Kaggle Playground

Problem Statement / Real World Implementations

In [1]:
```
# --- 1. Importing Libraries ---
import numpy as np
import pandas as pd
import warnings
import matplotlib.pyplot as plt
import seaborn as sns
from IPython.display import display
from sklearn.model_selection import StratifiedKFold, train_test_split # Import S
from sklearn.preprocessing import OrdinalEncoder, StandardScaler
from sklearn.metrics import mean_squared_error, mean_absolute_error, r2_score, r
from xgboost import XGBRegressor
from lightgbm import LGBMRegressor
import optuna

# Notebook settings
warnings.filterwarnings('ignore')
pd.set_option('display.max_columns', None)

# --- 2. Loading Dataset ---
TRAIN_PATH = "/kaggle/input/playground-series-s5e11/train.csv"
TEST_PATH = "/kaggle/input/playground-series-s5e11/test.csv"
SUBMISSION_PATH = "/kaggle/input/playground-series-s5e11/sample_submission.csv"

train_df = pd.read_csv(TRAIN_PATH)
test_df = pd.read_csv(TEST_PATH)
submission_df = pd.read_csv(SUBMISSION_PATH)

# Save the test IDs now
test_ids = test_df['id']

# Drop 'id' from both
train_df = train_df.drop('id', axis=1)
test_df = test_df.drop('id', axis=1)


# --- 3. Feature Engineering (Financial Ratios) ---
def create_financial_features(df):
    df['monthly_income'] = df['annual_income'] / 12
    df['total_monthly_debt'] = df['debt_to_income_ratio'] * df['monthly_income']
    df['available_income'] = df['monthly_income'] - df['total_monthly_debt']
    df['loan_to_income_ratio'] = df['loan_amount'] / df['annual_income']
    df['loan_to_available_income'] = df['loan_amount'] / df['available_income']
    df.replace([np.inf, -np.inf], np.nan, inplace=True)
    cols_to_drop = ['annual_income', 'debt_to_income_ratio']
    df = df.drop(columns=cols_to_drop)
    return df

print("Creating financial features for train_df...")
train_df = create_financial_features(train_df)
print("Creating financial features for test_df...")
test_df = create_financial_features(test_df)


# --- 4. Smart Encoding & Processing (Using fillna=-1) ---
```

```python
def process_and_encode_features(df_train, df_test):
    train_target = df_train['loan_paid_back']
    df_train = df_train.drop('loan_paid_back', axis=1)

    df_train['source'] = 'train'
    df_test['source'] = 'test'
    combined_df = pd.concat([df_train, df_test], ignore_index=True)

    # Bin Credit Score
    score_bins = [300, 579, 669, 739, 799, 850]
    score_labels = ['Poor', 'Fair', 'Good', 'Very Good', 'Excellent']
    combined_df['credit_score_bin'] = pd.cut(combined_df['credit_score'],
                                             bins=score_bins,
                                             labels=score_labels,
                                             include_lowest=True)

    # Logical Ordinal Mapping
    education_map = {'Other': 0, 'High School': 1, 'Bachelor\'s': 2, 'Master\'s'
    grades = ['A', 'B', 'C', 'D', 'E', 'F', 'G']
    subgrades = ['1', '2', '3', '4', '5']
    grade_map = {g + s: i for i, (g, s) in enumerate((g, s) for g in grades for
    combined_df['education_level_ordinal'] = combined_df['education_level'].map(
    combined_df['grade_subgrade_ordinal'] = combined_df['grade_subgrade'].map(gr

    # Ordinal Encode Remaining Categoricals
    categorical_cols = ['gender', 'marital_status', 'employment_status', 'loan_p
    encoder = OrdinalEncoder(handle_unknown='use_encoded_value', unknown_value=-
    combined_df['credit_score_bin'] = combined_df['credit_score_bin'].astype(str
    combined_df[categorical_cols] = encoder.fit_transform(combined_df[categorica

    # HANDLE NaNs (The FIX)
    if combined_df['education_level_ordinal'].isnull().any():
        mode_val = combined_df['education_level_ordinal'].mode()[0]
        combined_df['education_level_ordinal'] = combined_df['education_level_or

    if combined_df['loan_to_available_income'].isnull().any():
        combined_df['loan_to_available_income'] = combined_df['loan_to_available

    # Drop old columns and split back
    cols_to_drop = ['credit_score', 'education_level', 'grade_subgrade']
    combined_df = combined_df.drop(columns=cols_to_drop)

    train_processed = combined_df[combined_df['source'] == 'train'].drop('source
    test_processed = combined_df[combined_df['source'] == 'test'].drop('source',

    train_processed['loan_paid_back'] = train_target
    return train_processed, test_processed

print("Processing and encoding all features (filling NaNs with -1)...")
train_processed, test_processed = process_and_encode_features(train_df, test_df)
print("Processing complete.")


# --- 5. Train-Test Split (for Optuna Validation ONLY) ---
X = train_processed.drop("loan_paid_back", axis=1)
y = train_processed["loan_paid_back"]
X = X.select_dtypes(include=[np.number])
X_submission = test_processed.select_dtypes(include=[np.number])
X_submission = X_submission[X.columns] # Align column order NOW
```

```python
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_

# --- 6. Scaling (for Optuna Validation) ---
scaler_optuna = StandardScaler()
X_train_scaled = scaler_optuna.fit_transform(X_train)
X_test_scaled = scaler_optuna.transform(X_test)
print("Scaling for Optuna complete.")


# --- 7. Hyperparameter Tuning (Optuna, n_trials=50) ---
# We use n_trials=50 because it gave the best score (0.92149)
def objective_xgb(trial):
    param = {
        'tree_method': 'gpu_hist', 'predictor': 'gpu_predictor', 'gpu_id': 0,
        'lambda': trial.suggest_loguniform('lambda', 1e-3, 10.0),
        'alpha': trial.suggest_loguniform('alpha', 1e-3, 10.0),
        'colsample_bytree': trial.suggest_categorical('colsample_bytree', [0.3,
        'subsample': trial.suggest_categorical('subsample', [0.5, 0.6, 0.7, 0.8,
        'learning_rate': trial.suggest_float('learning_rate', 0.005, 0.05, log=T
        'n_estimators': trial.suggest_int('n_estimators', 200, 1000, step=100),
        'max_depth': trial.suggest_int('max_depth', 3, 12),
        'min_child_weight': trial.suggest_int('min_child_weight', 1, 300),
        'random_state': 42
    }
    model = XGBRegressor(**param, verbosity=0)
    model.fit(X_train_scaled, y_train)
    y_pred = model.predict(X_test_scaled)
    mse = mean_squared_error(y_test, y_pred)
    return mse

def objective_lgbm(trial):
    param = {
        'device': 'gpu', 'gpu_platform_id': 0, 'gpu_device_id': 0,
        'boosting_type': 'gbdt', 'objective': 'regression', 'metric': 'mse',
        'lambda_l1': trial.suggest_float('lambda_l1', 1e-5, 1.0, log=True),
        'lambda_l2': trial.suggest_float('lambda_l2', 1e-5, 1.0, log=True),
        'num_leaves': trial.suggest_int('num_leaves', 16, 256),
        'feature_fraction': trial.suggest_float('feature_fraction', 0.5, 1.0),
        'bagging_fraction': trial.suggest_float('bagging_fraction', 0.5, 1.0),
        'bagging_freq': trial.suggest_int('bagging_freq', 1, 7),
        'min_child_samples': trial.suggest_int('min_child_samples', 10, 100),
        'learning_rate': trial.suggest_float('learning_rate', 0.005, 0.3, log=Tr
        'n_estimators': trial.suggest_int('n_estimators', 200, 1000, step=100),
        'max_depth': trial.suggest_int('max_depth', 3, 12),
        'random_state': 42, 'verbosity': -1
    }
    model = LGBMRegressor(**param)
    model.fit(X_train_scaled, y_train)
    y_pred = model.predict(X_test_scaled)
    mse = mean_squared_error(y_test, y_pred)
    return mse

print("🚀 Tuning XGBRegressor (GPU)...")
study_xgb = optuna.create_study(direction='minimize')
study_xgb.optimize(objective_xgb, n_trials=50, timeout=1200) # n_trials=50
best_params_xgb = study_xgb.best_params
print(f"✅ Best XGBRegressor parameters: {best_params_xgb}")

print("\n🚀 Tuning LGBMRegressor (GPU)...")
