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 KFold, train_test_split, StratifiedKFold
from sklearn.preprocessing import OrdinalEncoder, StandardScaler
from sklearn.metrics import mean_squared_error, mean_absolute_error, r2_score
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 (From Champion V4) ---
def create_financial_features(df):
    """
    Creates new financial features from the existing columns.
    """
    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']

    # Clean up any 'inf' values created by dividing by zero
    df.replace([np.inf, -np.inf], np.nan, inplace=True)

    # Drop the original, redundant columns
    cols_to_drop = ['annual_income', 'debt_to_income_ratio']
    df = df.drop(columns=cols_to_drop)

    return df
```

```python
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 (From Champion V4, with fillna=-1) ---
def process_and_encode_features(df_train, df_test):
    """
    Applies binning, logical ordinal mapping, and
    ordinal encoding to both train and test sets.
    Fills NaNs with -1 so the Scaler can run.
    """
    # Save target and combine for consistent processing
    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)

    # --- 1. 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)

    # --- 2. Logical Ordinal Mapping ---
    education_map = {
        'Other': 0, 'High School': 1, 'Bachelor\'s': 2, 'Master\'s': 3, 'PhD': 4
    }
    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

    # --- 3. Ordinal Encode Remaining Categoricals ---
    categorical_cols = [
        'gender', 'marital_status', 'employment_status',
        'loan_purpose', 'credit_score_bin'
    ]

    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

    # --- 4. 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

    # Fill our powerful ratio feature with -1
    if combined_df['loan_to_available_income'].isnull().any():
        combined_df['loan_to_available_income'] = combined_df['loan_to_available
```

```
    # --- 5. 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',

    # Add target back
    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) ---
X = train_processed.drop("loan_paid_back", axis=1)
y = train_processed["loan_paid_back"]
X = X.select_dtypes(include=[np.number])

# We stratify by the target 'y' for a more stable validation set
X_train, X_test, y_train, y_test = train_test_split(
    X, y, test_size=0.2, random_state=42, stratify=y
)

# --- 6. Scaling (Essential Step from V4) ---
scaler = StandardScaler()
X_train_scaled = scaler.fit_transform(X_train)
X_test_scaled = scaler.transform(X_test)
print("Scaling complete.")


# --- 7. Hyperparameter Tuning (n_trials=50, the "Goldilocks" zone) ---
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. Initialize and Evaluate Tuned Models (on Validation Set) ---
xgb_model = XGBRegressor(**best_params_xgb, tree_method='gpu_hist', predictor='g
lgbm_model = LGBMRegressor(**best_params_lgbm, device='gpu', verbosity=-1)
models = [("XGBRegressor (GPU)", xgb_model), ("LGBMRegressor (GPU)", lgbm_model)

print("\n⚡ Evaluating Tuned Models on GPU...\n")
mse_scores = {}
for name, model in models:
    model.fit(X_train_scaled, y_train)
    y_pred = model.predict(X_test_scaled)
    mse = mean_squared_error(y_test, y_pred)
    mae = mean_absolute_error(y_test, y_pred)
    r2 = r2_score(y_test, y_pred)
    mse_scores[name] = mse # Save MSE for blending
    print(f"{name:<30} | Validation MSE: {mse:.5f} | MAE: {mae:.5f} | R²: {r2:.5


# --- 9. Final Training on Full Data (Both Models) ---
print("\n🚀 Retraining BOTH models on full training data...")
X_full = train_processed.drop(columns=['loan_paid_back'], errors='ignore')
y_full = train_processed['loan_paid_back']
X_full = X_full.select_dtypes(include=[np.number])

# Re-fit the scaler on the FULL training data
scaler_final = StandardScaler()
X_full_scaled = scaler_final.fit_transform(X_full)

# Retrain both models
lgbm_model.fit(X_full_scaled, y_full)
xgb_model.fit(X_full_scaled, y_full)
```

```
print("✅ Models retrained successfully.")


# --- 10. Generate BLENDED Submission (The "Version 8" Step) ---
print("🚀 Generating blended predictions...")

# Prepare submission data (using the 'test_processed' dataframe)
X_submission = test_processed.select_dtypes(include=[np.number])
X_submission = X_submission[X_full.columns] # Align column order

# Scale submission data using the scaler fit on X_full
X_submission_scaled = scaler_final.transform(X_submission)

# Generate predictions from BOTH models
preds_lgbm = lgbm_model.predict(X_submission_scaled)
preds_xgb = xgb_model.predict(X_submission_scaled)

# --- Create the Blend ---
# Give weight based on which model had lower MSE on the validation set
if mse_scores["LGBMRegressor (GPU)"] < mse_scores["XGBRegressor (GPU)"]:
    best_model_name = "LGBMRegressor (GPU)"
    weight_lgbm = 0.6
    weight_xgb = 0.4
else:
    best_model_name = "XGBRegressor (GPU)"
    weight_lgbm = 0.4
    weight_xgb = 0.6

print(f"Best model was {best_model_name}. Using {weight_lgbm*100}% LGBM and {wei
blended_preds = (weight_lgbm * preds_lgbm) + (weight_xgb * preds_xgb)

# Clip the final blended predictions
submission_preds = np.clip(blended_preds, 0, 1)

# --- Create Submission File ---
submission = pd.DataFrame({
    'id': test_ids,  # This was correctly defined at the top
    'loan_paid_back': submission_preds
})
submission.to_csv('submission_V8_Blend.csv', index=False)
print("\n✅ Submission file 'submission_V8_Blend.csv' generated successfully!")
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')
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 07:05:26,265] A new study created in memory with name: no-name-e537e49
a1d2-40e4-91db-c543b6648c68
```

