Enhanced SMOTE Evaluation Framework v2.0

======================================================================

Enhanced SMOTE Evaluation Framework v2.0

============================================================

Environment Info:

Python: 3.11.13

NumPy: 2.0.2

Pandas: 2.2.2

Scikit-learn: 1.6.1

Imbalanced-learn: 0.13.0

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

Wine Quality loaded: 1599 samples, 11 features

Imbalance ratio: 6.37:1

Effective dimensionality: 9

Breast Cancer loaded: 569 samples, 30 features

Imbalance ratio: 1.68:1

Effective dimensionality: 10

Wine (sklearn) loaded: 178 samples, 13 features

Imbalance ratio: 2.02:1

Effective dimensionality: 10

Credit Fraud (synthetic) loaded: 2000 samples, 28 features

Imbalance ratio: 18.23:1

Effective dimensionality: 19

High Dimensional loaded: 1500 samples, 100 features

Imbalance ratio: 7.62:1

Effective dimensionality: 64

======================================================================

PROCESSING WineQuality

======================================================================

============================================================

EVALUATING WINEQUALITY DATASET

============================================================

Samples: 1599, Features: 11

Imbalance ratio: 6.37:1

Class distribution: {0: np.int64(1382), 1: np.int64(217)}

Effective dimensionality: 9

Class separability: 0.178

==================================================

K-NEIGHBORS SENSITIVITY ANALYSIS - WineQuality

==================================================

k=3: F1 = 0.606 ± 0.040 (3 folds)

k=5: F1 = 0.603 ± 0.031 (3 folds)

k=7: F1 = 0.586 ± 0.051 (3 folds)

Testing No\_Oversampling...

Progress: 1/35 - RandomForest

RandomForest: 5/5 successful folds

Progress: 2/35 - LogisticRegression

LogisticRegression: 5/5 successful folds

Progress: 3/35 - SVM

SVM: 5/5 successful folds

Progress: 4/35 - BalancedRF

BalancedRF: 5/5 successful folds

Progress: 5/35 - MLP

MLP: 5/5 successful folds

Testing RandomOver...

Progress: 6/35 - RandomForest

RandomForest: 5/5 successful folds

Progress: 7/35 - LogisticRegression

LogisticRegression: 5/5 successful folds

Progress: 8/35 - SVM

SVM: 5/5 successful folds

Progress: 9/35 - BalancedRF

BalancedRF: 5/5 successful folds

Progress: 10/35 - MLP

MLP: 5/5 successful folds

Testing SMOTE...

Progress: 11/35 - RandomForest

RandomForest: 5/5 successful folds

Progress: 12/35 - LogisticRegression

LogisticRegression: 5/5 successful folds

Progress: 13/35 - SVM

SVM: 5/5 successful folds

Progress: 14/35 - BalancedRF

BalancedRF: 5/5 successful folds

Progress: 15/35 - MLP

MLP: 5/5 successful folds

Testing BorderlineSMOTE...

Progress: 16/35 - RandomForest

RandomForest: 5/5 successful folds

Progress: 17/35 - LogisticRegression

LogisticRegression: 5/5 successful folds

Progress: 18/35 - SVM

SVM: 5/5 successful folds

Progress: 19/35 - BalancedRF

BalancedRF: 5/5 successful folds

Progress: 20/35 - MLP

MLP: 5/5 successful folds

Testing ADASYN...

Progress: 21/35 - RandomForest

RandomForest: 5/5 successful folds

Progress: 22/35 - LogisticRegression

LogisticRegression: 5/5 successful folds

Progress: 23/35 - SVM

SVM: 5/5 successful folds

Progress: 24/35 - BalancedRF

BalancedRF: 5/5 successful folds

Progress: 25/35 - MLP

MLP: 5/5 successful folds

Testing SMOTETomek...