```

```
study_lgbm = optuna.create_study(direction='minimize')
study_lgbm.optimize(objective_lgbm, n_trials=50, timeout=1200) # n_trials=50
best_params_lgbm = study_lgbm.best_params
print(f"✅ Best LGBMRegressor parameters: {best_params_lgbm}")


# --- 8. K-Fold Blending and Submission (NEW) ---
print("\n🚀 Starting 10-Fold Cross-Validation for robust submission...")

# Initialize K-Fold
N_SPLITS = 10
skf = StratifiedKFold(n_splits=N_SPLITS, shuffle=True, random_state=42)

# Arrays to store out-of-fold and test predictions
oof_preds_xgb = np.zeros(len(X))
test_preds_xgb = np.zeros(len(X_submission))
oof_preds_lgbm = np.zeros(len(X))
test_preds_lgbm = np.zeros(len(X_submission))

# Initialize models with best params from Optuna
xgb_model = XGBRegressor(**best_params_xgb, tree_method='gpu_hist', predictor='g
lgbm_model = LGBMRegressor(**best_params_lgbm, device='gpu', verbosity=-1)

for fold, (train_idx, val_idx) in enumerate(skf.split(X, y)):
    print(f"--- Fold {fold+1}/{N_SPLITS} ---")

    # --- Get fold data ---
    X_train_fold, X_val_fold = X.iloc[train_idx], X.iloc[val_idx]
    y_train_fold, y_val_fold = y.iloc[train_idx], y.iloc[val_idx]

    # --- Fit Scaler INSIDE the fold ---
    scaler_fold = StandardScaler()
    X_train_fold_scaled = scaler_fold.fit_transform(X_train_fold)
    X_val_fold_scaled = scaler_fold.transform(X_val_fold)
    X_submission_scaled_fold = scaler_fold.transform(X_submission) # Scale test

    # --- Train XGB ---
    print("Training XGB...")
    xgb_model.fit(X_train_fold_scaled, y_train_fold)
    oof_preds_xgb[val_idx] = xgb_model.predict(X_val_fold_scaled)
    test_preds_xgb += xgb_model.predict(X_submission_scaled_fold) / N_SPLITS

    # --- Train LGBM ---
    print("Training LGBM...")
    lgbm_model.fit(X_train_fold_scaled, y_train_fold)
    oof_preds_lgbm[val_idx] = lgbm_model.predict(X_val_fold_scaled)
    test_preds_lgbm += lgbm_model.predict(X_submission_scaled_fold) / N_SPLITS

# --- 9. Evaluate OOF Predictions ---
print("\n--- OOF (Out-of-Fold) Validation Scores ---")
oof_auc_xgb = roc_auc_score(y, oof_preds_xgb)
oof_auc_lgbm = roc_auc_score(y, oof_preds_lgbm)
print(f"OOF XGB Regressor AUC: {oof_auc_xgb:.5f}")
print(f"OOF LGBM Regressor AUC: {oof_auc_lgbm:.5f}")

# Blend OOF predictions to see which blend is best
oof_blend = (0.5 * oof_preds_xgb) + (0.5 * oof_preds_lgbm)
oof_auc_blend = roc_auc_score(y, oof_blend)
print(f"OOF 50/50 Blend AUC: {oof_auc_blend:.5f}")
```

```python

# --- 10. Create Blended Submission ---
print("\n🎁 Generating blended submission...")
# We use the averaged test predictions
blended_submission_preds = (0.5 * test_preds_xgb) + (0.5 * test_preds_lgbm)
final_submission_preds = np.clip(blended_submission_preds, 0, 1)

submission = pd.DataFrame({
    'id': test_ids,
    'loan_paid_back': final_submission_preds
})
submission.to_csv('submission_v6_kfold_blend.csv', index=False)
print("\n✅ Submission file 'submission_v6_kfold_blend.csv' generated successful
display(submission.head())


# --- 11. Final Plot ---
plt.figure(figsize=(8, 5))
sns.histplot(submission['loan_paid_back'], bins=30, kde=True)
plt.title('Distribution of Blended Predicted Loan Payback (K-Fold)')
plt.xlabel('Loan Payback Probability')
plt.ylabel('Frequency')
plt.show()
```

```
Creating financial features for train_df...
Creating financial features for test_df...
Processing and encoding all features (filling NaNs with -1)...
Processing complete.
[I 2025-11-04 04:54:21,752] A new study created in memory with name: no-name-bb750fce
e431-440a-9bba-fec93c590c35
Scaling for Optuna complete.
🚀 Tuning XGBRegressor (GPU)...
```

```
[I 2025-11-04 04:54:31,385] Trial 0 finished with value: 0.07691319884759817 and
parameters: {'lambda': 0.006536490722353928, 'alpha': 0.7172647449625539,
'colsample_bytree': 0.3, 'subsample': 0.7, 'learning_rate': 0.01696089211255123,
'n_estimators': 700, 'max_depth': 10, 'min_child_weight': 205}. Best is trial 0 with
0.07691319884759817.
[I 2025-11-04 04:54:34,320] Trial 1 finished with value: 0.08485592841948011 and
parameters: {'lambda': 0.02142596838788338, 'alpha': 0.03523520336557538,
'colsample_bytree': 0.9, 'subsample': 0.5, 'learning_rate': 0.006451407089780623,
'n_estimators': 200, 'max_depth': 9, 'min_child_weight': 174}. Best is trial 0 with v
0.07691319884759817.
[I 2025-11-04 04:54:40,405] Trial 2 finished with value: 0.07577932417721207 and
parameters: {'lambda': 0.34261277574743854, 'alpha': 0.005782564320658176,
'colsample_bytree': 1.0, 'subsample': 1.0, 'learning_rate': 0.02736760949366159,
'n_estimators': 900, 'max_depth': 7, 'min_child_weight': 289}. Best is trial 2 with v
0.07577932417721207.
[I 2025-11-04 04:54:45,632] Trial 3 finished with value: 0.08049626566934051 and
parameters: {'lambda': 0.00308717143510703, 'alpha': 0.02353165565692343,
'colsample_bytree': 0.7, 'subsample': 0.6, 'learning_rate': 0.005645284184940208,
'n_estimators': 400, 'max_depth': 9, 'min_child_weight': 300}. Best is trial 2 with v
0.07577932417721207.
[I 2025-11-04 04:54:50,844] Trial 4 finished with value: 0.07585574848892591 and
parameters: {'lambda': 0.0035770470046680063, 'alpha': 0.014382445790953399,
'colsample_bytree': 0.7, 'subsample': 0.5, 'learning_rate': 0.017382499551105407,
'n_estimators': 700, 'max_depth': 7, 'min_child_weight': 49}. Best is trial 2 with va
0.07577932417721207.
[I 2025-11-04 04:54:52,753] Trial 5 finished with value: 0.0765101109695809 and paran
{'lambda': 0.0020692876659881435, 'alpha': 0.03291571332505468, 'colsample_bytree': 1
'subsample': 0.8, 'learning_rate': 0.017350800955896743, 'n_estimators': 300, 'max_de
5, 'min_child_weight': 167}. Best is trial 2 with value: 0.07577932417721207.
[I 2025-11-04 04:54:54,659] Trial 6 finished with value: 0.07737419694314629 and
parameters: {'lambda': 1.1135341342099463, 'alpha': 0.010933587935860599,
'colsample_bytree': 0.9, 'subsample': 1.0, 'learning_rate': 0.02840062707523592,
'n_estimators': 400, 'max_depth': 3, 'min_child_weight': 266}. Best is trial 2 with v
0.07577932417721207.
[I 2025-11-04 04:54:57,495] Trial 7 finished with value: 0.0772644626103382 and paran
{'lambda': 0.03277054291169017, 'alpha': 3.8128854156484966, 'colsample_bytree': 0.7,
'subsample': 0.8, 'learning_rate': 0.009115496100450222, 'n_estimators': 400, 'max_de
6, 'min_child_weight': 12}. Best is trial 2 with value: 0.07577932417721207.
[I 2025-11-04 04:55:01,441] Trial 8 finished with value: 0.08116272451723641 and
parameters: {'lambda': 0.06508734097109464, 'alpha': 0.014068347357435972,
'colsample_bytree': 0.3, 'subsample': 1.0, 'learning_rate': 0.007195791667184582,
'n_estimators': 700, 'max_depth': 5, 'min_child_weight': 259}. Best is trial 2 with v
0.07577932417721207.