```
Scaling complete.
🚀 Tuning XGBRegressor (GPU)...
```

```
[I 2025-11-04 07:05:31,601] Trial 0 finished with value: 0.07602376323618378 and
parameters: {'lambda': 0.009713524662965236, 'alpha': 0.009655403737294023,
'colsample_bytree': 1.0, 'subsample': 0.6, 'learning_rate': 0.009876450003425631,
'n_estimators': 400, 'max_depth': 9, 'min_child_weight': 235}. Best is trial 0 with v
0.07602376323618378.
[I 2025-11-04 07:05:33,746] Trial 1 finished with value: 0.07638982607543607 and
parameters: {'lambda': 2.456924988757906, 'alpha': 0.02042967269454827, 'colsample_by
0.7, 'subsample': 0.6, 'learning_rate': 0.019146038617756024, 'n_estimators': 300,
'max_depth': 6, 'min_child_weight': 290}. Best is trial 0 with value: 0.0760237632361
[I 2025-11-04 07:05:35,340] Trial 2 finished with value: 0.08326397767182682 and
parameters: {'lambda': 0.12552693247035865, 'alpha': 0.05778751403528924,
'colsample_bytree': 0.9, 'subsample': 0.8, 'learning_rate': 0.007094395158609372,
'n_estimators': 300, 'max_depth': 3, 'min_child_weight': 40}. Best is trial 0 with va
0.07602376323618378.
[I 2025-11-04 07:05:40,307] Trial 3 finished with value: 0.07580646591788548 and
parameters: {'lambda': 2.060612755551336, 'alpha': 0.01997512361324366, 'colsample_by
0.9, 'subsample': 1.0, 'learning_rate': 0.019894214335143656, 'n_estimators': 700,
'max_depth': 7, 'min_child_weight': 122}. Best is trial 3 with value: 0.0758064659178
[I 2025-11-04 07:05:49,279] Trial 4 finished with value: 0.0759493255891977 and paran
{'lambda': 0.7934539542539585, 'alpha': 0.06741439572195976, 'colsample_bytree': 0.5,
'subsample': 0.6, 'learning_rate': 0.02684484324672441, 'n_estimators': 800, 'max_dep
10, 'min_child_weight': 212}. Best is trial 3 with value: 0.07580646591788548.
[I 2025-11-04 07:05:51,798] Trial 5 finished with value: 0.07757922052025905 and
parameters: {'lambda': 0.007329248356885279, 'alpha': 2.916322058061389,
'colsample_bytree': 1.0, 'subsample': 0.5, 'learning_rate': 0.00839095705694639,
'n_estimators': 500, 'max_depth': 4, 'min_child_weight': 103}. Best is trial 3 with v
0.07580646591788548.
[I 2025-11-04 07:05:59,797] Trial 6 finished with value: 0.07599151152369328 and
parameters: {'lambda': 0.0018437675688638372, 'alpha': 0.25455877386768644,
'colsample_bytree': 1.0, 'subsample': 0.6, 'learning_rate': 0.014838230230213351,
'n_estimators': 500, 'max_depth': 10, 'min_child_weight': 14}. Best is trial 3 with v
0.07580646591788548.
[I 2025-11-04 07:06:04,375] Trial 7 finished with value: 0.07631634705071262 and
parameters: {'lambda': 0.0038503680367713744, 'alpha': 0.008449836947072053,
'colsample_bytree': 0.5, 'subsample': 0.5, 'learning_rate': 0.04980035895981791,
'n_estimators': 500, 'max_depth': 8, 'min_child_weight': 3}. Best is trial 3 with val
0.07580646591788548.
[I 2025-11-04 07:06:09,665] Trial 8 finished with value: 0.07600259567003377 and
parameters: {'lambda': 0.007106651742887392, 'alpha': 0.16295931689958468,
'colsample_bytree': 0.5, 'subsample': 0.7, 'learning_rate': 0.0444103317050353,
'n_estimators': 900, 'max_depth': 6, 'min_child_weight': 218}. Best is trial 3 with v
0.07580646591788548.
[I 2025-11-04 07:06:13,421] Trial 9 finished with value: 0.07770404442378276 and
parameters: {'lambda': 0.04873046731907212, 'alpha': 2.5123403442185515,
'colsample_bytree': 0.9, 'subsample': 0.5, 'learning_rate': 0.009138495880315359,
'n_estimators': 900, 'max_depth': 3, 'min_child_weight': 152}. Best is trial 3 with v
0.07580646591788548.
[I 2025-11-04 07:06:26,100] Trial 10 finished with value: 0.07674100107819326 and
parameters: {'lambda': 9.711022751716799, 'alpha': 0.0013638497376314634,
'colsample_bytree': 0.3, 'subsample': 1.0, 'learning_rate': 0.02756048515162493,
'n_estimators': 700, 'max_depth': 12, 'min_child_weight': 105}. Best is trial 3 with
0.07580646591788548.
[I 2025-11-04 07:06:35,729] Trial 11 finished with value: 0.07593440441271941 and
parameters: {'lambda': 0.6815884943581209, 'alpha': 0.6877614143447837, 'colsample_by
0.5, 'subsample': 1.0, 'learning_rate': 0.026960530873060436, 'n_estimators': 700,
'max_depth': 11, 'min_child_weight': 176}. Best is trial 3 with value: 0.075806465917
[I 2025-11-04 07:06:47,710] Trial 12 finished with value: 0.0760783044376235 and
parameters: {'lambda': 0.5347734146651184, 'alpha': 0.5545911728626289, 'colsample_by
0.9, 'subsample': 1.0, 'learning_rate': 0.016881790692203916, 'n_estimators': 700,
'max_depth': 12, 'min_child_weight': 153}. Best is trial 3 with value: 0.075806465917
```

```
[I 2025-11-04 07:06:53,290] Trial 13 finished with value: 0.07588848668518207 and
parameters: {'lambda': 2.3619978477174315, 'alpha': 0.898386685476339, 'colsample_byt
0.7, 'subsample': 1.0, 'learning_rate': 0.028981333622944645, 'n_estimators': 1000,
'max_depth': 6, 'min_child_weight': 105}. Best is trial 3 with value: 0.0758064659178
[I 2025-11-04 07:06:59,000] Trial 14 finished with value: 0.07582842555685963 and
parameters: {'lambda': 4.224234336144367, 'alpha': 8.730890722287004, 'colsample_bytr
0.7, 'subsample': 1.0, 'learning_rate': 0.034023303502699755, 'n_estimators': 1000,
'max_depth': 6, 'min_child_weight': 81}. Best is trial 3 with value: 0.0758064659178
[I 2025-11-04 07:07:05,737] Trial 15 finished with value: 0.0758057881018206 and
parameters: {'lambda': 6.318025292618003, 'alpha': 6.661307978778664, 'colsample_bytr
0.7, 'subsample': 1.0, 'learning_rate': 0.036742606850254926, 'n_estimators': 1000,
'max_depth': 7, 'min_child_weight': 60}. Best is trial 15 with value: 0.075805788101
[I 2025-11-04 07:07:12,862] Trial 16 finished with value: 0.07703876178672087 and
parameters: {'lambda': 9.879656123768246, 'alpha': 0.001304017881656144,
'colsample_bytree': 0.3, 'subsample': 0.8, 'learning_rate': 0.013414100135095967,
'n_estimators': 800, 'max_depth': 8, 'min_child_weight': 59}. Best is trial 15 with v
0.0758057881018206.
[I 2025-11-04 07:07:17,087] Trial 17 finished with value: 0.07585771271634564 and
parameters: {'lambda': 0.13491803484259854, 'alpha': 0.03251601620945474,
'colsample_bytree': 0.7, 'subsample': 0.7, 'learning_rate': 0.0382729246806276,
'n_estimators': 600, 'max_depth': 7, 'min_child_weight': 57}. Best is trial 15 with v
0.0758057881018206.
[I 2025-11-04 07:07:18,454] Trial 18 finished with value: 0.07679513502450991 and
parameters: {'lambda': 0.35617940873775344, 'alpha': 0.0038932003724297982,
'colsample_bytree': 0.9, 'subsample': 1.0, 'learning_rate': 0.021097927036427384,
'n_estimators': 200, 'max_depth': 5, 'min_child_weight': 129}. Best is trial 15 with
0.0758057881018206.
[I 2025-11-04 07:07:24,883] Trial 19 finished with value: 0.0763369055508708 and
parameters: {'lambda': 0.040619846656214154, 'alpha': 6.971540932111194,
'colsample_bytree': 0.7, 'subsample': 1.0, 'learning_rate': 0.005662950700209693,
'n_estimators': 900, 'max_depth': 7, 'min_child_weight': 184}. Best is trial 15 with
0.0758057881018206.
[I 2025-11-04 07:07:33,887] Trial 20 finished with value: 0.07589020106506654 and
parameters: {'lambda': 1.6866903378739608, 'alpha': 0.24752333541325683,
'colsample_bytree': 0.9, 'subsample': 1.0, 'learning_rate': 0.012079887792374922,
'n_estimators': 800, 'max_depth': 9, 'min_child_weight': 33}. Best is trial 15 with v
0.0758057881018206.
[I 2025-11-04 07:07:38,855] Trial 21 finished with value: 0.07599849927813049 and
parameters: {'lambda': 4.497075657764624, 'alpha': 8.328361957816304, 'colsample_bytr
0.7, 'subsample': 1.0, 'learning_rate': 0.036069996300014 57, 'n_estimators': 1000,
'max_depth': 5, 'min_child_weight': 82}. Best is trial 15 with value: 0.075805788101
[I 2025-11-04 07:07:45,505] Trial 22 finished with value: 0.07582443172137532 and
parameters: {'lambda': 4.522371380603157, 'alpha': 2.3639491621753246, 'colsample_byt
0.7, 'subsample': 1.0, 'learning_rate': 0.035986938423444095, 'n_estimators': 1000,
'max_depth': 7, 'min_child_weight': 76}. Best is trial 15 with value: 0.075805788101
[I 2025-11-04 07:07:52,915] Trial 23 finished with value: 0.07577588923702314 and
parameters: {'lambda': 1.402148220923321, 'alpha': 1.9503215092805053, 'colsample_byt
0.7, 'subsample': 1.0, 'learning_rate': 0.02221651019692315, 'n_estimators': 900,
'max_depth': 8, 'min_child_weight': 79}. Best is trial 23 with value: 0.075775889237
[I 2025-11-04 07:08:01,580] Trial 24 finished with value: 0.07582398508274045 and
parameters: {'lambda': 1.2722951352628433, 'alpha': 1.244754192237977, 'colsample_byt
0.7, 'subsample': 1.0, 'learning_rate': 0.02220978208678578, 'n_estimators': 900,
'max_depth': 9, 'min_child_weight': 134}. Best is trial 23 with value: 0.07577588923
[I 2025-11-04 07:08:08,312] Trial 25 finished with value: 0.07681945098056822 and
parameters: {'lambda': 0.2805011772950726, 'alpha': 3.7455755847687655, 'colsample_by
0.3, 'subsample': 0.8, 'learning_rate': 0.01782955548109853, 'n_estimators': 800,
'max_depth': 8, 'min_child_weight': 124}. Best is trial 23 with value: 0.07577588923
[I 2025-11-04 07:08:11,527] Trial 26 finished with value: 0.07604025566949645 and
parameters: {'lambda': 1.1163454482844781, 'alpha': 0.023799383618906225,
'colsample_bytree': 0.9, 'subsample': 0.7, 'learning_rate': 0.022770981925602517,
```