Progress: 26/35 - RandomForest

RandomForest: 5/5 successful folds

Progress: 27/35 - LogisticRegression

LogisticRegression: 5/5 successful folds

Progress: 28/35 - SVM

SVM: 5/5 successful folds

Progress: 29/35 - BalancedRF

BalancedRF: 5/5 successful folds

Progress: 30/35 - MLP

MLP: 5/5 successful folds

Testing SMOTEENN...

Progress: 31/35 - RandomForest

RandomForest: 5/5 successful folds

Progress: 32/35 - LogisticRegression

LogisticRegression: 5/5 successful folds

Progress: 33/35 - SVM

SVM: 5/5 successful folds

Progress: 34/35 - BalancedRF

BalancedRF: 5/5 successful folds

Progress: 35/35 - MLP

MLP: 5/5 successful folds

======================================================================

ENHANCED STATISTICAL ANALYSIS - WineQuality

======================================================================

RandomForest - F1 Score Analysis:

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

Test type: Parametric

Baseline performance: 0.604 ± 0.048

RandomOver vs Baseline: p\_raw=0.1835, p\_corr=0.9176 Δ=+0.029, d=0.631 (medium)

SMOTE vs Baseline: p\_raw=0.8883, p\_corr=1.0000 Δ=+0.005, d=0.079 (negligible)

BorderlineSMOTE vs Baseline: p\_raw=0.8547, p\_corr=1.0000 Δ=+0.005, d=0.125 (negligible)

ADASYN vs Baseline: p\_raw=0.4566, p\_corr=1.0000 Δ=+0.027, d=0.499 (small)

SMOTETomek vs Baseline: p\_raw=0.6035, p\_corr=1.0000 Δ=+0.018, d=0.294 (small)

SMOTEENN vs Baseline: p\_raw=0.0291, p\_corr=0.1745 Δ=-0.065, d=-1.382 (large) [PRACTICAL]

LogisticRegression - F1 Score Analysis:

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

Test type: Parametric

Baseline performance: 0.428 ± 0.095

RandomOver vs Baseline: p\_raw=0.1273, p\_corr=0.6159 Δ=+0.085, d=1.117 (large) [PRACTICAL]

SMOTE vs Baseline: p\_raw=0.1027, p\_corr=0.6159 Δ=+0.087, d=1.151 (large) [PRACTICAL]

BorderlineSMOTE vs Baseline: p\_raw=0.1454, p\_corr=0.6159 Δ=+0.077, d=0.984 (large) [PRACTICAL]

ADASYN vs Baseline: p\_raw=0.1833, p\_corr=0.6159 Δ=+0.068, d=0.900 (large) [PRACTICAL]

SMOTETomek vs Baseline: p\_raw=0.1027, p\_corr=0.6159 Δ=+0.087, d=1.151 (large) [PRACTICAL]

SMOTEENN vs Baseline: p\_raw=0.2452, p\_corr=0.6159 Δ=+0.051, d=0.655 (medium) [PRACTICAL]

SVM - F1 Score Analysis:

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

Test type: Parametric

Baseline performance: 0.417 ± 0.043

RandomOver vs Baseline: p\_raw=0.0008, p\_corr=0.0031\*\* Δ=+0.131, d=2.706 (large) [PRACTICAL]

SMOTE vs Baseline: p\_raw=0.0012, p\_corr=0.0037\*\* Δ=+0.111, d=2.331 (large) [PRACTICAL]

BorderlineSMOTE vs Baseline: p\_raw=0.0005, p\_corr=0.0024\*\* Δ=+0.116, d=2.972 (large) [PRACTICAL]

ADASYN vs Baseline: p\_raw=0.0003, p\_corr=0.0019\*\* Δ=+0.112, d=2.726 (large) [PRACTICAL]

SMOTETomek vs Baseline: p\_raw=0.0016, p\_corr=0.0037\*\* Δ=+0.113, d=2.309 (large) [PRACTICAL]

SMOTEENN vs Baseline: p\_raw=0.0027, p\_corr=0.0037\*\* Δ=+0.086, d=2.033 (large) [PRACTICAL]

BalancedRF - F1 Score Analysis:

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

Test type: Parametric

Baseline performance: 0.615 ± 0.058

RandomOver vs Baseline: p\_raw=0.5165, p\_corr=1.0000 Δ=+0.018, d=0.339 (small)

SMOTE vs Baseline: p\_raw=0.8368, p\_corr=1.0000 Δ=-0.006, d=-0.098 (negligible)

BorderlineSMOTE vs Baseline: p\_raw=0.8565, p\_corr=1.0000 Δ=-0.006, d=-0.116 (negligible)

ADASYN vs Baseline: p\_raw=0.7983, p\_corr=1.0000 Δ=+0.010, d=0.162 (negligible)

SMOTETomek vs Baseline: p\_raw=0.8047, p\_corr=1.0000 Δ=+0.007, d=0.109 (negligible)

SMOTEENN vs Baseline: p\_raw=0.0058, p\_corr=0.0350\* Δ=-0.074, d=-1.339 (large) [PRACTICAL]

MLP - F1 Score Analysis:

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

Test type: Parametric

Baseline performance: 0.601 ± 0.027

RandomOver vs Baseline: p\_raw=0.6678, p\_corr=1.0000 Δ=-0.008, d=-0.256 (small)

SMOTE vs Baseline: p\_raw=0.9340, p\_corr=1.0000 Δ=-0.002, d=-0.038 (negligible)

BorderlineSMOTE vs Baseline: p\_raw=0.3833, p\_corr=1.0000 Δ=-0.029, d=-0.674 (medium)

ADASYN vs Baseline: p\_raw=0.5850, p\_corr=1.0000 Δ=-0.024, d=-0.417 (small)

SMOTETomek vs Baseline: p\_raw=0.6414, p\_corr=1.0000 Δ=+0.007, d=0.235 (small)

SMOTEENN vs Baseline: p\_raw=0.0181, p\_corr=0.1086 Δ=-0.049, d=-1.413 (large)

======================================================================

PROCESSING BreastCancer

======================================================================

============================================================

EVALUATING BREASTCANCER DATASET

============================================================

Samples: 569, Features: 30

Imbalance ratio: 1.68:1

Class distribution: {1: np.int64(357), 0: np.int64(212)}

Effective dimensionality: 10

Class separability: 1.026

Testing No\_Oversampling...

Progress: 1/35 - RandomForest

RandomForest: 5/5 successful folds

Progress: 2/35 - LogisticRegression

LogisticRegression: 5/5 successful folds

Progress: 3/35 - SVM

SVM: 5/5 successful folds

Progress: 4/35 - BalancedRF

BalancedRF: 5/5 successful folds

Progress: 5/35 - MLP

MLP: 5/5 successful folds

Testing RandomOver...

Progress: 6/35 - RandomForest

RandomForest: 5/5 successful folds

Progress: 7/35 - LogisticRegression

LogisticRegression: 5/5 successful folds

Progress: 8/35 - SVM

SVM: 5/5 successful folds

Progress: 9/35 - BalancedRF

BalancedRF: 5/5 successful folds

Progress: 10/35 - MLP

MLP: 5/5 successful folds

Testing SMOTE...

Progress: 11/35 - RandomForest

RandomForest: 5/5 successful folds

Progress: 12/35 - LogisticRegression

LogisticRegression: 5/5 successful folds

Progress: 13/35 - SVM

SVM: 5/5 successful folds

Progress: 14/35 - BalancedRF

BalancedRF: 5/5 successful folds

Progress: 15/35 - MLP

MLP: 5/5 successful folds

Testing BorderlineSMOTE...

Progress: 16/35 - RandomForest

RandomForest: 5/5 successful folds

Progress: 17/35 - LogisticRegression

LogisticRegression: 5/5 successful folds

Progress: 18/35 - SVM

SVM: 5/5 successful folds

Progress: 19/35 - BalancedRF

BalancedRF: 5/5 successful folds

Progress: 20/35 - MLP

MLP: 5/5 successful folds

Testing ADASYN...