[I 2025-11-04 04:55:05,302] Trial 9 finished with value: 0.07622494579225507 and
parameters: {'lambda': 0.08468415413966579, 'alpha': 0.919731913498164, 'colsample_by
0.9, 'subsample': 0.7, 'learning_rate': 0.012182974394475831, 'n_estimators': 700,
'max_depth': 5, 'min_child_weight': 289}. Best is trial 2 with value: 0.0757793241772
[I 2025-11-04 04:55:18,369] Trial 10 finished with value: 0.07737220578457936 and
parameters: {'lambda': 1.135294182067493, 'alpha': 0.001006267933929177,
'colsample_bytree': 1.0, 'subsample': 1.0, 'learning_rate': 0.04881977280934676,
'n_estimators': 1000, 'max_depth': 12, 'min_child_weight': 102}. Best is trial 2 with
value: 0.07577932417721207.
[I 2025-11-04 04:55:25,089] Trial 11 finished with value: 0.07590077703767155 and
parameters: {'lambda': 6.989221694902858, 'alpha': 0.0010184853060830898,
'colsample_bytree': 0.5, 'subsample': 0.5, 'learning_rate': 0.02720521958908951,
'n_estimators': 1000, 'max_depth': 7, 'min_child_weight': 77}. Best is trial 2 with v
0.07577932417721207.
[I 2025-11-04 04:55:32,769] Trial 12 finished with value: 0.07624362177890016 and
parameters: {'lambda': 0.327413832864268, 'alpha': 0.004640713781942907,
'colsample_bytree': 1.0, 'subsample': 0.5, 'learning_rate': 0.02965423829257462,
```

```
'n_estimators': 900, 'max_depth': 8, 'min_child_weight': 5}. Best is trial 2 with val
0.07577932417721207.
[I 2025-11-04 04:55:38,206] Trial 13 finished with value: 0.07579101558456162 and
parameters: {'lambda': 0.3364764603391273, 'alpha': 0.16879298715544888,
'colsample_bytree': 0.7, 'subsample': 0.6, 'learning_rate': 0.021794887698589012,
'n_estimators': 800, 'max_depth': 7, 'min_child_weight': 93}. Best is trial 2 with va
0.07577932417721207.
[I 2025-11-04 04:55:41,735] Trial 14 finished with value: 0.07709610208605015 and
parameters: {'lambda': 0.5910936734050312, 'alpha': 0.1782197642248231, 'colsample_by
0.5, 'subsample': 0.6, 'learning_rate': 0.04152012220077804, 'n_estimators': 900,
'max_depth': 3, 'min_child_weight': 126}. Best is trial 2 with value: 0.0757793241772
[I 2025-11-04 04:55:51,806] Trial 15 finished with value: 0.07592997027769705 and
parameters: {'lambda': 5.215789670371063, 'alpha': 0.14036662290619273, 'colsample_by
1.0, 'subsample': 0.6, 'learning_rate': 0.022405881983297796, 'n_estimators': 800,
'max_depth': 11, 'min_child_weight': 216}. Best is trial 2 with value: 0.075779324177
[I 2025-11-04 04:55:57,292] Trial 16 finished with value: 0.07587373408114644 and
parameters: {'lambda': 0.24375293036779747, 'alpha': 0.363736203739205, 'colsample_by
0.7, 'subsample': 1.0, 'learning_rate': 0.012616555710842683, 'n_estimators': 600,
'max_depth': 8, 'min_child_weight': 139}. Best is trial 2 with value: 0.0757793241772
[I 2025-11-04 04:56:02,700] Trial 17 finished with value: 0.07586079182424789 and
parameters: {'lambda': 2.8359682754467666, 'alpha': 5.17028089899592, 'colsample_bytr
0.7, 'subsample': 0.6, 'learning_rate': 0.03625757455324622, 'n_estimators': 900,
'max_depth': 6, 'min_child_weight': 57}. Best is trial 2 with value: 0.075779324177217
[I 2025-11-04 04:56:08,482] Trial 18 finished with value: 0.07587049092848526 and
parameters: {'lambda': 0.18996516126995666, 'alpha': 0.003429814691652379,
'colsample_bytree': 1.0, 'subsample': 1.0, 'learning_rate': 0.022539569090244783,
'n_estimators': 600, 'max_depth': 9, 'min_child_weight': 224}. Best is trial 2 with v
0.07577932417721207.
[I 2025-11-04 04:56:12,133] Trial 19 finished with value: 0.07676820443473917 and
parameters: {'lambda': 0.013900157693385701, 'alpha': 0.10483726845992128,
'colsample_bytree': 0.5, 'subsample': 0.6, 'learning_rate': 0.02290695757077798,
'n_estimators': 800, 'max_depth': 4, 'min_child_weight': 97}. Best is trial 2 with va
0.07577932417721207.
[I 2025-11-04 04:56:16,972] Trial 20 finished with value: 0.07602282344186845 and
parameters: {'lambda': 1.9692720881977488, 'alpha': 1.7056930165335702, 'colsample_by
0.7, 'subsample': 0.7, 'learning_rate': 0.013747470762755756, 'n_estimators': 800,
'max_depth': 6, 'min_child_weight': 186}. Best is trial 2 with value: 0.0757793241772
[I 2025-11-04 04:56:20,732] Trial 21 finished with value: 0.07584254704680034 and
parameters: {'lambda': 0.0010098997051152631, 'alpha': 0.003119323780108489,
'colsample_bytree': 0.7, 'subsample': 0.5, 'learning_rate': 0.020407713262452918,
'n_estimators': 500, 'max_depth': 7, 'min_child_weight': 41}. Best is trial 2 with va
0.07577932417721207.
[I 2025-11-04 04:56:24,357] Trial 22 finished with value: 0.07585064086298851 and
parameters: {'lambda': 0.0012075847494701702, 'alpha': 0.0036862318394770338,
'colsample_bytree': 0.7, 'subsample': 0.5, 'learning_rate': 0.034468791850433465,
'n_estimators': 500, 'max_depth': 7, 'min_child_weight': 40}. Best is trial 2 with va
0.07577932417721207.
[I 2025-11-04 04:56:28,864] Trial 23 finished with value: 0.07578274858543312 and
parameters: {'lambda': 0.4665113658603051, 'alpha': 0.06723296046658565,
'colsample_bytree': 0.7, 'subsample': 0.8, 'learning_rate': 0.019957747033670648,
'n_estimators': 500, 'max_depth': 8, 'min_child_weight': 113}. Best is trial 2 with v
0.07577932417721207.
[I 2025-11-04 04:56:35,108] Trial 24 finished with value: 0.08056990922861779 and
parameters: {'lambda': 0.5160219511603732, 'alpha': 0.05788280032366768,
'colsample_bytree': 0.3, 'subsample': 0.8, 'learning_rate': 0.010009797331843245,
'n_estimators': 500, 'max_depth': 9, 'min_child_weight': 111}. Best is trial 2 with v
0.07577932417721207.
[I 2025-11-04 04:56:42,924] Trial 25 finished with value: 0.07583431938150846 and
parameters: {'lambda': 0.15804831736074468, 'alpha': 0.23885240718733813,
'colsample_bytree': 1.0, 'subsample': 0.8, 'learning_rate': 0.026310535485063232,
```

```
'n_estimators': 1000, 'max_depth': 8, 'min_child_weight': 151}. Best is trial 2 with
0.07577932417721207.
[I 2025-11-04 04:56:52,896] Trial 26 finished with value: 0.07587564294075905 and
parameters: {'lambda': 0.7027595242640685, 'alpha': 0.05985725188423339,
'colsample_bytree': 0.7, 'subsample': 0.8, 'learning_rate': 0.01966658767161045,
'n_estimators': 800, 'max_depth': 10, 'min_child_weight': 73}. Best is trial 2 with v
0.07577932417721207.
[I 2025-11-04 04:56:58,033] Trial 27 finished with value: 0.07588077918989385 and
parameters: {'lambda': 0.056291053822106404, 'alpha': 0.5579528740215823,
'colsample_bytree': 0.7, 'subsample': 1.0, 'learning_rate': 0.033129466033158514,
'n_estimators': 900, 'max_depth': 6, 'min_child_weight': 123}. Best is trial 2 with v
0.07577932417721207.
[I 2025-11-04 04:57:03,366] Trial 28 finished with value: 0.07578646823793785 and
parameters: {'lambda': 0.12324645726448236, 'alpha': 0.006674103925222324,
'colsample_bytree': 1.0, 'subsample': 0.6, 'learning_rate': 0.014200163120762837,
'n_estimators': 600, 'max_depth': 8, 'min_child_weight': 84}. Best is trial 2 with va
0.07577932417721207.
