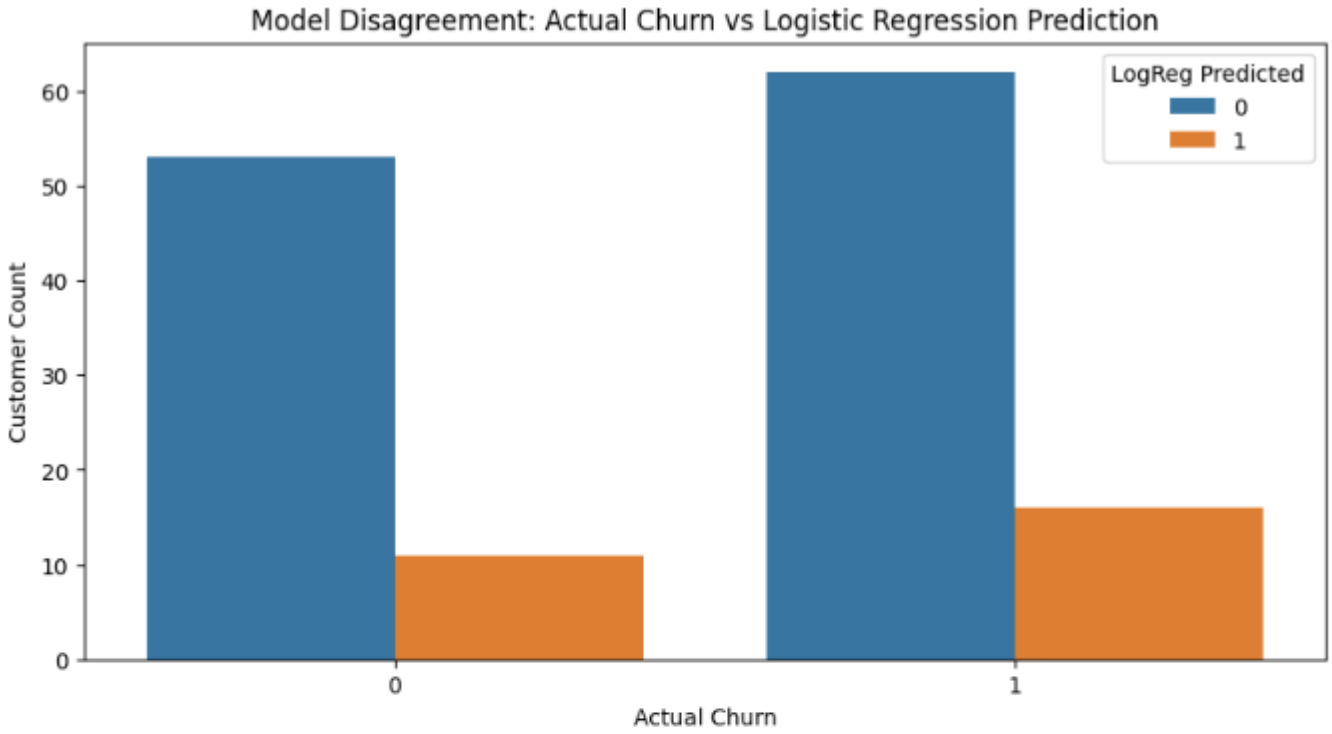
TOP 10 PREDICTIONS

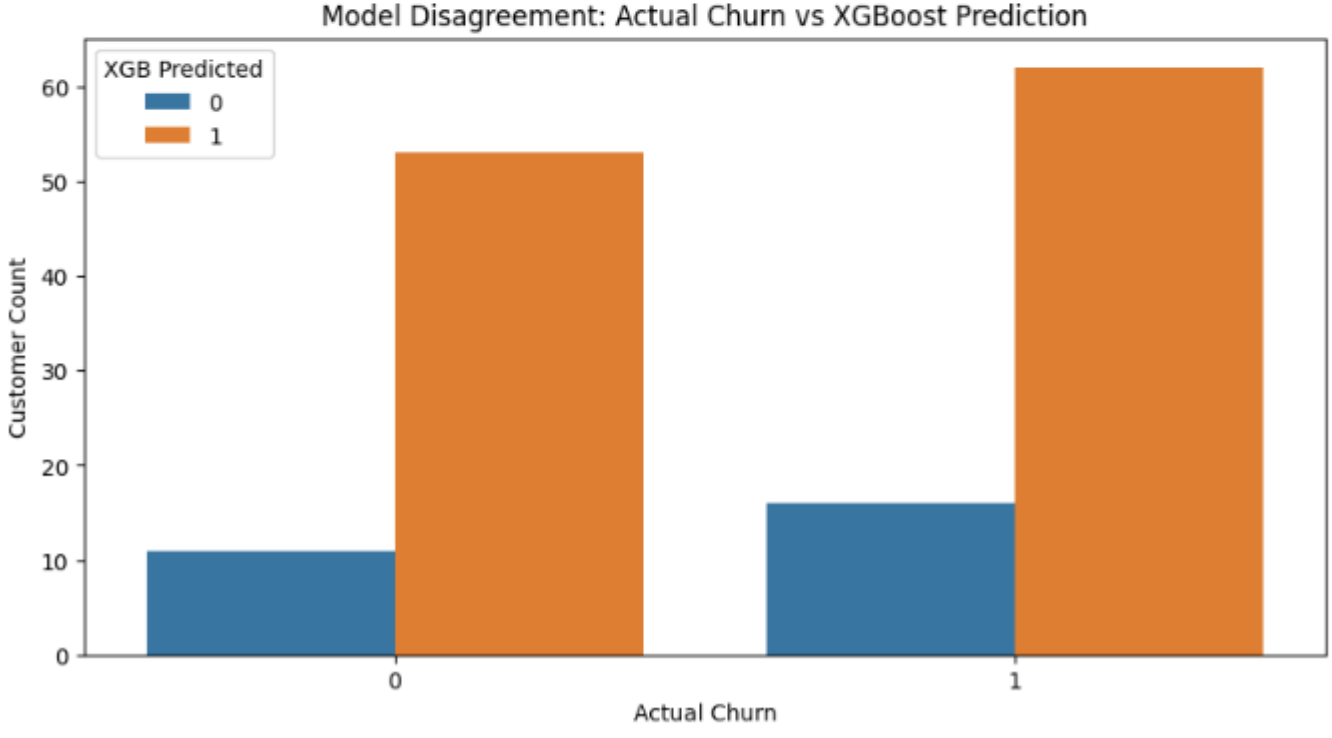
	Actual	LogReg_Predicted	LogReg_Probability	XGB_Predicted	XGB_Probability
0	0	0	0.014116	0	0.005628
1	0	0	0.616168	0	0.668626
2	0	0	0.005123	0	0.021080
3	1	0	0.296936	0	0.108084
4	0	0	0.109429	0	0.546587
5	1	0	0.513419	0	0.456047
6	0	0	0.024770	0	0.049399
7	0	0	0.240843	0	0.103120
8	1	0	0.681514	1	0.715994
9	0	0	0.012032	0	0.003061

Predictions saved to churn_predictions_threshold_0.7.csv

Customers with model disagreement:

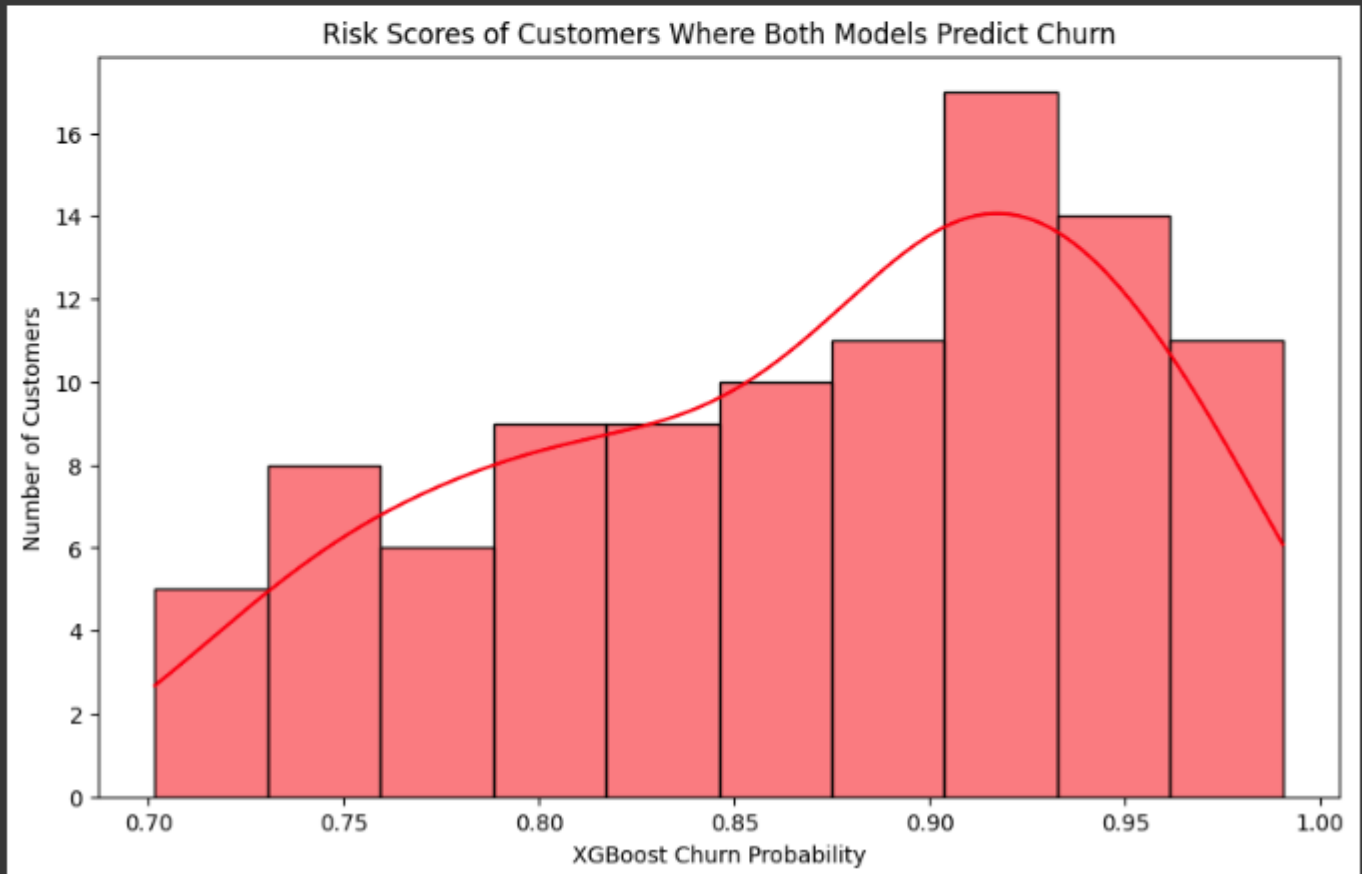
	Actual	LogReg_Predicted	LogReg_Probability	XGB_Predicted	XGB_Probability
8	1	0	0.681514	1	0.715994
10	0	1	0.741091	0	0.638119
12	0	0	0.690320	1	0.878543
32	0	0	0.386750	1	0.908299
53	1	0	0.624098	1	0.742643
76	0	0	0.491503	1	0.810211
91	1	1	0.710360	0	0.661225
107	0	0	0.621353	1	0.934654
108	0	1	0.716069	0	0.666903
109	1	0	0.597525	1	0.825495