Progress: 21/35 - RandomForest

RandomForest: 5/5 successful folds

Progress: 22/35 - LogisticRegression

LogisticRegression: 5/5 successful folds

Progress: 23/35 - SVM

SVM: 5/5 successful folds

Progress: 24/35 - BalancedRF

BalancedRF: 5/5 successful folds

Progress: 25/35 - MLP

MLP: 5/5 successful folds

Testing SMOTETomek...

Progress: 26/35 - RandomForest

RandomForest: 5/5 successful folds

Progress: 27/35 - LogisticRegression

LogisticRegression: 5/5 successful folds

Progress: 28/35 - SVM

SVM: 5/5 successful folds

Progress: 29/35 - BalancedRF

BalancedRF: 5/5 successful folds

Progress: 30/35 - MLP

MLP: 5/5 successful folds

Testing SMOTEENN...

Progress: 31/35 - RandomForest

RandomForest: 5/5 successful folds

Progress: 32/35 - LogisticRegression

LogisticRegression: 5/5 successful folds

Progress: 33/35 - SVM

SVM: 5/5 successful folds

Progress: 34/35 - BalancedRF

BalancedRF: 5/5 successful folds

Progress: 35/35 - MLP

MLP: 5/5 successful folds

======================================================================

ENHANCED STATISTICAL ANALYSIS - BreastCancer

======================================================================

RandomForest - F1 Score Analysis:

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

Test type: Parametric

Baseline performance: 0.965 ± 0.010

RandomOver vs Baseline: p\_raw=0.3739, p\_corr=1.0000 Δ=+0.003, d=0.262 (small)

SMOTE vs Baseline: p\_raw=0.8166, p\_corr=1.0000 Δ=+0.001, d=0.093 (negligible)

BorderlineSMOTE vs Baseline: p\_raw=0.6693, p\_corr=1.0000 Δ=-0.002, d=-0.190 (negligible)

ADASYN vs Baseline: p\_raw=0.2208, p\_corr=1.0000 Δ=+0.006, d=0.498 (small)

SMOTETomek vs Baseline: p\_raw=0.8008, p\_corr=1.0000 Δ=+0.001, d=0.101 (negligible)

SMOTEENN vs Baseline: p\_raw=0.4907, p\_corr=1.0000 Δ=-0.005, d=-0.293 (small)

LogisticRegression - F1 Score Analysis:

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

Test type: Parametric

Baseline performance: 0.979 ± 0.013

RandomOver vs Baseline: p\_raw=0.7454, p\_corr=1.0000 Δ=-0.002, d=-0.153 (negligible)

SMOTE vs Baseline: p\_raw=0.6802, p\_corr=1.0000 Δ=-0.002, d=-0.143 (negligible)

BorderlineSMOTE vs Baseline: p\_raw=0.1541, p\_corr=0.9247 Δ=-0.008, d=-0.539 (medium)

ADASYN vs Baseline: p\_raw=0.1932, p\_corr=0.9662 Δ=-0.008, d=-0.576 (medium)

SMOTETomek vs Baseline: p\_raw=0.4503, p\_corr=1.0000 Δ=-0.003, d=-0.225 (small)

SMOTEENN vs Baseline: p\_raw=0.4022, p\_corr=1.0000 Δ=-0.004, d=-0.334 (small)

SVM - F1 Score Analysis:

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

Test type: Parametric

Baseline performance: 0.982 ± 0.013

RandomOver vs Baseline: p\_raw=0.7104, p\_corr=1.0000 Δ=-0.002, d=-0.131 (negligible)

SMOTE vs Baseline: p\_raw=0.7258, p\_corr=1.0000 Δ=-0.002, d=-0.111 (negligible)

BorderlineSMOTE vs Baseline: p\_raw=0.2119, p\_corr=1.0000 Δ=-0.012, d=-0.938 (large)

ADASYN vs Baseline: p\_raw=0.5194, p\_corr=1.0000 Δ=-0.005, d=-0.383 (small)