[I 2025-11-04 04:57:10,725] Trial 29 finished with value: 0.0758056369785339 and
parameters: {'lambda': 2.3370468410881, 'alpha': 0.007101653497704365, 'colsample_byt
1.0, 'subsample': 0.7, 'learning_rate': 0.014953568721777437, 'n_estimators': 600,
'max_depth': 10, 'min_child_weight': 238}. Best is trial 2 with value: 0.075779324177
[I 2025-11-04 04:57:16,239] Trial 30 finished with value: 0.07583419396090015 and
parameters: {'lambda': 0.11894498475285764, 'alpha': 0.002250820388454961,
'colsample_bytree': 1.0, 'subsample': 0.8, 'learning_rate': 0.010648175888653834,
'n_estimators': 600, 'max_depth': 8, 'min_child_weight': 150}. Best is trial 2 with v
0.07577932417721207.
[I 2025-11-04 04:57:22,505] Trial 31 finished with value: 0.07696359578013912 and
parameters: {'lambda': 0.33564117043811853, 'alpha': 0.05906529076984881,
'colsample_bytree': 0.3, 'subsample': 0.6, 'learning_rate': 0.016287694085884933,
'n_estimators': 700, 'max_depth': 8, 'min_child_weight': 86}. Best is trial 2 with va
0.07577932417721207.
[I 2025-11-04 04:57:26,201] Trial 32 finished with value: 0.07581318864685303 and
parameters: {'lambda': 0.039441346778858015, 'alpha': 0.023467613885649823,
'colsample_bytree': 1.0, 'subsample': 0.6, 'learning_rate': 0.01953060057167055,
'n_estimators': 500, 'max_depth': 7, 'min_child_weight': 194}. Best is trial 2 with v
0.07577932417721207.
[I 2025-11-04 04:57:29,386] Trial 33 finished with value: 0.07589447602600517 and
parameters: {'lambda': 1.0578695400468847, 'alpha': 0.008047682210255574,
'colsample_bytree': 0.9, 'subsample': 0.6, 'learning_rate': 0.024457898661668996,
'n_estimators': 200, 'max_depth': 10, 'min_child_weight': 116}. Best is trial 2 with
0.07577932417721207.
[I 2025-11-04 04:57:36,910] Trial 34 finished with value: 0.0758346206432474 and
parameters: {'lambda': 0.018272014036110763, 'alpha': 0.001903650348985143,
'colsample_bytree': 1.0, 'subsample': 0.6, 'learning_rate': 0.01483548841416126,
'n_estimators': 700, 'max_depth': 9, 'min_child_weight': 62}. Best is trial 2 with va
0.07577932417721207.
[I 2025-11-04 04:57:39,459] Trial 35 finished with value: 0.07607245926108121 and
parameters: {'lambda': 0.3696014889196376, 'alpha': 0.039857494396439534,
'colsample_bytree': 0.7, 'subsample': 0.6, 'learning_rate': 0.0186715439509748,
'n_estimators': 300, 'max_depth': 7, 'min_child_weight': 33}. Best is trial 2 with va
0.07577932417721207.
[I 2025-11-04 04:57:44,221] Trial 36 finished with value: 0.07583988269431835 and
parameters: {'lambda': 0.1304548049953708, 'alpha': 0.02291911790110607,
'colsample_bytree': 1.0, 'subsample': 0.8, 'learning_rate': 0.016769979117779995,
'n_estimators': 400, 'max_depth': 9, 'min_child_weight': 90}. Best is trial 2 with va
0.07577932417721207.
[I 2025-11-04 04:57:48,693] Trial 37 finished with value: 0.0758535359095205 and
parameters: {'lambda': 0.007090384419164969, 'alpha': 0.3449840139041035,
'colsample_bytree': 0.9, 'subsample': 1.0, 'learning_rate': 0.030449531341651435,
'n_estimators': 800, 'max_depth': 6, 'min_child_weight': 168}. Best is trial 2 with v
```

```
0.07577932417721207.
[I 2025-11-04 04:57:55,276] Trial 38 finished with value: 0.0760397650294606 and
parameters: {'lambda': 0.21793623911111978, 'alpha': 0.007162538959517217,
'colsample_bytree': 0.7, 'subsample': 0.6, 'learning_rate': 0.007591271891897522,
'n_estimators': 700, 'max_depth': 8, 'min_child_weight': 138}. Best is trial 2 with v
0.07577932417721207.
[I 2025-11-04 04:57:58,044] Trial 39 finished with value: 0.07703072976183137 and
parameters: {'lambda': 0.8862191350965941, 'alpha': 1.0282388841106263, 'colsample_by
0.3, 'subsample': 0.8, 'learning_rate': 0.03841166594332766, 'n_estimators': 500,
'max_depth': 5, 'min_child_weight': 19}. Best is trial 2 with value: 0.07577932417721
[I 2025-11-04 04:58:06,519] Trial 40 finished with value: 0.07683041213469038 and
parameters: {'lambda': 0.087433128434581, 'alpha': 0.01647427338043978, 'colsample_by
0.5, 'subsample': 0.7, 'learning_rate': 0.01161529434277946, 'n_estimators': 400,
'max_depth': 11, 'min_child_weight': 72}. Best is trial 2 with value: 0.0757793241772
[I 2025-11-04 04:58:13,764] Trial 41 finished with value: 0.0758133695641511 and
parameters: {'lambda': 2.139899800436914, 'alpha': 0.007885677261470618,
'colsample_bytree': 1.0, 'subsample': 0.7, 'learning_rate': 0.014534364580289783,
'n_estimators': 600, 'max_depth': 10, 'min_child_weight': 245}. Best is trial 2 with
0.07577932417721207.
[I 2025-11-04 04:58:26,016] Trial 42 finished with value: 0.07622772454931856 and
parameters: {'lambda': 2.6243024443129777, 'alpha': 0.005104393141034697,
'colsample_bytree': 1.0, 'subsample': 0.7, 'learning_rate': 0.005320234036944517,
'n_estimators': 600, 'max_depth': 12, 'min_child_weight': 280}. Best is trial 2 with
0.07577932417721207.
[I 2025-11-04 04:58:31,018] Trial 43 finished with value: 0.07590928297450394 and
parameters: {'lambda': 0.4545048350747507, 'alpha': 0.001685673055446316,
'colsample_bytree': 1.0, 'subsample': 0.7, 'learning_rate': 0.017592789782183014,
'n_estimators': 300, 'max_depth': 11, 'min_child_weight': 265}. Best is trial 2 with
0.07577932417721207.
[I 2025-11-04 04:58:37,216] Trial 44 finished with value: 0.07588398074633898 and
parameters: {'lambda': 9.220128016654504, 'alpha': 0.009658148008387733,
'colsample_bytree': 1.0, 'subsample': 1.0, 'learning_rate': 0.013198386995836213,
'n_estimators': 600, 'max_depth': 9, 'min_child_weight': 229}. Best is trial 2 with v
0.07577932417721207.
[I 2025-11-04 04:58:43,269] Trial 45 finished with value: 0.07577781607064375 and
parameters: {'lambda': 4.804798323874949, 'alpha': 0.017892342626778596,
'colsample_bytree': 1.0, 'subsample': 0.7, 'learning_rate': 0.01547757984593959,
'n_estimators': 900, 'max_depth': 7, 'min_child_weight': 289}. Best is trial 45 with
0.07577781607064375.
[I 2025-11-04 04:58:49,157] Trial 46 finished with value: 0.07577502190172707 and
parameters: {'lambda': 0.04749456195602267, 'alpha': 0.0159232099360248,
'colsample_bytree': 0.9, 'subsample': 1.0, 'learning_rate': 0.020737340574116376,
'n_estimators': 900, 'max_depth': 7, 'min_child_weight': 296}. Best is trial 46 with
0.07577502190172707.
[I 2025-11-04 04:58:57,324] Trial 47 finished with value: 0.07583496848573983 and
parameters: {'lambda': 0.03458670507795095, 'alpha': 0.014003615574500411,
'colsample_bytree': 0.9, 'subsample': 1.0, 'learning_rate': 0.008795292029105643,
'n_estimators': 1000, 'max_depth': 8, 'min_child_weight': 298}. Best is trial 46 with
value: 0.07577502190172707.
[I 2025-11-04 04:59:01,705] Trial 48 finished with value: 0.07599715003018585 and
parameters: {'lambda': 0.0655429072471182, 'alpha': 0.041978275207405755,
'colsample_bytree': 0.9, 'subsample': 1.0, 'learning_rate': 0.02539489115920805,
'n_estimators': 900, 'max_depth': 5, 'min_child_weight': 284}. Best is trial 46 with
0.07577502190172707.