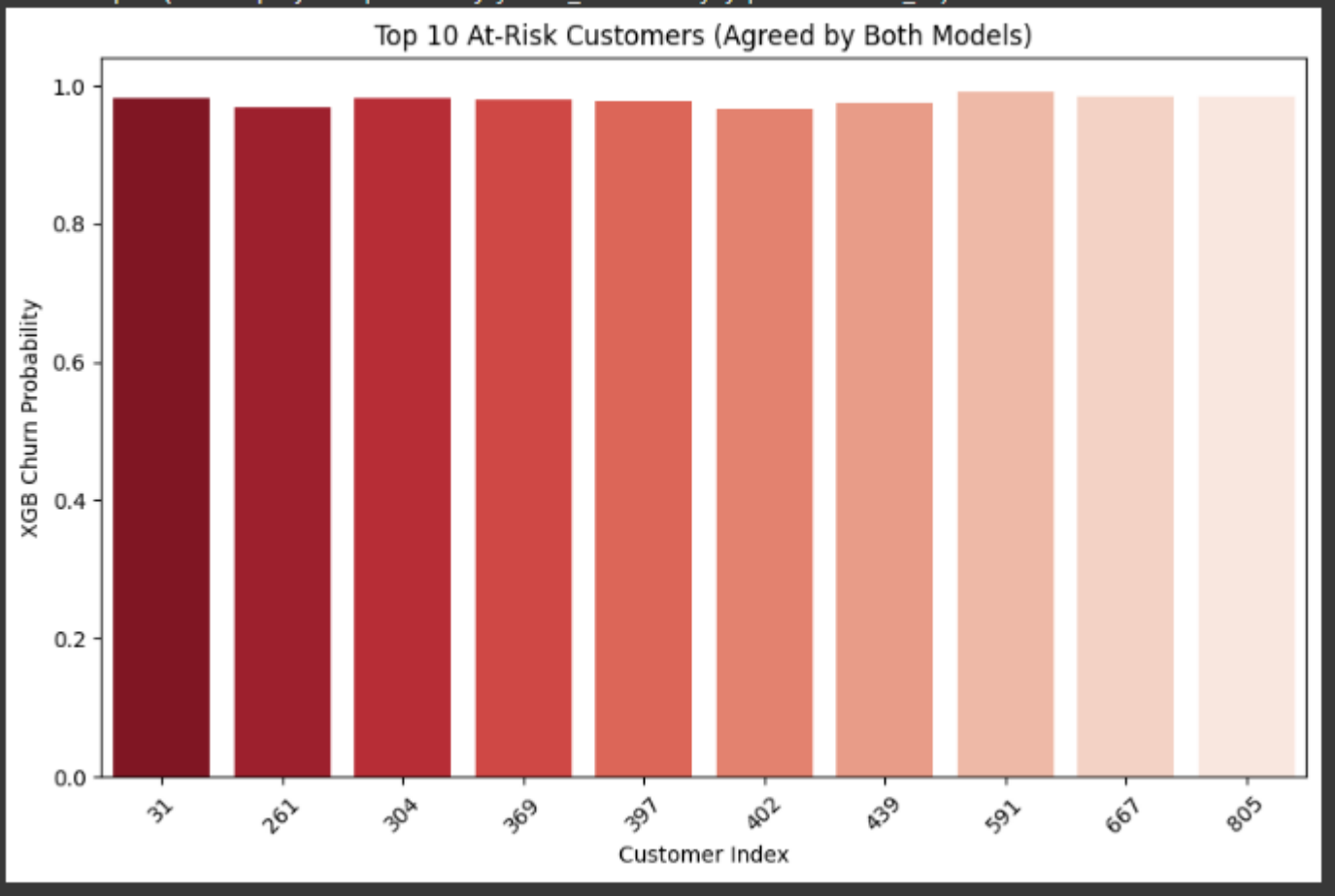

Model Disagreement: Actual Churn vs Logistic Regression Prediction
LogReg Predicted
0
1
Customer Count
0
10
20
30
40
50
60
0
1
Actual Churn


Model Disagreement: Actual Churn vs XGBoost Prediction
XGB Predicted
0
1
Customer Count
0
10
20
30
40
50
60
0
1
Actual Churn

Customers with high-confidence churn predictions (both models agree):