SMOTETomek vs Baseline: p\_raw=0.7258, p\_corr=1.0000 Δ=-0.002, d=-0.111 (negligible)

SMOTEENN vs Baseline: p\_raw=0.1045, p\_corr=0.6273 Δ=-0.009, d=-0.622 (medium)

BalancedRF - F1 Score Analysis:

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

Test type: Parametric

Baseline performance: 0.972 ± 0.009

RandomOver vs Baseline: p\_raw=0.1806, p\_corr=0.9028 Δ=-0.005, d=-0.504 (medium)

SMOTE vs Baseline: p\_raw=0.2040, p\_corr=0.9028 Δ=-0.006, d=-0.634 (medium)

BorderlineSMOTE vs Baseline: p\_raw=0.1856, p\_corr=0.9028 Δ=-0.009, d=-0.871 (large)

ADASYN vs Baseline: p\_raw=0.9185, p\_corr=0.9185 Δ=-0.001, d=-0.051 (negligible)

SMOTETomek vs Baseline: p\_raw=0.2050, p\_corr=0.9028 Δ=-0.006, d=-0.624 (medium)

SMOTEENN vs Baseline: p\_raw=0.1288, p\_corr=0.7731 Δ=-0.010, d=-0.749 (medium)

MLP - F1 Score Analysis:

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

Test type: Parametric

Baseline performance: 0.983 ± 0.010

RandomOver vs Baseline: p\_raw=0.4600, p\_corr=1.0000 Δ=-0.003, d=-0.247 (small)

SMOTE vs Baseline: p\_raw=0.6276, p\_corr=1.0000 Δ=+0.001, d=0.134 (negligible)

BorderlineSMOTE vs Baseline: p\_raw=0.2897, p\_corr=1.0000 Δ=-0.007, d=-0.613 (medium)

ADASYN vs Baseline: p\_raw=0.0678, p\_corr=0.4068 Δ=-0.008, d=-0.774 (medium)

SMOTETomek vs Baseline: p\_raw=0.6179, p\_corr=1.0000 Δ=-0.001, d=-0.131 (negligible)

SMOTEENN vs Baseline: p\_raw=0.4068, p\_corr=1.0000 Δ=-0.004, d=-0.435 (small)

======================================================================

PROCESSING WineSklearn

======================================================================

============================================================

EVALUATING WINESKLEARN DATASET

============================================================

Samples: 178, Features: 13

Imbalance ratio: 2.02:1

Class distribution: {0: np.int64(119), 1: np.int64(59)}

Effective dimensionality: 10

Class separability: 1.069

==================================================

K-NEIGHBORS SENSITIVITY ANALYSIS - WineSklearn

==================================================

k=3: F1 = 0.983 ± 0.012 (3 folds)

k=5: F1 = 0.983 ± 0.012 (3 folds)

k=7: F1 = 0.974 ± 0.020 (3 folds)

Testing No\_Oversampling...

Progress: 1/35 - RandomForest

RandomForest: 5/5 successful folds

Progress: 2/35 - LogisticRegression

LogisticRegression: 5/5 successful folds

Progress: 3/35 - SVM

SVM: 5/5 successful folds

Progress: 4/35 - BalancedRF

BalancedRF: 5/5 successful folds

Progress: 5/35 - MLP

MLP: 5/5 successful folds

Testing RandomOver...

Progress: 6/35 - RandomForest

RandomForest: 5/5 successful folds

Progress: 7/35 - LogisticRegression

LogisticRegression: 5/5 successful folds

Progress: 8/35 - SVM

SVM: 5/5 successful folds

Progress: 9/35 - BalancedRF

BalancedRF: 5/5 successful folds

Progress: 10/35 - MLP

MLP: 5/5 successful folds

Testing SMOTE...

Progress: 11/35 - RandomForest

RandomForest: 5/5 successful folds

Progress: 12/35 - LogisticRegression

LogisticRegression: 5/5 successful folds

Progress: 13/35 - SVM

SVM: 5/5 successful folds

Progress: 14/35 - BalancedRF

BalancedRF: 5/5 successful folds

Progress: 15/35 - MLP

MLP: 5/5 successful folds

Testing BorderlineSMOTE...