[I 2025-11-04 04:59:07,391] Trial 49 finished with value: 0.07594826944287923 and
parameters: {'lambda': 0.006966150933041557, 'alpha': 0.0158959990194188,
'colsample_bytree': 0.9, 'subsample': 1.0, 'learning_rate': 0.011609681531105682,
'n_estimators': 1000, 'max_depth': 6, 'min_child_weight': 250}. Best is trial 46 with
value: 0.07577502190172707.
```

```
[I 2025-11-04 04:59:07,392] A new study created in memory with name: no-name-5a608597-6711-42de-b473-1a09d3781945
✅ Best XGBRegressor parameters: {'lambda': 0.04749456195602267, 'alpha': 0.0159232099360248, 'colsample_bytree': 0.9, 'subsample': 1.0, 'learning_rate': 0.020737340574116376, 'n_estimators': 900, 'max_depth': 7, 'min_child_weight': 296}

🚀 Tuning LGBMRegressor (GPU)...
```

```
1 warning generated.
1 warning generated.
1 warning generated.
1 warning generated.
1 warning generated.
1 warning generated.
1 warning generated.
1 warning generated.
1 warning generated.
1 warning generated.
1 warning generated.
1 warning generated.
1 warning generated.
1 warning generated.
1 warning generated.
1 warning generated.
1 warning generated.
1 warning generated.
1 warning generated.
1 warning generated.
1 warning generated.
1 warning generated.
1 warning generated.
1 warning generated.
1 warning generated.
1 warning generated.
1 warning generated.
1 warning generated.
1 warning generated.
1 warning generated.
1 warning generated.
1 warning generated.
1 warning generated.
[I 2025-11-04 04:59:28,662] Trial 0 finished with value: 0.07765877301061974 and
parameters: {'lambda_l1': 0.28262816331972807, 'lambda_l2': 0.00010814096082141773,
'num_leaves': 92, 'feature_fraction': 0.8310686596837054, 'bagging_fraction':
0.6729300442995474, 'bagging_freq': 3, 'min_child_samples': 32, 'learning_rate':
0.1524680568323368, 'n_estimators': 500, 'max_depth': 11}. Best is trial 0 with value
0.07765877301061974.
[I 2025-11-04 04:59:40,918] Trial 1 finished with value: 0.07584788486062444 and
parameters: {'lambda_l1': 3.982392428955434e-05, 'lambda_l2': 0.00016700643096115547,
'num_leaves': 194, 'feature_fraction': 0.9277273888454847, 'bagging_fraction':
0.6219738741664562, 'bagging_freq': 1, 'min_child_samples': 85, 'learning_rate':
0.047429790018915306, 'n_estimators': 400, 'max_depth': 7}. Best is trial 1 with valu
0.07584788486062444.
[I 2025-11-04 05:00:15,835] Trial 2 finished with value: 0.07705112327096797 and
parameters: {'lambda_l1': 0.02109571410537063, 'lambda_l2': 1.9127051798818298e-05,
'num_leaves': 145, 'feature_fraction': 0.5372557584054836, 'bagging_fraction':
0.6530250077882451, 'bagging_freq': 2, 'min_child_samples': 100, 'learning_rate':
0.005454225527112974, 'n_estimators': 800, 'max_depth': 6}. Best is trial 1 with valu
0.07584788486062444.
[I 2025-11-04 05:00:46,347] Trial 3 finished with value: 0.07606139163616132 and
parameters: {'lambda_l1': 0.05260404482549688, 'lambda_l2': 0.35111443851392427,
'num_leaves': 110, 'feature_fraction': 0.8613006607882044, 'bagging_fraction':
0.5433033845009425, 'bagging_freq': 5, 'min_child_samples': 75, 'learning_rate':
0.006263357301659411, 'n_estimators': 700, 'max_depth': 7}. Best is trial 1 with valu
0.07584788486062444.
[I 2025-11-04 05:01:24,914] Trial 4 finished with value: 0.07603277432688997 and
parameters: {'lambda_l1': 0.032483091378342814, 'lambda_l2': 0.01393808468399702,
'num_leaves': 212, 'feature_fraction': 0.6115354322269747, 'bagging_fraction':
```

```
0.8637626935172595, 'bagging_freq': 6, 'min_child_samples': 44, 'learning_rate':
0.009990813475338483, 'n_estimators': 1000, 'max_depth': 6}. Best is trial 1 with val
0.07584788486062444.
[I 2025-11-04 05:01:57,893] Trial 5 finished with value: 0.07581642643708364 and
parameters: {'lambda_l1': 5.888740080544136e-05, 'lambda_l2': 0.13091195947282785,
'num_leaves': 81, 'feature_fraction': 0.8649115693078284, 'bagging_fraction':
0.9532173895348398, 'bagging_freq': 1, 'min_child_samples': 29, 'learning_rate':
0.00966930894730397, 'n_estimators': 1000, 'max_depth': 10}. Best is trial 5 with val
0.07581642643708364.
[I 2025-11-04 05:02:16,539] Trial 6 finished with value: 0.07738332672886346 and
parameters: {'lambda_l1': 0.04279846770582742, 'lambda_l2': 0.6222048934583551,
'num_leaves': 64, 'feature_fraction': 0.5812322883541539, 'bagging_fraction':
0.5054442813774868, 'bagging_freq': 7, 'min_child_samples': 33, 'learning_rate':
0.12727018913905888, 'n_estimators': 700, 'max_depth': 10}. Best is trial 5 with valu
0.07581642643708364.
[I 2025-11-04 05:02:47,202] Trial 7 finished with value: 0.07594736923188722 and
parameters: {'lambda_l1': 6.37420667266903e-05, 'lambda_l2': 0.00025011334714759316,
'num_leaves': 226, 'feature_fraction': 0.9991441564570797, 'bagging_fraction':
0.8223581228283313, 'bagging_freq': 4, 'min_child_samples': 47, 'learning_rate':
0.039271880470331484, 'n_estimators': 600, 'max_depth': 8}. Best is trial 5 with valu
0.07581642643708364.
[I 2025-11-04 05:03:00,261] Trial 8 finished with value: 0.07716614324780534 and
parameters: {'lambda_l1': 0.0016451269200100465, 'lambda_l2': 0.0046101584566970956,
'num_leaves': 121, 'feature_fraction': 0.9924892136336382, 'bagging_fraction':
0.543726255264579, 'bagging_freq': 7, 'min_child_samples': 27, 'learning_rate':
0.018960794277951228, 'n_estimators': 800, 'max_depth': 3}. Best is trial 5 with valu
0.07581642643708364.
[I 2025-11-04 05:03:34,777] Trial 9 finished with value: 0.07587880174703297 and
parameters: {'lambda_l1': 0.030674887624860012, 'lambda_l2': 2.8639780849234527e-05,
'num_leaves': 88, 'feature_fraction': 0.6842810015900076, 'bagging_fraction':
0.7927970888741973, 'bagging_freq': 7, 'min_child_samples': 14, 'learning_rate':
0.027942622491865073, 'n_estimators': 900, 'max_depth': 8}. Best is trial 5 with valu
0.07581642643708364.
[I 2025-11-04 05:03:39,216] Trial 10 finished with value: 0.07948091177406245 and
parameters: {'lambda_l1': 0.000468496137839768, 'lambda_l2': 0.06982043765799723,
'num_leaves': 19, 'feature_fraction': 0.7598871241312204, 'bagging_fraction':
0.9446663524641087, 'bagging_freq': 1, 'min_child_samples': 66, 'learning_rate':
0.012271853679485563, 'n_estimators': 200, 'max_depth': 12}. Best is trial 5 with val
0.07581642643708364.
[I 2025-11-04 05:03:53,698] Trial 11 finished with value: 0.07605080114649475 and
parameters: {'lambda_l1': 1.1506351271187898e-05, 'lambda_l2': 0.001083728377537169,
'num_leaves': 176, 'feature_fraction': 0.8984046164163104, 'bagging_fraction':
0.9981656281287794, 'bagging_freq': 1, 'min_child_samples': 90, 'learning_rate':
0.06474378672725688, 'n_estimators': 400, 'max_depth': 9}. Best is trial 5 with value
0.07581642643708364.