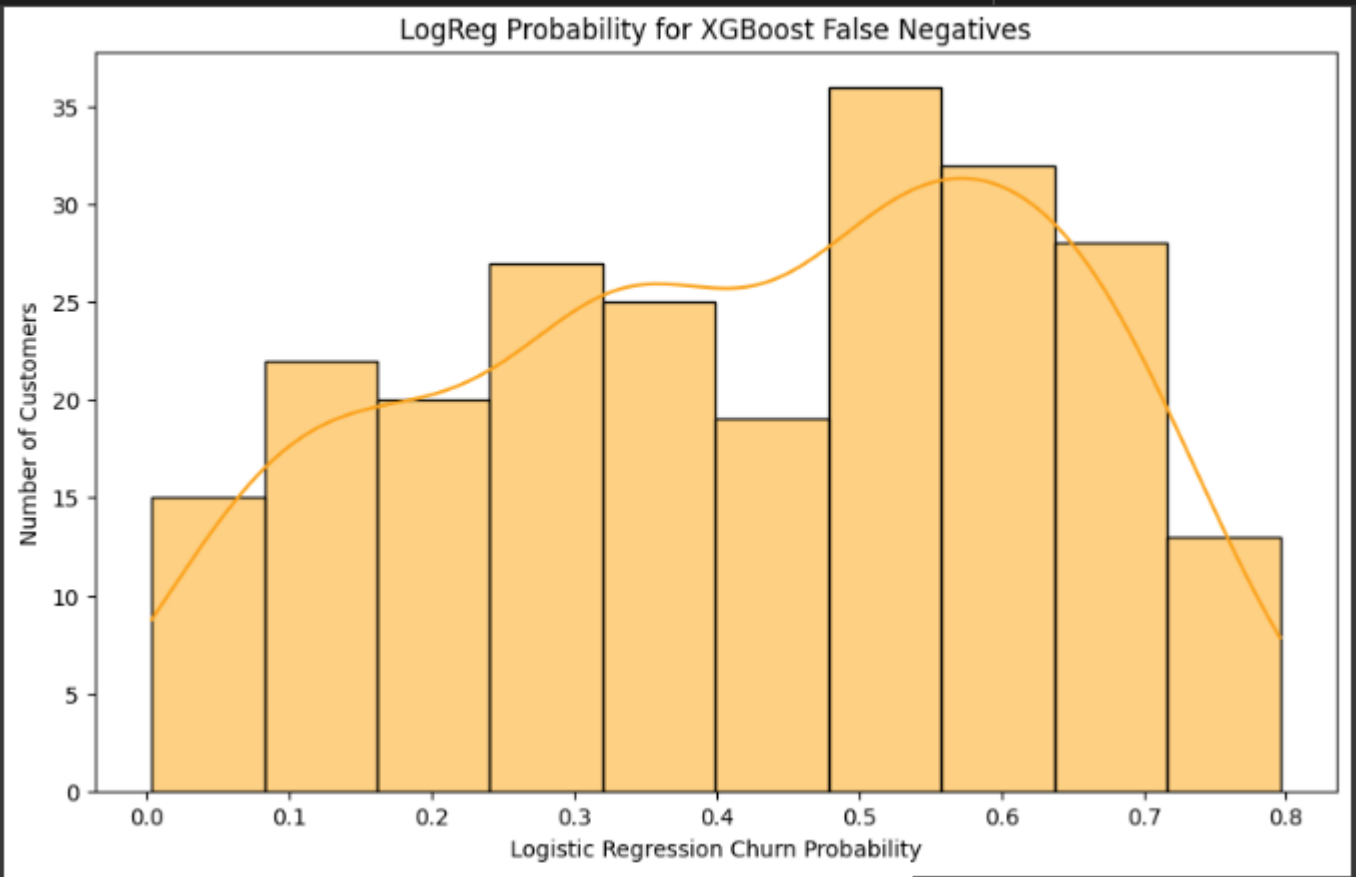
	Actual	LogReg_Predicted	LogReg_Probability	XGB_Predicted	XGB_Probability
591	1	1	0.827168	1	0.990364
805	1	1	0.793616	1	0.983712
667	1	1	0.748259	1	0.983559
31	1	1	0.755957	1	0.981304
304	1	1	0.754535	1	0.981304
369	1	1	0.781424	1	0.979757
397	1	1	0.776491	1	0.977343
439	1	1	0.814610	1	0.974331
261	1	1	0.757458	1	0.968428
402	0	1	0.735962	1	0.965864