Progress: 16/35 - RandomForest

RandomForest: 5/5 successful folds

Progress: 17/35 - LogisticRegression

LogisticRegression: 5/5 successful folds

Progress: 18/35 - SVM

SVM: 5/5 successful folds

Progress: 19/35 - BalancedRF

BalancedRF: 5/5 successful folds

Progress: 20/35 - MLP

MLP: 5/5 successful folds

Testing ADASYN...

Progress: 21/35 - RandomForest

Error in fold 0 for ADASYN+RandomForest: Not any neigbours belong to the majority class. This case will induce a NaN case with a division by zero. ADASYN is not suited for this specific dataset. Use SMOTE instead.

RandomForest: 4/5 successful folds

Progress: 22/35 - LogisticRegression

Error in fold 0 for ADASYN+LogisticRegression: Not any neigbours belong to the majority class. This case will induce a NaN case with a division by zero. ADASYN is not suited for this specific dataset. Use SMOTE instead.

LogisticRegression: 4/5 successful folds

Progress: 23/35 - SVM

Error in fold 0 for ADASYN+SVM: Not any neigbours belong to the majority class. This case will induce a NaN case with a division by zero. ADASYN is not suited for this specific dataset. Use SMOTE instead.

SVM: 4/5 successful folds

Progress: 24/35 - BalancedRF

Error in fold 0 for ADASYN+BalancedRF: Not any neigbours belong to the majority class. This case will induce a NaN case with a division by zero. ADASYN is not suited for this specific dataset. Use SMOTE instead.

BalancedRF: 4/5 successful folds

Progress: 25/35 - MLP

Error in fold 0 for ADASYN+MLP: Not any neigbours belong to the majority class. This case will induce a NaN case with a division by zero. ADASYN is not suited for this specific dataset. Use SMOTE instead.

MLP: 4/5 successful folds

Testing SMOTETomek...

Progress: 26/35 - RandomForest

RandomForest: 5/5 successful folds

Progress: 27/35 - LogisticRegression

LogisticRegression: 5/5 successful folds

Progress: 28/35 - SVM

SVM: 5/5 successful folds

Progress: 29/35 - BalancedRF

BalancedRF: 5/5 successful folds

Progress: 30/35 - MLP

MLP: 5/5 successful folds

Testing SMOTEENN...

Progress: 31/35 - RandomForest

RandomForest: 5/5 successful folds

Progress: 32/35 - LogisticRegression

LogisticRegression: 5/5 successful folds

Progress: 33/35 - SVM

SVM: 5/5 successful folds

Progress: 34/35 - BalancedRF

BalancedRF: 5/5 successful folds

Progress: 35/35 - MLP

MLP: 5/5 successful folds

======================================================================

ENHANCED STATISTICAL ANALYSIS - WineSklearn

======================================================================

RandomForest - F1 Score Analysis:

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

Test type: Parametric

Baseline performance: 0.964 ± 0.034

RandomOver vs Baseline: p\_raw=0.1778, p\_corr=0.8890 Δ=+0.019, d=0.607 (medium)

SMOTE vs Baseline: p\_raw=0.1778, p\_corr=0.8890 Δ=+0.019, d=0.607 (medium)

BorderlineSMOTE vs Baseline: p\_raw=0.3739, p\_corr=0.8890 Δ=+0.010, d=0.244 (small)

SMOTETomek vs Baseline: p\_raw=0.1778, p\_corr=0.8890 Δ=+0.019, d=0.607 (medium)

SMOTEENN vs Baseline: p\_raw=0.5798, p\_corr=0.8890 Δ=+0.010, d=0.328 (small)

LogisticRegression - F1 Score Analysis:

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

Test type: Non-parametric

Baseline performance: 0.992 ± 0.016

RandomOver vs Baseline: p\_raw=1.0000, p\_corr=1.0000 Δ=-0.007, d=-0.269 (small)