[I 2025-11-04 05:04:02,918] Trial 12 finished with value: 0.07647767437107672 and
parameters: {'lambda_l1': 0.00015692717541239642, 'lambda_l2': 0.04281323793475333,
'num_leaves': 170, 'feature_fraction': 0.8837686500826157, 'bagging_fraction':
0.7061707170216156, 'bagging_freq': 2, 'min_child_samples': 64, 'learning_rate':
0.05197061264886313, 'n_estimators': 300, 'max_depth': 4}. Best is trial 5 with value
0.07581642643708364.
[I 2025-11-04 05:04:26,141] Trial 13 finished with value: 0.07623170490818111 and
parameters: {'lambda_l1': 1.57407118110948e-05, 'lambda_l2': 0.0009384401333527208,
'num_leaves': 256, 'feature_fraction': 0.7831023347243212, 'bagging_fraction':
0.6200835431390181, 'bagging_freq': 2, 'min_child_samples': 81, 'learning_rate':
0.06884175340294539, 'n_estimators': 400, 'max_depth': 9}. Best is trial 5 with value
0.07581642643708364.
[I 2025-11-04 05:05:00,692] Trial 14 finished with value: 0.07593333158890274 and
parameters: {'lambda_l1': 8.172236540372778e-05, 'lambda_l2': 0.0001833951554543194,
'num_leaves': 45, 'feature_fraction': 0.9384746893927635, 'bagging_fraction':
```

```
0.8983592448007888, 'bagging_freq': 3, 'min_child_samples': 13, 'learning_rate':
0.022351726901417544, 'n_estimators': 1000, 'max_depth': 5}. Best is trial 5 with val
0.07581642643708364.
[I 2025-11-04 05:05:20,677] Trial 15 finished with value: 0.08320496943588748 and
parameters: {'lambda_l1': 0.0009518562738260364, 'lambda_l2': 0.11126121520253092,
'num_leaves': 154, 'feature_fraction': 0.9346768499975922, 'bagging_fraction':
0.7611696815244935, 'bagging_freq': 1, 'min_child_samples': 57, 'learning_rate':
0.2976567846547768, 'n_estimators': 500, 'max_depth': 10}. Best is trial 5 with value
0.07581642643708364.
[I 2025-11-04 05:05:33,319] Trial 16 finished with value: 0.07761908899148641 and
parameters: {'lambda_l1': 0.005443165581374431, 'lambda_l2': 0.006873750972716945,
'num_leaves': 195, 'feature_fraction': 0.8102442038143446, 'bagging_fraction':
0.6200914426290455, 'bagging_freq': 3, 'min_child_samples': 42, 'learning_rate':
0.012701563727792443, 'n_estimators': 200, 'max_depth': 12}. Best is trial 5 with val
0.07581642643708364.
[I 2025-11-04 05:05:57,861] Trial 17 finished with value: 0.07643023405212239 and
parameters: {'lambda_l1': 0.00030423313862114283, 'lambda_l2': 0.0012350061614621918,
'num_leaves': 251, 'feature_fraction': 0.7151494001984205, 'bagging_fraction':
0.7278686977683421, 'bagging_freq': 4, 'min_child_samples': 98, 'learning_rate':
0.1039524349136606, 'n_estimators': 600, 'max_depth': 7}. Best is trial 5 with value:
0.07581642643708364.
[I 2025-11-04 05:06:07,930] Trial 18 finished with value: 0.0758227174482881 and
parameters: {'lambda_l1': 3.467851034941089e-05, 'lambda_l2': 0.017721031211949102,
'num_leaves': 61, 'feature_fraction': 0.9400672801668579, 'bagging_fraction':
0.988379014486396, 'bagging_freq': 1, 'min_child_samples': 80, 'learning_rate':
0.03678526491931854, 'n_estimators': 400, 'max_depth': 10}. Best is trial 5 with valu
0.07581642643708364.
[I 2025-11-04 05:06:54,111] Trial 19 finished with value: 0.0758490345280599 and
parameters: {'lambda_l1': 2.4398033630702697e-05, 'lambda_l2': 0.21215824138717132,
'num_leaves': 58, 'feature_fraction': 0.8368373421942693, 'bagging_fraction':
0.9518976391222704, 'bagging_freq': 2, 'min_child_samples': 71, 'learning_rate':
0.009062561183905008, 'n_estimators': 900, 'max_depth': 10}. Best is trial 5 with val
0.07581642643708364.
[I 2025-11-04 05:07:12,709] Trial 20 finished with value: 0.07606423089555786 and
parameters: {'lambda_l1': 0.006188955360416726, 'lambda_l2': 0.022362303502876556,
'num_leaves': 38, 'feature_fraction': 0.6821068080414932, 'bagging_fraction':
0.9933397046119087, 'bagging_freq': 5, 'min_child_samples': 54, 'learning_rate':
0.016945056607425638, 'n_estimators': 500, 'max_depth': 11}. Best is trial 5 with val
0.07581642643708364.
[I 2025-11-04 05:07:22,085] Trial 21 finished with value: 0.07579642111053878 and
parameters: {'lambda_l1': 4.020946987914563e-05, 'lambda_l2': 0.9614917278978373,
'num_leaves': 77, 'feature_fraction': 0.9416390849549193, 'bagging_fraction':
0.9156083926404995, 'bagging_freq': 1, 'min_child_samples': 85, 'learning_rate':
0.029056320791731868, 'n_estimators': 300, 'max_depth': 9}. Best is trial 21 with val
0.07579642111053878.
[I 2025-11-04 05:07:31,633] Trial 22 finished with value: 0.07580877002085862 and
parameters: {'lambda_l1': 0.00013033915215473018, 'lambda_l2': 0.8741767425555733,
'num_leaves': 82, 'feature_fraction': 0.9629683107424664, 'bagging_fraction':
0.9057382886028528, 'bagging_freq': 1, 'min_child_samples': 87, 'learning_rate':
0.032883622120744804, 'n_estimators': 300, 'max_depth': 9}. Best is trial 21 with val
0.07579642111053878.
[I 2025-11-04 05:07:47,455] Trial 23 finished with value: 0.07581018855134965 and
parameters: {'lambda_l1': 0.00014684965419214992, 'lambda_l2': 0.5734463079333217,
'num_leaves': 85, 'feature_fraction': 0.9809148526964439, 'bagging_fraction':
0.8958687458431609, 'bagging_freq': 2, 'min_child_samples': 92, 'learning_rate':
0.02852446290134402, 'n_estimators': 300, 'max_depth': 9}. Best is trial 21 with valu
0.07579642111053878.
[I 2025-11-04 05:08:04,790] Trial 24 finished with value: 0.07584281528363841 and
parameters: {'lambda_l1': 0.00023596936709468802, 'lambda_l2': 0.8034676666910727,
'num_leaves': 121, 'feature_fraction': 0.9731777471876049, 'bagging_fraction':
```

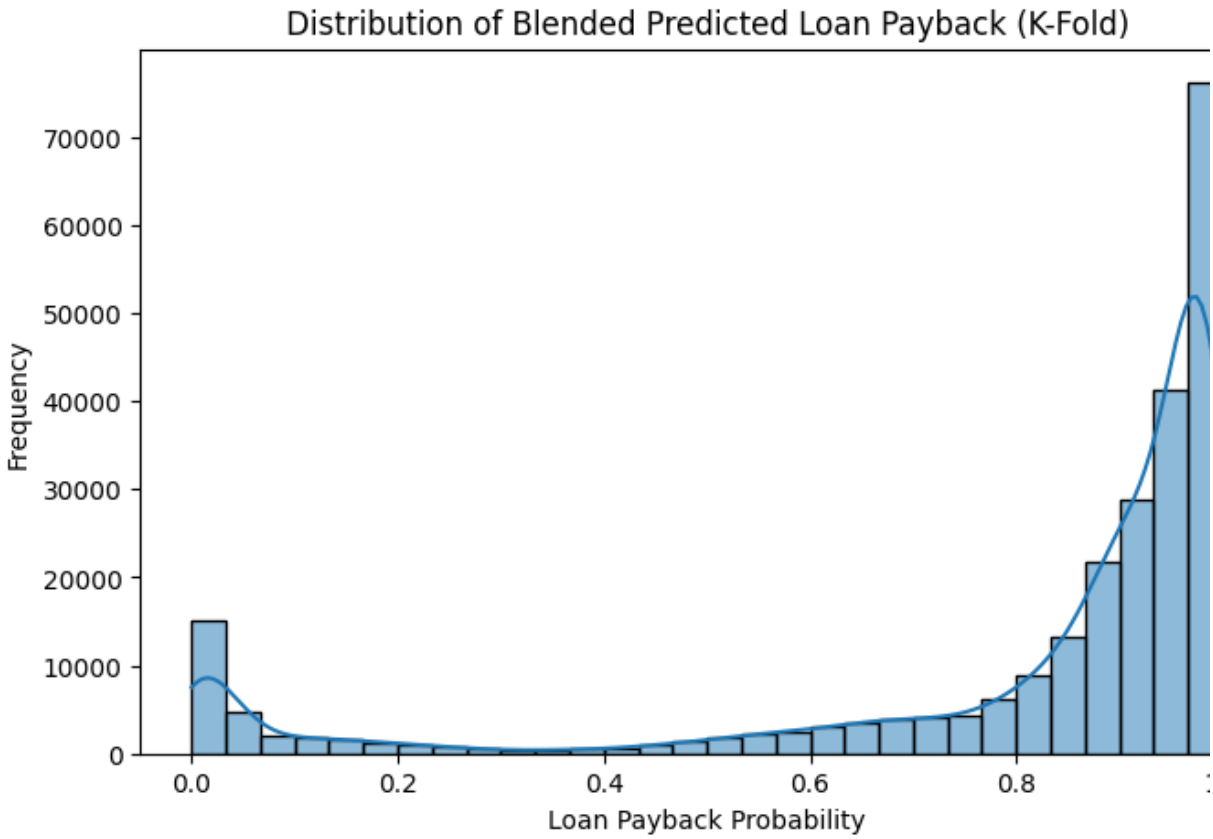
```
0.8832306264891359, 'bagging_freq': 2, 'min_child_samples': 90, 'learning_rate':
0.03264502009919488, 'n_estimators': 300, 'max_depth': 9}. Best is trial 21 with valu
0.07579642111053878.