```
'n_estimators': 600, 'max_depth': 5, 'min_child_weight': 49}. Best is trial 23 with v
0.07577588923702314.
[I 2025-11-04 07:08:17,992] Trial 27 finished with value: 0.07586882284278347 and
parameters: {'lambda': 4.662691839270933, 'alpha': 1.506615854508816, 'colsample_bytr
0.7, 'subsample': 1.0, 'learning_rate': 0.011962348401267196, 'n_estimators': 900,
'max_depth': 7, 'min_child_weight': 23}. Best is trial 23 with value: 0.075775889237
[I 2025-11-04 07:08:23,664] Trial 28 finished with value: 0.07580093508356274 and
parameters: {'lambda': 0.28633026622062224, 'alpha': 0.3713032320615905,
'colsample_bytree': 0.7, 'subsample': 1.0, 'learning_rate': 0.031481125856815756,
'n_estimators': 700, 'max_depth': 8, 'min_child_weight': 74}. Best is trial 23 with v
0.07577588923702314.
[I 2025-11-04 07:08:34,656] Trial 29 finished with value: 0.07613213431369044 and
parameters: {'lambda': 0.030545781117600476, 'alpha': 0.366698226196754,
'colsample_bytree': 0.7, 'subsample': 1.0, 'learning_rate': 0.03127003816639134,
'n_estimators': 1000, 'max_depth': 10, 'min_child_weight': 67}. Best is trial 23 with
value: 0.07577588923702314.
[I 2025-11-04 07:08:42,874] Trial 30 finished with value: 0.07596705868081885 and
parameters: {'lambda': 0.22652417965557362, 'alpha': 4.752607277050509, 'colsample_by
0.7, 'subsample': 0.8, 'learning_rate': 0.04209271332664782, 'n_estimators': 800,
'max_depth': 9, 'min_child_weight': 98}. Best is trial 23 with value: 0.075775889237
[I 2025-11-04 07:08:48,584] Trial 31 finished with value: 0.07586706209961687 and
parameters: {'lambda': 2.6941837176614376, 'alpha': 0.13024674983255552,
'colsample_bytree': 1.0, 'subsample': 1.0, 'learning_rate': 0.024690923898771564,
'n_estimators': 700, 'max_depth': 8, 'min_child_weight': 85}. Best is trial 23 with v
0.07577588923702314.
[I 2025-11-04 07:08:54,588] Trial 32 finished with value: 0.07583634662192104 and
parameters: {'lambda': 0.46105548414118097, 'alpha': 0.012287855111844263,
'colsample_bytree': 0.7, 'subsample': 1.0, 'learning_rate': 0.020524903693085274,
'n_estimators': 600, 'max_depth': 9, 'min_child_weight': 283}. Best is trial 23 with
0.07577588923702314.
[I 2025-11-04 07:08:58,891] Trial 33 finished with value: 0.07582948011228509 and
parameters: {'lambda': 1.959776268182457, 'alpha': 1.5932011520516425, 'colsample_byt
0.7, 'subsample': 0.6, 'learning_rate': 0.0324168306502065, 'n_estimators': 600,
'max_depth': 7, 'min_child_weight': 117}. Best is trial 23 with value: 0.075775889237
[I 2025-11-04 07:09:01,497] Trial 34 finished with value: 0.07597871635381567 and
parameters: {'lambda': 0.9782760863242627, 'alpha': 0.04941358800948751,
'colsample_bytree': 0.9, 'subsample': 1.0, 'learning_rate': 0.024121419271443737,
'n_estimators': 400, 'max_depth': 6, 'min_child_weight': 37}. Best is trial 23 with v
0.07577588923702314.
[I 2025-11-04 07:09:07,451] Trial 35 finished with value: 0.07586427519707108 and
parameters: {'lambda': 0.14617405176881954, 'alpha': 4.887919608485469, 'colsample_by
0.7, 'subsample': 0.5, 'learning_rate': 0.018123286410116186, 'n_estimators': 700,
'max_depth': 8, 'min_child_weight': 168}. Best is trial 23 with value: 0.075775889237
[I 2025-11-04 07:09:15,607] Trial 36 finished with value: 0.0758160404267982 and
parameters: {'lambda': 0.08371720498722263, 'alpha': 0.07630625475467527,
'colsample_bytree': 1.0, 'subsample': 0.6, 'learning_rate': 0.015316972207631549,
'n_estimators': 800, 'max_depth': 9, 'min_child_weight': 91}. Best is trial 23 with v
0.07577588923702314.
[I 2025-11-04 07:09:21,339] Trial 37 finished with value: 0.07587113130073411 and
parameters: {'lambda': 6.565377724319948, 'alpha': 0.00595370411578853, 'colsample_by
0.9, 'subsample': 1.0, 'learning_rate': 0.0430846602305503, 'n_estimators': 900,
'max_depth': 7, 'min_child_weight': 67}. Best is trial 23 with value: 0.075775889237
[I 2025-11-04 07:09:27,273] Trial 38 finished with value: 0.0758287723920729 and
parameters: {'lambda': 2.976572571119637, 'alpha': 0.4348612165128597, 'colsample_byt
0.7, 'subsample': 0.7, 'learning_rate': 0.020099195418669297, 'n_estimators': 400,
'max_depth': 10, 'min_child_weight': 44}. Best is trial 23 with value: 0.075775889237
[I 2025-11-04 07:09:31,620] Trial 39 finished with value: 0.07590740382912146 and
parameters: {'lambda': 0.01639087438439517, 'alpha': 0.23027211917836585,
'colsample_bytree': 0.5, 'subsample': 0.5, 'learning_rate': 0.030083920458376753,
'n_estimators': 500, 'max_depth': 8, 'min_child_weight': 140}. Best is trial 23 with
```