SMOTE vs Baseline: p\_raw=1.0000, p\_corr=1.0000 Δ=-0.007, d=-0.269 (small)

BorderlineSMOTE vs Baseline: p\_raw=1.0000, p\_corr=1.0000 Δ=-0.007, d=-0.269 (small)

SMOTETomek vs Baseline: p\_raw=1.0000, p\_corr=1.0000 Δ=-0.007, d=-0.269 (small)

SMOTEENN vs Baseline: p\_raw=0.2500, p\_corr=1.0000 Δ=-0.023, d=-0.894 (large)

SVM - F1 Score Analysis:

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

Test type: Non-parametric

Baseline performance: 0.991 ± 0.017

RandomOver vs Baseline: p\_raw=1.0000, p\_corr=1.0000 Δ=+0.009, d=0.632 (medium)

SMOTE vs Baseline: p\_raw=1.0000, p\_corr=1.0000 Δ=+0.009, d=0.632 (medium)

BorderlineSMOTE vs Baseline: p\_raw=1.0000, p\_corr=1.0000 Δ=+0.000, d=0.000 (negligible)

SMOTETomek vs Baseline: p\_raw=1.0000, p\_corr=1.0000 Δ=+0.009, d=0.632 (medium)

SMOTEENN vs Baseline: p\_raw=1.0000, p\_corr=1.0000 Δ=+0.001, d=0.037 (negligible)

BalancedRF - F1 Score Analysis:

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

Test type: Parametric

Baseline performance: 0.965 ± 0.034

RandomOver vs Baseline: p\_raw=0.1783, p\_corr=0.8917 Δ=+0.018, d=0.583 (medium)

SMOTE vs Baseline: p\_raw=0.1783, p\_corr=0.8917 Δ=+0.018, d=0.583 (medium)

BorderlineSMOTE vs Baseline: p\_raw=nan, p\_corr=nan Δ=+0.000, d=0.000 (negligible)

SMOTETomek vs Baseline: p\_raw=0.1783, p\_corr=0.8917 Δ=+0.018, d=0.583 (medium)

SMOTEENN vs Baseline: p\_raw=0.1783, p\_corr=0.8917 Δ=+0.018, d=0.583 (medium)

MLP - F1 Score Analysis:

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

Test type: Parametric

Baseline performance: 1.000 ± 0.000

RandomOver vs Baseline: p\_raw=nan, p\_corr=nan Δ=+0.000, d=0.000 (negligible)

SMOTE vs Baseline: p\_raw=nan, p\_corr=nan Δ=+0.000, d=0.000 (negligible)

BorderlineSMOTE vs Baseline: p\_raw=nan, p\_corr=nan Δ=+0.000, d=0.000 (negligible)

SMOTETomek vs Baseline: p\_raw=nan, p\_corr=nan Δ=+0.000, d=0.000 (negligible)

SMOTEENN vs Baseline: p\_raw=0.0161, p\_corr=0.0807 Δ=-0.032, d=-2.530 (large)

======================================================================

PROCESSING CreditFraud

======================================================================

============================================================

EVALUATING CREDITFRAUD DATASET

============================================================

Samples: 2000, Features: 28

Imbalance ratio: 18.23:1

Class distribution: {0: np.int64(1896), 1: np.int64(104)}

Effective dimensionality: 19

Class separability: 0.069

==================================================

K-NEIGHBORS SENSITIVITY ANALYSIS - CreditFraud

==================================================

k=3: F1 = 0.506 ± 0.039 (3 folds)

k=5: F1 = 0.536 ± 0.038 (3 folds)

k=7: F1 = 0.473 ± 0.018 (3 folds)

Testing No\_Oversampling...

Progress: 1/35 - RandomForest

RandomForest: 5/5 successful folds

Progress: 2/35 - LogisticRegression

LogisticRegression: 5/5 successful folds

Progress: 3/35 - SVM

SVM: 5/5 successful folds

Progress: 4/35 - BalancedRF

BalancedRF: 5/5 successful folds

Progress: 5/35 - MLP

MLP: 5/5 successful folds

Testing RandomOver...