[I 2025-11-04 05:08:19,847] Trial 25 finished with value: 0.07583703655523588 and
parameters: {'lambda_l1': 0.0006684859588643083, 'lambda_l2': 0.9042932292229805,
'num_leaves': 101, 'feature_fraction': 0.9679369810382639, 'bagging_fraction':
0.8386902290678018, 'bagging_freq': 3, 'min_child_samples': 92, 'learning_rate':
0.026244116403732514, 'n_estimators': 300, 'max_depth': 8}. Best is trial 21 with val
0.07579642111053878.
[I 2025-11-04 05:08:29,157] Trial 26 finished with value: 0.07588871863974847 and
parameters: {'lambda_l1': 0.00010455241306671173, 'lambda_l2': 0.3172581503902186,
'num_leaves': 79, 'feature_fraction': 0.9008438314333815, 'bagging_fraction':
0.914927483087206, 'bagging_freq': 2, 'min_child_samples': 77, 'learning_rate':
0.08245259763713383, 'n_estimators': 200, 'max_depth': 9}. Best is trial 21 with valu
0.07579642111053878.
[I 2025-11-04 05:08:35,795] Trial 27 finished with value: 0.07641054016505311 and
parameters: {'lambda_l1': 0.0015571489583083428, 'lambda_l2': 0.3728468457919803,
'num_leaves': 19, 'feature_fraction': 0.9629661068650422, 'bagging_fraction':
0.8503485879936098, 'bagging_freq': 1, 'min_child_samples': 86, 'learning_rate':
0.01809333903252007, 'n_estimators': 300, 'max_depth': 11}. Best is trial 21 with val
0.07579642111053878.
[I 2025-11-04 05:08:45,662] Trial 28 finished with value: 0.07582358739255829 and
parameters: {'lambda_l1': 0.0001833524122481643, 'lambda_l2': 0.0565551606590138,
'num_leaves': 128, 'feature_fraction': 0.915188667312976, 'bagging_fraction':
0.8006952932253381, 'bagging_freq': 4, 'min_child_samples': 95, 'learning_rate':
0.0520365157376325, 'n_estimators': 200, 'max_depth': 8}. Best is trial 21 with value
0.07579642111053878.
[I 2025-11-04 05:09:05,687] Trial 29 finished with value: 0.07769386542127639 and
parameters: {'lambda_l1': 0.6788430646983427, 'lambda_l2': 0.1545207369445848,
'num_leaves': 96, 'feature_fraction': 0.8415126746527607, 'bagging_fraction':
0.9144669123661121, 'bagging_freq': 2, 'min_child_samples': 70, 'learning_rate':
0.19618566724588626, 'n_estimators': 500, 'max_depth': 11}. Best is trial 21 with val
0.07579642111053878.
[I 2025-11-04 05:09:19,853] Trial 30 finished with value: 0.07589796393664393 and
parameters: {'lambda_l1': 1.0395707747334452e-05, 'lambda_l2': 0.5730686351432336,
'num_leaves': 71, 'feature_fraction': 0.8050162959249645, 'bagging_fraction':
0.8767588143410059, 'bagging_freq': 3, 'min_child_samples': 87, 'learning_rate':
0.02412963381705634, 'n_estimators': 300, 'max_depth': 9}. Best is trial 21 with valu
0.07579642111053878.
[I 2025-11-04 05:09:33,494] Trial 31 finished with value: 0.0767670016969343 and
parameters: {'lambda_l1': 4.545689188115205e-05, 'lambda_l2': 0.9579351168344001,
'num_leaves': 83, 'feature_fraction': 0.8691767612854905, 'bagging_fraction':
0.9639349256756383, 'bagging_freq': 1, 'min_child_samples': 25, 'learning_rate':
0.007221236460773306, 'n_estimators': 400, 'max_depth': 10}. Best is trial 21 with va
0.07579642111053878.
[I 2025-11-04 05:09:52,156] Trial 32 finished with value: 0.07582551422262035 and
parameters: {'lambda_l1': 2.6064893542662255e-05, 'lambda_l2': 0.13305340368448537,
'num_leaves': 108, 'feature_fraction': 0.9548134017336578, 'bagging_fraction':
0.9292282469322558, 'bagging_freq': 1, 'min_child_samples': 60, 'learning_rate':
0.013375448359384198, 'n_estimators': 500, 'max_depth': 9}. Best is trial 21 with val
0.07579642111053878.
[I 2025-11-04 05:10:04,058] Trial 33 finished with value: 0.0757680749732203 and
parameters: {'lambda_l1': 9.048819005386943e-05, 'lambda_l2': 0.24630433706632957,
'num_leaves': 42, 'feature_fraction': 0.9972325420474497, 'bagging_fraction':
0.9555368332137306, 'bagging_freq': 1, 'min_child_samples': 83, 'learning_rate':
0.04390381068955899, 'n_estimators': 600, 'max_depth': 11}. Best is trial 33 with val
0.0757680749732203.
[I 2025-11-04 05:10:19,085] Trial 34 finished with value: 0.07581480139989184 and
parameters: {'lambda_l1': 0.0004272768473553185, 'lambda_l2': 0.2975273533966043,
'num_leaves': 41, 'feature_fraction': 0.9993068753743434, 'bagging_fraction':
```

```
0.8968955192532189, 'bagging_freq': 2, 'min_child_samples': 100, 'learning_rate':
0.04378510581134612, 'n_estimators': 400, 'max_depth': 12}. Best is trial 33 with val
0.0757680749732203.
[I 2025-11-04 05:10:38,228] Trial 35 finished with value: 0.0757417006343995 and
parameters: {'lambda_l1': 0.00010271764220650896, 'lambda_l2': 0.4571566495468093,
'num_leaves': 53, 'feature_fraction': 0.9230902922463312, 'bagging_fraction':
0.8201913378864691, 'bagging_freq': 1, 'min_child_samples': 81, 'learning_rate':
0.028619192797307225, 'n_estimators': 700, 'max_depth': 7}. Best is trial 35 with val
0.0757417006343995.
[I 2025-11-04 05:10:52,628] Trial 36 finished with value: 0.07583152633610264 and
parameters: {'lambda_l1': 0.08853711176084066, 'lambda_l2': 0.08082859572833334,
'num_leaves': 32, 'feature_fraction': 0.9201025126137943, 'bagging_fraction':
0.8212320786236739, 'bagging_freq': 1, 'min_child_samples': 82, 'learning_rate':
0.06337928209731615, 'n_estimators': 700, 'max_depth': 6}. Best is trial 35 with valu
0.0757417006343995.
[I 2025-11-04 05:11:11,503] Trial 37 finished with value: 0.07577691029884757 and
parameters: {'lambda_l1': 9.406458050327709e-05, 'lambda_l2': 0.30157916052971945,
'num_leaves': 53, 'feature_fraction': 0.9515406888199109, 'bagging_fraction':
0.7813502250620008, 'bagging_freq': 1, 'min_child_samples': 75, 'learning_rate':
0.034170428668426865, 'n_estimators': 700, 'max_depth': 7}. Best is trial 35 with val
0.0757417006343995.