```
0.07577588923702314.
[I 2025-11-04 07:09:35,578] Trial 40 finished with value: 0.07710844527502307 and
parameters: {'lambda': 0.7736851584570628, 'alpha': 0.013935756151288878,
'colsample_bytree': 0.3, 'subsample': 0.6, 'learning_rate': 0.04764181779698659,
'n_estimators': 900, 'max_depth': 4, 'min_child_weight': 3}. Best is trial 23 with va
0.07577588923702314.
[I 2025-11-04 07:09:43,762] Trial 41 finished with value: 0.07581838713729581 and
parameters: {'lambda': 0.06541683236313371, 'alpha': 0.05160917410851224,
'colsample_bytree': 1.0, 'subsample': 0.6, 'learning_rate': 0.015459812392374863,
'n_estimators': 800, 'max_depth': 9, 'min_child_weight': 90}. Best is trial 23 with v
0.07577588923702314.
[I 2025-11-04 07:09:49,861] Trial 42 finished with value: 0.07577777728116247 and
parameters: {'lambda': 0.0889189756766029, 'alpha': 0.08488334057739802,
'colsample_bytree': 1.0, 'subsample': 0.6, 'learning_rate': 0.013736361529120285,
'n_estimators': 700, 'max_depth': 8, 'min_child_weight': 115}. Best is trial 23 with
0.07577588923702314.
[I 2025-11-04 07:09:56,102] Trial 43 finished with value: 0.07579576286084325 and
parameters: {'lambda': 0.18769299878418427, 'alpha': 0.02903911886309175,
'colsample_bytree': 1.0, 'subsample': 0.6, 'learning_rate': 0.010028382895445302,
'n_estimators': 700, 'max_depth': 8, 'min_child_weight': 109}. Best is trial 23 with
0.07577588923702314.
[I 2025-11-04 07:10:02,537] Trial 44 finished with value: 0.07584766129573972 and
parameters: {'lambda': 0.1738058436605229, 'alpha': 0.09968321102989532,
'colsample_bytree': 1.0, 'subsample': 0.6, 'learning_rate': 0.007754716079512187,
'n_estimators': 700, 'max_depth': 8, 'min_child_weight': 101}. Best is trial 23 with
0.07577588923702314.
[I 2025-11-04 07:10:10,623] Trial 45 finished with value: 0.07584340758742077 and
parameters: {'lambda': 0.018838806179028514, 'alpha': 0.13361245551398784,
'colsample_bytree': 1.0, 'subsample': 0.6, 'learning_rate': 0.011927820865902758,
'n_estimators': 600, 'max_depth': 10, 'min_child_weight': 116}. Best is trial 23 with
value: 0.07577588923702314.
[I 2025-11-04 07:10:16,964] Trial 46 finished with value: 0.07578354192454474 and
parameters: {'lambda': 0.0886656658076851, 'alpha': 0.9656581141388152, 'colsample_by
1.0, 'subsample': 0.6, 'learning_rate': 0.009681315268898155, 'n_estimators': 700,
'max_depth': 8, 'min_child_weight': 70}. Best is trial 23 with value: 0.0757758892376
[I 2025-11-04 07:10:21,619] Trial 47 finished with value: 0.07587450440261852 and
parameters: {'lambda': 0.10095758200472067, 'alpha': 0.7310686609326719,
'colsample_bytree': 1.0, 'subsample': 0.6, 'learning_rate': 0.010551100567998833,
'n_estimators': 500, 'max_depth': 8, 'min_child_weight': 112}. Best is trial 23 with
0.07577588923702314.
[I 2025-11-04 07:10:33,322] Trial 48 finished with value: 0.07593084484658102 and
parameters: {'lambda': 0.0689466611224349, 'alpha': 0.9362435610077919, 'colsample_by
1.0, 'subsample': 0.6, 'learning_rate': 0.006365188591562221, 'n_estimators': 700,
'max_depth': 11, 'min_child_weight': 143}. Best is trial 23 with value:
0.07577588923702314.
[I 2025-11-04 07:10:39,709] Trial 49 finished with value: 0.07579352721219712 and
parameters: {'lambda': 0.2517948292508937, 'alpha': 0.4087010540213433, 'colsample_by
1.0, 'subsample': 0.6, 'learning_rate': 0.009237312123332557, 'n_estimators': 700,
'max_depth': 8, 'min_child_weight': 72}. Best is trial 23 with value: 0.0757758892376
[I 2025-11-04 07:10:39,711] A new study created in memory with name: no-name-40e3e1bb
ad72-40c2-8979-ef0ed82397e6
✅ Best XGBRegressor parameters: {'lambda': 1.402148220923321, 'alpha': 1.95032150928
'colsample_bytree': 0.7, 'subsample': 1.0, 'learning_rate': 0.02221651019692315,
'n_estimators': 900, 'max_depth': 8, 'min_child_weight': 79}

🚀 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 07:10:49,729] Trial 0 finished with value: 0.0770235239870468 and paran
{'lambda_l1': 0.12656623505929554, 'lambda_l2': 0.000159697449866596, 'num_leaves': 1
'feature_fraction': 0.6528263660187879, 'bagging_fraction': 0.7721848642759286,
'bagging_freq': 5, 'min_child_samples': 99, 'learning_rate': 0.039087134279140325,
'n_estimators': 200, 'max_depth': 4}. Best is trial 0 with value: 0.0770235239870468.
[I 2025-11-04 07:11:12,150] Trial 1 finished with value: 0.0758159689374141 and paran
{'lambda_l1': 0.32898173059999225, 'lambda_l2': 0.06584995276317418, 'num_leaves': 16
'feature_fraction': 0.9364605132932545, 'bagging_fraction': 0.7000194945610758,
'bagging_freq': 1, 'min_child_samples': 100, 'learning_rate': 0.026271726212986395,
'n_estimators': 500, 'max_depth': 12}. Best is trial 1 with value: 0.0758159689374141.
[I 2025-11-04 07:11:20,492] Trial 2 finished with value: 0.07606269623144041 and
parameters: {'lambda_l1': 0.021960739012937998, 'lambda_l2': 0.00014308302950825496,
'num_leaves': 55, 'feature_fraction': 0.9494578826491208, 'bagging_fraction':
0.8276257577833694, 'bagging_freq': 4, 'min_child_samples': 48, 'learning_rate':
0.022457473405630726, 'n_estimators': 200, 'max_depth': 9}. Best is trial 1 with valu
0.0758159689374141.
[I 2025-11-04 07:11:26,212] Trial 3 finished with value: 0.07735932459693931 and
parameters: {'lambda_l1': 0.4914966951794588, 'lambda_l2': 0.0031351289565769197,
'num_leaves': 69, 'feature_fraction': 0.6244992520906398, 'bagging_fraction':
0.6018818246532573, 'bagging_freq': 5, 'min_child_samples': 24, 'learning_rate':
0.05347628762865249, 'n_estimators': 300, 'max_depth': 3}. Best is trial 1 with value
0.0758159689374141.
[I 2025-11-04 07:11:34,265] Trial 4 finished with value: 0.07618580090102985 and
parameters: {'lambda_l1': 0.3237367244498713, 'lambda_l2': 0.17907887050358365,
'num_leaves': 121, 'feature_fraction': 0.6317587730529074, 'bagging_fraction':
0.7415142186283761, 'bagging_freq': 4, 'min_child_samples': 26, 'learning_rate':
0.09655542874039638, 'n_estimators': 200, 'max_depth': 12}. Best is trial 1 with valu
```