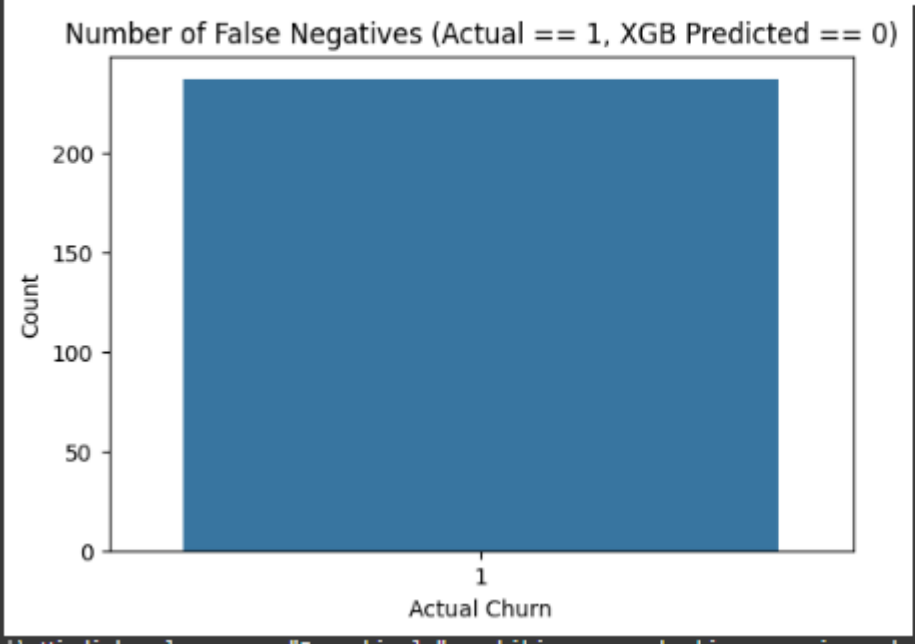



Top 10 At-Risk Customers (Agreed by Both Models)
XGB Churn Probability
1.0
0.8
0.6
0.4
0.2
0.0
31
261
304
369
397
402
439
591
667
805
Customer Index

False negatives (actual churn but model missed):

	Actual	LogReg_Predicted	LogReg_Probability	XGB_Predicted	XGB_Probability
3	1	0	0.296936	0	0.108084
5	1	0	0.513419	0	0.456047
14	1	0	0.171549	0	0.015584
16	1	0	0.657338	0	0.673382
17	1	0	0.595503	0	0.649206
23	1	0	0.153976	0	0.039058
25	1	0	0.412559	0	0.444015
29	1	0	0.309959	0	0.093763
38	1	0	0.304124	0	0.277071
73	1	0	0.371406	0	0.239424


LogReg Probability for XGBoost False Negatives
Number of Customers
0
5
10
15
20
25
30
35
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Logistic Regression Churn Probability


Number of False Negatives (Actual == 1, XGB Predicted == 0)
Count
0
50
100
150
200
1
Actual Churn

```
Common Categories in high-risk churners:

OnlineSecurity_No = 99.0% of high-risk customers are 'No'
Dependents_No = 94.0% of high-risk customers are 'No'
PhoneService_Yes = 93.0% of high-risk customers are 'Yes'
InternetService_Fiber optic = 93.0% of high-risk customers are 'Fiber optic'
OnlineBackup_No = 92.0% of high-risk customers are 'No'
PaperlessBilling_Yes = 88.0% of high-risk customers are 'Yes'
PaymentMethod_Electronic check = 87.0% of high-risk customers are 'Electronic check'
DeviceProtection_No = 77.0% of high-risk customers are 'No'
Partner_No = 76.0% of high-risk customers are 'No'
```