[I 2025-11-04 05:11:38,428] Trial 38 finished with value: 0.07624090269171506 and
parameters: {'lambda_l1': 6.031593674770254e-05, 'lambda_l2': 0.0374977653111804,
'num_leaves': 52, 'feature_fraction': 0.8938106763289704, 'bagging_fraction':
0.7900434759782741, 'bagging_freq': 5, 'min_child_samples': 76, 'learning_rate':
0.09519663125509602, 'n_estimators': 800, 'max_depth': 6}. Best is trial 35 with valu
0.0757417006343995.
[I 2025-11-04 05:11:52,704] Trial 39 finished with value: 0.07580065093855536 and
parameters: {'lambda_l1': 1.9682177908578995e-05, 'lambda_l2': 0.23783822892442436,
'num_leaves': 31, 'feature_fraction': 0.9205348928366259, 'bagging_fraction':
0.7632406659349685, 'bagging_freq': 1, 'min_child_samples': 72, 'learning_rate':
0.04560681384533644, 'n_estimators': 700, 'max_depth': 7}. Best is trial 35 with valu
0.0757417006343995.
[I 2025-11-04 05:12:10,206] Trial 40 finished with value: 0.07635095226394512 and
parameters: {'lambda_l1': 0.00326552867063609, 'lambda_l2': 0.010823278417931672,
'num_leaves': 71, 'feature_fraction': 0.5465231687706762, 'bagging_fraction':
0.7163361239811076, 'bagging_freq': 6, 'min_child_samples': 65, 'learning_rate':
0.020433108016856195, 'n_estimators': 600, 'max_depth': 5}. Best is trial 35 with val
0.0757417006343995.
[I 2025-11-04 05:12:24,145] Trial 41 finished with value: 0.07578879673029675 and
parameters: {'lambda_l1': 2.0162399268668184e-05, 'lambda_l2': 0.225885233053178,
'num_leaves': 29, 'feature_fraction': 0.9241460212916822, 'bagging_fraction':
0.7643749919872278, 'bagging_freq': 1, 'min_child_samples': 72, 'learning_rate':
0.04461787545387367, 'n_estimators': 700, 'max_depth': 7}. Best is trial 35 with valu
0.0757417006343995.
[I 2025-11-04 05:12:47,530] Trial 42 finished with value: 0.07576180799870298 and
parameters: {'lambda_l1': 3.9781309378030306e-05, 'lambda_l2': 0.4330639791068937,
'num_leaves': 53, 'feature_fraction': 0.8681351702926994, 'bagging_fraction':
0.6782206238771991, 'bagging_freq': 1, 'min_child_samples': 82, 'learning_rate':
0.0333132553055315, 'n_estimators': 800, 'max_depth': 7}. Best is trial 35 with value
0.0757417006343995.
[I 2025-11-04 05:12:59,986] Trial 43 finished with value: 0.07603016094646861 and
parameters: {'lambda_l1': 7.745957601008046e-05, 'lambda_l2': 0.42376689636265924,
'num_leaves': 16, 'feature_fraction': 0.866717576593628, 'bagging_fraction':
0.6589280045895441, 'bagging_freq': 1, 'min_child_samples': 77, 'learning_rate':
0.04015873373541019, 'n_estimators': 700, 'max_depth': 7}. Best is trial 35 with valu
0.0757417006343995.
[I 2025-11-04 05:13:27,018] Trial 44 finished with value: 0.07590430402104238 and
parameters: {'lambda_l1': 2.950324591607729e-05, 'lambda_l2': 0.181896715352428,
'num_leaves': 50, 'feature_fraction': 0.854412567610834, 'bagging_fraction':
```

```
0.679176307754032, 'bagging_freq': 2, 'min_child_samples': 70, 'learning_rate':
0.05393827533298867, 'n_estimators': 800, 'max_depth': 5}. Best is trial 35 with valu
0.0757417006343995.
[I 2025-11-04 05:13:40,155] Trial 45 finished with value: 0.07587320900121872 and
parameters: {'lambda_l1': 1.5391330196404055e-05, 'lambda_l2': 0.09334093066623739,
'num_leaves': 28, 'feature_fraction': 0.886468600491373, 'bagging_fraction':
0.687595379735968, 'bagging_freq': 1, 'min_child_samples': 81, 'learning_rate':
0.03568302617300457, 'n_estimators': 600, 'max_depth': 6}. Best is trial 35 with valu
0.0757417006343995.
[I 2025-11-04 05:14:17,852] Trial 46 finished with value: 0.07576506826793832 and
parameters: {'lambda_l1': 0.0002570966015638234, 'lambda_l2': 0.026798406509719597,
'num_leaves': 65, 'feature_fraction': 0.9123014811927647, 'bagging_fraction':
0.7453762343569348, 'bagging_freq': 2, 'min_child_samples': 73, 'learning_rate':
0.016024190025977793, 'n_estimators': 800, 'max_depth': 7}. Best is trial 35 with val
0.0757417006343995.
[I 2025-11-04 05:14:56,896] Trial 47 finished with value: 0.07606959712009932 and
parameters: {'lambda_l1': 0.00028459356318807276, 'lambda_l2': 0.026266480019042127,
'num_leaves': 64, 'feature_fraction': 0.5006357563257727, 'bagging_fraction':
0.7372820181252391, 'bagging_freq': 2, 'min_child_samples': 61, 'learning_rate':
0.016954314795131598, 'n_estimators': 900, 'max_depth': 6}. Best is trial 35 with val
0.0757417006343995.
[I 2025-11-04 05:15:27,399] Trial 48 finished with value: 0.07585247477822145 and
parameters: {'lambda_l1': 0.000883604289665248, 'lambda_l2': 0.04809715674292045,
'num_leaves': 47, 'feature_fraction': 0.9817521287126304, 'bagging_fraction':
0.6316991027414784, 'bagging_freq': 3, 'min_child_samples': 49, 'learning_rate':
0.01367206724800336, 'n_estimators': 800, 'max_depth': 7}. Best is trial 35 with valu
0.0757417006343995.
[I 2025-11-04 05:15:53,177] Trial 49 finished with value: 0.07579448210595306 and
parameters: {'lambda_l1': 0.00044567254398050944, 'lambda_l2': 0.0038194648137507494,
'num_leaves': 58, 'feature_fraction': 0.8140838113059308, 'bagging_fraction':
0.5847634602682009, 'bagging_freq': 1, 'min_child_samples': 82, 'learning_rate':
0.02319523463463237, 'n_estimators': 800, 'max_depth': 8}. Best is trial 35 with valu
0.0757417006343995.
```

```
✅ Best LGBMRegressor parameters: {'lambda_l1': 0.00010271764220650896, 'lambda_l2':
0.4571566495468093, 'num_leaves': 53, 'feature_fraction': 0.9230902922463312,
'bagging_fraction': 0.8201913378864691, 'bagging_freq': 1, 'min_child_samples': 81,
'learning_rate': 0.028619192797307225, 'n_estimators': 700, 'max_depth': 7}

🚀 Starting 10-Fold Cross-Validation for robust submission...
--- Fold 1/10 ---
Training XGB...
Training LGBM...
--- Fold 2/10 ---
Training XGB...
Training LGBM...
--- Fold 3/10 ---
Training XGB...
Training LGBM...
--- Fold 4/10 ---
Training XGB...
Training LGBM...
--- Fold 5/10 ---
Training XGB...
Training LGBM...
--- Fold 6/10 ---
Training XGB...
Training LGBM...
--- Fold 7/10 ---
Training XGB...
Training LGBM...
--- Fold 8/10 ---
Training XGB...
Training LGBM...
--- Fold 9/10 ---
Training XGB...
Training LGBM...
--- Fold 10/10 ---
Training XGB...
Training LGBM...

--- OOF (Out-of-Fold) Validation Scores ---
OOF XGB Regressor AUC: 0.91043
OOF LGBM Regressor AUC: 0.91061
OOF 50/50 Blend AUC: 0.91072

💡 Generating blended submission...

✅ Submission file 'submission_v6_kfold_blend.csv' generated successfully!
```

	id	loan_paid_back
0	593994	0.949698
1	593995	0.953973
2	593996	0.512640
3	593997	0.964671
4	593998	0.984425


Distribution of Blended Predicted Loan Payback (K-Fold)
Frequency
70000
60000
50000
40000
30000
20000
10000
0
0.0
0.2
0.4
0.6
0.8
Loan Payback Probability