```
0.0758159689374141.
[I 2025-11-04 07:12:02,318] Trial 5 finished with value: 0.07693753660618721 and
parameters: {'lambda_l1': 0.00042688193137557074, 'lambda_l2': 0.00473334799049252,
'num_leaves': 76, 'feature_fraction': 0.8996461410559274, 'bagging_fraction':
0.6118230001502464, 'bagging_freq': 1, 'min_child_samples': 65, 'learning_rate':
0.08281546963068322, 'n_estimators': 1000, 'max_depth': 10}. Best is trial 1 with val
0.0758159689374141.
[I 2025-11-04 07:12:20,110] Trial 6 finished with value: 0.07682959484095904 and
parameters: {'lambda_l1': 0.00025651564040863776, 'lambda_l2': 0.002761262548345872,
'num_leaves': 42, 'feature_fraction': 0.6768795621460244, 'bagging_fraction':
0.6204266597804473, 'bagging_freq': 3, 'min_child_samples': 48, 'learning_rate':
0.07282548871136835, 'n_estimators': 900, 'max_depth': 3}. Best is trial 1 with value
0.0758159689374141.
[I 2025-11-04 07:12:27,918] Trial 7 finished with value: 0.07630342401508927 and
parameters: {'lambda_l1': 0.0019809905024697765, 'lambda_l2': 0.8509725878955606,
'num_leaves': 48, 'feature_fraction': 0.8184630318233934, 'bagging_fraction':
0.921111082916612, 'bagging_freq': 4, 'min_child_samples': 24, 'learning_rate':
0.12345525574820329, 'n_estimators': 300, 'max_depth': 4}. Best is trial 1 with value
0.0758159689374141.
[I 2025-11-04 07:12:50,619] Trial 8 finished with value: 0.0780356991415857 and paran
{'lambda_l1': 0.0015645619978071172, 'lambda_l2': 0.004601833917491327, 'num_leaves':
'feature_fraction': 0.5636365279349685, 'bagging_fraction': 0.7810231826430611,
'bagging_freq': 3, 'min_child_samples': 49, 'learning_rate': 0.005818281175912864,
'n_estimators': 800, 'max_depth': 4}. Best is trial 1 with value: 0.0758159689374141.
[I 2025-11-04 07:13:30,224] Trial 9 finished with value: 0.07612337721144598 and
parameters: {'lambda_l1': 0.026900630271654142, 'lambda_l2': 0.8674740272273208,
'num_leaves': 104, 'feature_fraction': 0.7222851517799193, 'bagging_fraction':
0.650853095475267, 'bagging_freq': 5, 'min_child_samples': 45, 'learning_rate':
0.03469078075175619, 'n_estimators': 1000, 'max_depth': 10}. Best is trial 1 with val
0.0758159689374141.
[I 2025-11-04 07:13:49,104] Trial 10 finished with value: 0.07990984865243361 and
parameters: {'lambda_l1': 2.6900098931141996e-05, 'lambda_l2': 0.04777298500123246,
'num_leaves': 198, 'feature_fraction': 0.8213533214664667, 'bagging_fraction':
0.5128758898774867, 'bagging_freq': 1, 'min_child_samples': 100, 'learning_rate':
0.28648196336751075, 'n_estimators': 600, 'max_depth': 7}. Best is trial 1 with value
0.0758159689374141.
[I 2025-11-04 07:14:18,706] Trial 11 finished with value: 0.07591103591544943 and
parameters: {'lambda_l1': 0.02524201516283813, 'lambda_l2': 1.1099959322690147e-05,
'num_leaves': 181, 'feature_fraction': 0.9741633574847847, 'bagging_fraction':
0.8911492495192946, 'bagging_freq': 7, 'min_child_samples': 71, 'learning_rate':
0.016070793855446443, 'n_estimators': 500, 'max_depth': 12}. Best is trial 1 with val
0.0758159689374141.
[I 2025-11-04 07:14:49,597] Trial 12 finished with value: 0.07592220713059397 and
parameters: {'lambda_l1': 0.04611746886282343, 'lambda_l2': 1.2247296263359346e-05,
'num_leaves': 179, 'feature_fraction': 0.9991684555103744, 'bagging_fraction':
0.9597967481472489, 'bagging_freq': 7, 'min_child_samples': 80, 'learning_rate':
0.012677257350145256, 'n_estimators': 500, 'max_depth': 12}. Best is trial 1 with val
0.0758159689374141.
[I 2025-11-04 07:15:12,479] Trial 13 finished with value: 0.07588626328562481 and
parameters: {'lambda_l1': 0.009066357737116535, 'lambda_l2': 0.05316531722731784,
'num_leaves': 162, 'feature_fraction': 0.8753564348829883, 'bagging_fraction':
0.9222082135995252, 'bagging_freq': 7, 'min_child_samples': 81, 'learning_rate':
0.01350691102894569, 'n_estimators': 500, 'max_depth': 7}. Best is trial 1 with value
0.0758159689374141.
[I 2025-11-04 07:15:51,930] Trial 14 finished with value: 0.07599033613703061 and
parameters: {'lambda_l1': 0.9047170782236058, 'lambda_l2': 0.03870670100159581,
'num_leaves': 256, 'feature_fraction': 0.8722751324417255, 'bagging_fraction':
0.9920809683587417, 'bagging_freq': 2, 'min_child_samples': 86, 'learning_rate':
0.007533238866180151, 'n_estimators': 700, 'max_depth': 7}. Best is trial 1 with valu
0.0758159689374141.
```

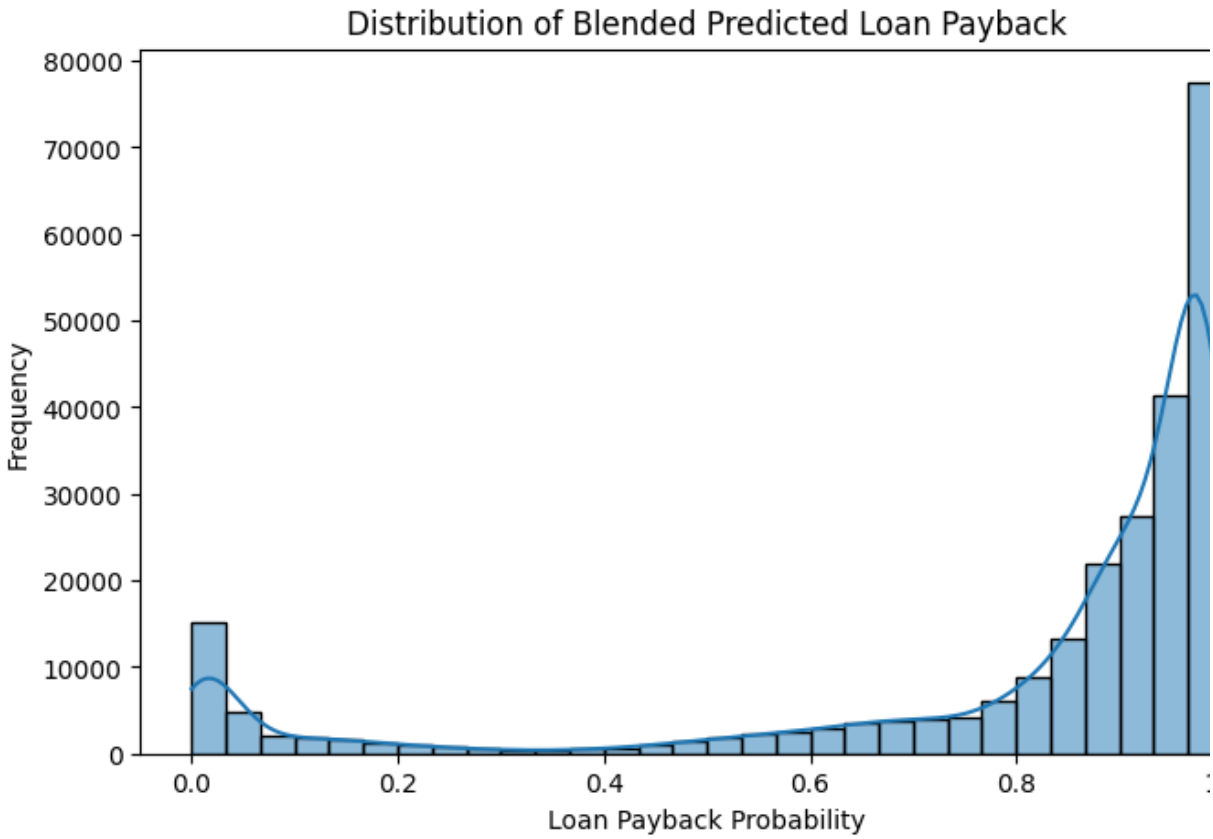
```
[I 2025-11-04 07:16:09,502] Trial 15 finished with value: 0.07621699739315711 and
parameters: {'lambda_l1': 0.006290636598217303, 'lambda_l2': 0.03763371788685522,
'num_leaves': 152, 'feature_fraction': 0.7844486742367427, 'bagging_fraction':
0.7178076643520375, 'bagging_freq': 6, 'min_child_samples': 89, 'learning_rate':
0.010364748831578884, 'n_estimators': 500, 'max_depth': 6}. Best is trial 1 with valu
0.0758159689374141.
[I 2025-11-04 07:16:36,307] Trial 16 finished with value: 0.07581297109930966 and
parameters: {'lambda_l1': 0.12585985912310999, 'lambda_l2': 0.15574576998635412,
'num_leaves': 218, 'feature_fraction': 0.8976492465662145, 'bagging_fraction':
0.8502434179033568, 'bagging_freq': 2, 'min_child_samples': 72, 'learning_rate':
0.021775143393970898, 'n_estimators': 400, 'max_depth': 9}. Best is trial 16 with val
0.07581297109930966.
[I 2025-11-04 07:17:01,309] Trial 17 finished with value: 0.07585780525686078 and
parameters: {'lambda_l1': 0.14051836408320556, 'lambda_l2': 0.3702099823006668,
'num_leaves': 224, 'feature_fraction': 0.9310287659188062, 'bagging_fraction':
0.7047512464115655, 'bagging_freq': 2, 'min_child_samples': 60, 'learning_rate':
0.026320874931798955, 'n_estimators': 400, 'max_depth': 9}. Best is trial 16 with val
0.07581297109930966.
[I 2025-11-04 07:17:50,519] Trial 18 finished with value: 0.07590247510474826 and
parameters: {'lambda_l1': 0.11446788193096062, 'lambda_l2': 0.013291912710243606,
'num_leaves': 222, 'feature_fraction': 0.847997610697181, 'bagging_fraction':
0.8207072926995985, 'bagging_freq': 2, 'min_child_samples': 72, 'learning_rate':
0.024336948578145518, 'n_estimators': 700, 'max_depth': 10}. Best is trial 16 with va
0.07581297109930966.
[I 2025-11-04 07:18:08,622] Trial 19 finished with value: 0.08073135930409348 and
parameters: {'lambda_l1': 1.013075449384724e-05, 'lambda_l2': 0.000716115782686848,
'num_leaves': 254, 'feature_fraction': 0.7411137265043937, 'bagging_fraction':
0.8607043669483487, 'bagging_freq': 1, 'min_child_samples': 36, 'learning_rate':
0.2173395307536511, 'n_estimators': 400, 'max_depth': 11}. Best is trial 16 with valu
0.07581297109930966.
[I 2025-11-04 07:18:44,919] Trial 20 finished with value: 0.07653974596706228 and
parameters: {'lambda_l1': 0.8003224812200754, 'lambda_l2': 0.1520884593312217,
'num_leaves': 215, 'feature_fraction': 0.934114875911028, 'bagging_fraction':
0.6773137040032616, 'bagging_freq': 3, 'min_child_samples': 12, 'learning_rate':
0.04909254852200837, 'n_estimators': 600, 'max_depth': 9}. Best is trial 16 with valu
0.07581297109930966.
[I 2025-11-04 07:19:10,117] Trial 21 finished with value: 0.0758578234083299 and
parameters: {'lambda_l1': 0.1152960891862247, 'lambda_l2': 0.24656039965721074,
'num_leaves': 227, 'feature_fraction': 0.9309042938643854, 'bagging_fraction':
0.6879544588279775, 'bagging_freq': 2, 'min_child_samples': 59, 'learning_rate':
0.0243255417609307, 'n_estimators': 400, 'max_depth': 9}. Best is trial 16 with value
0.07581297109930966.
[I 2025-11-04 07:19:30,270] Trial 22 finished with value: 0.07578013535181295 and
parameters: {'lambda_l1': 0.21762830306466474, 'lambda_l2': 0.37215433784614715,
'num_leaves': 200, 'feature_fraction': 0.9121622132533548, 'bagging_fraction':
0.5517640363041149, 'bagging_freq': 2, 'min_child_samples': 61, 'learning_rate':
0.03097762367464489, 'n_estimators': 400, 'max_depth': 8}. Best is trial 22 with valu
0.07578013535181295.
[I 2025-11-04 07:19:42,297] Trial 23 finished with value: 0.07586819719579511 and
parameters: {'lambda_l1': 0.2698098098649411, 'lambda_l2': 0.01416394318990604,
'num_leaves': 140, 'feature_fraction': 0.8913467423611526, 'bagging_fraction':
0.5082199099703736, 'bagging_freq': 1, 'min_child_samples': 69, 'learning_rate':
0.01701505032637976, 'n_estimators': 300, 'max_depth': 8}. Best is trial 22 with valu
0.07578013535181295.
[I 2025-11-04 07:19:56,743] Trial 24 finished with value: 0.07594822136125347 and
parameters: {'lambda_l1': 0.06543608202050705, 'lambda_l2': 0.11791600340763289,
'num_leaves': 181, 'feature_fraction': 0.7879310529399265, 'bagging_fraction':
0.5529790801022826, 'bagging_freq': 2, 'min_child_samples': 90, 'learning_rate':
0.03721015562869374, 'n_estimators': 400, 'max_depth': 6}. Best is trial 22 with valu
0.07578013535181295.
```

```
[I 2025-11-04 07:20:35,128] Trial 25 finished with value: 0.07656456998040335 and
parameters: {'lambda_l1': 0.01217942081881424, 'lambda_l2': 0.517997025881531,
'num_leaves': 200, 'feature_fraction': 0.9936095284631934, 'bagging_fraction':
0.8149454088185384, 'bagging_freq': 3, 'min_child_samples': 77, 'learning_rate':
0.05683761682731006, 'n_estimators': 600, 'max_depth': 11}. Best is trial 22 with val
0.07578013535181295.
[I 2025-11-04 07:20:46,981] Trial 26 finished with value: 0.07582462235911516 and
parameters: {'lambda_l1': 0.27058302560514746, 'lambda_l2': 0.016166816578982328,
'num_leaves': 201, 'feature_fraction': 0.8391750044373124, 'bagging_fraction':
0.5410279149939063, 'bagging_freq': 1, 'min_child_samples': 56, 'learning_rate':
0.03229579436501118, 'n_estimators': 300, 'max_depth': 8}. Best is trial 22 with valu
0.07578013535181295.
[I 2025-11-04 07:21:03,117] Trial 27 finished with value: 0.07650238531578149 and
parameters: {'lambda_l1': 0.4411854936539956, 'lambda_l2': 0.13958610447289135,
'num_leaves': 241, 'feature_fraction': 0.908947110256167, 'bagging_fraction':
0.6511274482304364, 'bagging_freq': 2, 'min_child_samples': 93, 'learning_rate':
0.009122038652186684, 'n_estimators': 400, 'max_depth': 6}. Best is trial 22 with val
0.07578013535181295.
[I 2025-11-04 07:21:25,309] Trial 28 finished with value: 0.07582943654990827 and
parameters: {'lambda_l1': 0.05235109044669711, 'lambda_l2': 0.08982421563431237,
'num_leaves': 157, 'feature_fraction': 0.9701846315745566, 'bagging_fraction':
0.5627883711909325, 'bagging_freq': 1, 'min_child_samples': 39, 'learning_rate':
0.018594494996177623, 'n_estimators': 500, 'max_depth': 11}. Best is trial 22 with va
0.07578013535181295.
[I 2025-11-04 07:21:59,907] Trial 29 finished with value: 0.07595601094305257 and
parameters: {'lambda_l1': 0.1620251990878633, 'lambda_l2': 0.38459425139013137,
'num_leaves': 115, 'feature_fraction': 0.5100985259530697, 'bagging_fraction':
0.7720471993676115, 'bagging_freq': 3, 'min_child_samples': 64, 'learning_rate':
0.04445592185581706, 'n_estimators': 700, 'max_depth': 8}. Best is trial 22 with valu
0.07578013535181295.
[I 2025-11-04 07:22:21,126] Trial 30 finished with value: 0.07598373126379374 and
parameters: {'lambda_l1': 0.004099353837528801, 'lambda_l2': 0.0003799763801828511,
'num_leaves': 171, 'feature_fraction': 0.8556667335757995, 'bagging_fraction':
0.875147391901157, 'bagging_freq': 2, 'min_child_samples': 95, 'learning_rate':
0.03315490817993467, 'n_estimators': 600, 'max_depth': 5}. Best is trial 22 with valu
0.07578013535181295.
[I 2025-11-04 07:22:33,033] Trial 31 finished with value: 0.07582183757186886 and
parameters: {'lambda_l1': 0.29809891960114504, 'lambda_l2': 0.016847386051828155,
'num_leaves': 201, 'feature_fraction': 0.8164391569850117, 'bagging_fraction':
0.5585981906279783, 'bagging_freq': 1, 'min_child_samples': 53, 'learning_rate':
0.031473015660988375, 'n_estimators': 300, 'max_depth': 8}. Best is trial 22 with val
0.07578013535181295.
[I 2025-11-04 07:22:41,491] Trial 32 finished with value: 0.07589332654014962 and
parameters: {'lambda_l1': 0.8904333671251609, 'lambda_l2': 0.0209345761335724,
'num_leaves': 196, 'feature_fraction': 0.9572111669648407, 'bagging_fraction':
0.5900405761231354, 'bagging_freq': 1, 'min_child_samples': 53, 'learning_rate':
0.028458100869134348, 'n_estimators': 200, 'max_depth': 8}. Best is trial 22 with val
0.07578013535181295.
[I 2025-11-04 07:22:48,649] Trial 33 finished with value: 0.07645212579465827 and
parameters: {'lambda_l1': 0.07943208368803822, 'lambda_l2': 0.0633975356372523,
'num_leaves': 20, 'feature_fraction': 0.778725094042737, 'bagging_fraction':
0.5737491157482204, 'bagging_freq': 1, 'min_child_samples': 43, 'learning_rate':
0.02092758684372338, 'n_estimators': 300, 'max_depth': 10}. Best is trial 22 with val
0.07578013535181295.
[I 2025-11-04 07:23:00,483] Trial 34 finished with value: 0.07604462879377966 and
parameters: {'lambda_l1': 0.20383149824450802, 'lambda_l2': 0.007882157350240093,
'num_leaves': 213, 'feature_fraction': 0.9081535477336548, 'bagging_fraction':
0.6467521771696558, 'bagging_freq': 2, 'min_child_samples': 54, 'learning_rate':
0.06248352602275216, 'n_estimators': 200, 'max_depth': 9}. Best is trial 22 with valu
0.07578013535181295.
```

```
[I 2025-11-04 07:23:11,075] Trial 35 finished with value: 0.07612614933869345 and
parameters: {'lambda_l1': 0.2861429740396104, 'lambda_l2': 0.27960471352135086,
'num_leaves': 239, 'feature_fraction': 0.8783795758807112, 'bagging_fraction':
0.7422812004110684, 'bagging_freq': 1, 'min_child_samples': 34, 'learning_rate':
0.013546280797091107, 'n_estimators': 300, 'max_depth': 7}. Best is trial 22 with val
0.07578013535181295.
[I 2025-11-04 07:23:31,079] Trial 36 finished with value: 0.07602313575129514 and
parameters: {'lambda_l1': 0.44485691107186714, 'lambda_l2': 0.03301485492130403,
'num_leaves': 145, 'feature_fraction': 0.8188789461053672, 'bagging_fraction':
0.5325655819472932, 'bagging_freq': 3, 'min_child_samples': 75, 'learning_rate':
0.04292912491125213, 'n_estimators': 400, 'max_depth': 11}. Best is trial 22 with val
0.07578013535181295.
[I 2025-11-04 07:23:41,128] Trial 37 finished with value: 0.07616705307670416 and
parameters: {'lambda_l1': 0.03704713367285057, 'lambda_l2': 0.0015374152272022888,
'num_leaves': 129, 'feature_fraction': 0.6996532610500684, 'bagging_fraction':
0.6291673911598812, 'bagging_freq': 2, 'min_child_samples': 65, 'learning_rate':
0.10942688215507396, 'n_estimators': 200, 'max_depth': 9}. Best is trial 22 with valu
0.07578013535181295.
[I 2025-11-04 07:23:59,820] Trial 38 finished with value: 0.07579102644199043 and
parameters: {'lambda_l1': 0.0006350152535533592, 'lambda_l2': 0.08064800725244257,
'num_leaves': 99, 'feature_fraction': 0.9219703147499971, 'bagging_fraction':
0.7860924594865673, 'bagging_freq': 4, 'min_child_samples': 84, 'learning_rate':
0.019229268734662457, 'n_estimators': 400, 'max_depth': 8}. Best is trial 22 with val
0.07578013535181295.
[I 2025-11-04 07:24:21,773] Trial 39 finished with value: 0.07578328773423659 and
parameters: {'lambda_l1': 0.00043248252813714316, 'lambda_l2': 0.5754881704239588,
'num_leaves': 83, 'feature_fraction': 0.9480898887655446, 'bagging_fraction':
0.7900343361982531, 'bagging_freq': 4, 'min_child_samples': 82, 'learning_rate':
0.01953111592250337, 'n_estimators': 500, 'max_depth': 10}. Best is trial 22 with val
0.07578013535181295.
[I 2025-11-04 07:24:44,905] Trial 40 finished with value: 0.07577216963310299 and
parameters: {'lambda_l1': 0.000498799267360053, 'lambda_l2': 0.5486845142496483,
'num_leaves': 94, 'feature_fraction': 0.949704647860536, 'bagging_fraction':
0.7923792104533629, 'bagging_freq': 4, 'min_child_samples': 83, 'learning_rate':
0.01957098504166999, 'n_estimators': 500, 'max_depth': 10}. Best is trial 40 with val
0.07577216963310299.
[I 2025-11-04 07:25:07,129] Trial 41 finished with value: 0.07577993106626774 and
parameters: {'lambda_l1': 0.0004833192616902038, 'lambda_l2': 0.6199880395111288,
'num_leaves': 87, 'feature_fraction': 0.9480412370537126, 'bagging_fraction':
0.783594114322256, 'bagging_freq': 4, 'min_child_samples': 83, 'learning_rate':
0.019495668312076678, 'n_estimators': 500, 'max_depth': 10}. Best is trial 40 with va
0.07577216963310299.
[I 2025-11-04 07:25:29,498] Trial 42 finished with value: 0.0758101771682915 and
parameters: {'lambda_l1': 0.00040380712823252226, 'lambda_l2': 0.9717539110342285,
'num_leaves': 87, 'feature_fraction': 0.9488513862939342, 'bagging_fraction':
0.7828828249318348, 'bagging_freq': 5, 'min_child_samples': 83, 'learning_rate':
0.01565423908372535, 'n_estimators': 500, 'max_depth': 10}. Best is trial 40 with val
0.07577216963310299.
[I 2025-11-04 07:25:53,444] Trial 43 finished with value: 0.07586643769369031 and
parameters: {'lambda_l1': 0.00013498063430750727, 'lambda_l2': 0.5358715962430444,
'num_leaves': 91, 'feature_fraction': 0.9717869382625031, 'bagging_fraction':
0.8019084744718706, 'bagging_freq': 4, 'min_child_samples': 86, 'learning_rate':
0.011004070132962247, 'n_estimators': 500, 'max_depth': 10}. Best is trial 40 with va
0.07577216963310299.
[I 2025-11-04 07:26:17,848] Trial 44 finished with value: 0.07580076137421789 and
parameters: {'lambda_l1': 0.0009955185980115195, 'lambda_l2': 0.6072676136614311,
'num_leaves': 70, 'feature_fraction': 0.9174591817506813, 'bagging_fraction':
0.7563292505359763, 'bagging_freq': 4, 'min_child_samples': 78, 'learning_rate':
0.018590456421098786, 'n_estimators': 600, 'max_depth': 11}. Best is trial 40 with va
0.07577216963310299.
```

```
[I 2025-11-04 07:26:36,393] Trial 45 finished with value: 0.07579984564622357 and
parameters: {'lambda_l1': 0.00012385970127139553, 'lambda_l2': 0.23859965638133843,
'num_leaves': 56, 'feature_fraction': 0.9845689352882391, 'bagging_fraction':
0.8408574092064759, 'bagging_freq': 5, 'min_child_samples': 84, 'learning_rate':
0.021348737028833886, 'n_estimators': 500, 'max_depth': 10}. Best is trial 40 with va
0.07577216963310299.
[I 2025-11-04 07:27:07,094] Trial 46 finished with value: 0.07591328443221589 and
parameters: {'lambda_l1': 0.0006280786533797081, 'lambda_l2': 0.9964762878849223,
'num_leaves': 102, 'feature_fraction': 0.9511606132732124, 'bagging_fraction':
0.7968208920570866, 'bagging_freq': 4, 'min_child_samples': 97, 'learning_rate':
0.007842966293954817, 'n_estimators': 600, 'max_depth': 12}. Best is trial 40 with va
0.07577216963310299.
[I 2025-11-04 07:27:24,882] Trial 47 finished with value: 0.07587578786292987 and
parameters: {'lambda_l1': 0.00014141515439572753, 'lambda_l2': 0.35452523556559046,
'num_leaves': 82, 'feature_fraction': 0.9561492020791145, 'bagging_fraction':
0.7227074250791501, 'bagging_freq': 4, 'min_child_samples': 91, 'learning_rate':
0.014321800810528968, 'n_estimators': 400, 'max_depth': 10}. Best is trial 40 with va
0.07577216963310299.
[I 2025-11-04 07:27:45,305] Trial 48 finished with value: 0.07694112421813724 and
parameters: {'lambda_l1': 0.0020155939729232107, 'lambda_l2': 0.09298732646414652,
'num_leaves': 61, 'feature_fraction': 0.998715314195159, 'bagging_fraction':
0.7614524633350024, 'bagging_freq': 5, 'min_child_samples': 88, 'learning_rate':
0.005148129883611812, 'n_estimators': 500, 'max_depth': 9}. Best is trial 40 with val
0.07577216963310299.
[I 2025-11-04 07:28:06,289] Trial 49 finished with value: 0.07582179493305422 and
parameters: {'lambda_l1': 0.00025655497170992003, 'lambda_l2': 4.537180708091205e-05,
'num_leaves': 98, 'feature_fraction': 0.6249124385485832, 'bagging_fraction':
0.8312291484487188, 'bagging_freq': 6, 'min_child_samples': 75, 'learning_rate':
0.02664808100228317, 'n_estimators': 500, 'max_depth': 7}. Best is trial 40 with valu
0.07577216963310299.
✅ Best LGBMRegressor parameters: {'lambda_l1': 0.000498799267360053, 'lambda_l2':
0.5486845142496483, 'num_leaves': 94, 'feature_fraction': 0.949704647860536,
'bagging_fraction': 0.7923792104533629, 'bagging_freq': 4, 'min_child_samples': 83,
'learning_rate': 0.01957098504166999, 'n_estimators': 500, 'max_depth': 10}

⚡ Evaluating Tuned Models on GPU...

XGBRegressor (GPU)             | Validation MSE: 0.07576 | MAE: 0.15426 | R²: 0.52856
LGBMRegressor (GPU)            | Validation MSE: 0.07576 | MAE: 0.15295 | R²: 0.52859

🚀 Retraining BOTH models on full training data...
✅ Models retrained successfully.
🧠 Generating blended predictions...
Best model was LGBMRegressor (GPU). Using 60.0% LGBM and 40.0% XGB blend.

✅ Submission file 'submission_V8_Blend.csv' generated successfully!
```

	id	loan_paid_back
0	593994	0.952720
1	593995	0.954779
2	593996	0.507743
3	593997	0.963556
4	593998	0.989941


Distribution of Blended Predicted Loan Payback
Frequency
80000
70000
60000
50000
40000
30000
20000
10000
0
0.0
0.2
0.4
0.6
0.8
Loan Payback Probability