Progress: 6/35 - RandomForest

RandomForest: 5/5 successful folds

Progress: 7/35 - LogisticRegression

LogisticRegression: 5/5 successful folds

Progress: 8/35 - SVM

SVM: 5/5 successful folds

Progress: 9/35 - BalancedRF

BalancedRF: 5/5 successful folds

Progress: 10/35 - MLP

MLP: 5/5 successful folds

Testing SMOTE...

Progress: 11/35 - RandomForest

RandomForest: 5/5 successful folds

Progress: 12/35 - LogisticRegression

LogisticRegression: 5/5 successful folds

Progress: 13/35 - SVM

SVM: 5/5 successful folds

Progress: 14/35 - BalancedRF

BalancedRF: 5/5 successful folds

Progress: 15/35 - MLP

MLP: 5/5 successful folds

Testing BorderlineSMOTE...

Progress: 16/35 - RandomForest

RandomForest: 5/5 successful folds

Progress: 17/35 - LogisticRegression

LogisticRegression: 5/5 successful folds

Progress: 18/35 - SVM

SVM: 5/5 successful folds

Progress: 19/35 - BalancedRF

BalancedRF: 5/5 successful folds

Progress: 20/35 - MLP

MLP: 5/5 successful folds

Testing ADASYN...

Progress: 21/35 - RandomForest

RandomForest: 5/5 successful folds

Progress: 22/35 - LogisticRegression

LogisticRegression: 5/5 successful folds

Progress: 23/35 - SVM

SVM: 5/5 successful folds

Progress: 24/35 - BalancedRF

BalancedRF: 5/5 successful folds

Progress: 25/35 - MLP

MLP: 5/5 successful folds

Testing SMOTETomek...

Progress: 26/35 - RandomForest

RandomForest: 5/5 successful folds

Progress: 27/35 - LogisticRegression

LogisticRegression: 5/5 successful folds

Progress: 28/35 - SVM

SVM: 5/5 successful folds

Progress: 29/35 - BalancedRF

BalancedRF: 5/5 successful folds

Progress: 30/35 - MLP

MLP: 5/5 successful folds

Testing SMOTEENN...

Progress: 31/35 - RandomForest

RandomForest: 5/5 successful folds

Progress: 32/35 - LogisticRegression

LogisticRegression: 5/5 successful folds

Progress: 33/35 - SVM

SVM: 5/5 successful folds

Progress: 34/35 - BalancedRF

BalancedRF: 5/5 successful folds

Progress: 35/35 - MLP

MLP: 5/5 successful folds

======================================================================

ENHANCED STATISTICAL ANALYSIS - CreditFraud

======================================================================

RandomForest - F1 Score Analysis:

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

Test type: Non-parametric

Baseline performance: 0.220 ± 0.065

RandomOver vs Baseline: p\_raw=0.1875, p\_corr=0.3750 Δ=+0.081, d=1.025 (large) [PRACTICAL]

SMOTE vs Baseline: p\_raw=0.0625, p\_corr=0.3750 Δ=+0.332, d=4.354 (large) [PRACTICAL]

BorderlineSMOTE vs Baseline: p\_raw=0.0625, p\_corr=0.3750 Δ=+0.270, d=4.694 (large) [PRACTICAL]

ADASYN vs Baseline: p\_raw=0.0625, p\_corr=0.3750 Δ=+0.269, d=4.745 (large) [PRACTICAL]

SMOTETomek vs Baseline: p\_raw=0.0625, p\_corr=0.3750 Δ=+0.332, d=4.354 (large) [PRACTICAL]

SMOTEENN vs Baseline: p\_raw=0.0625, p\_corr=0.3750 Δ=+0.328, d=5.201 (large) [PRACTICAL]

LogisticRegression - F1 Score Analysis:

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

Test type: Parametric

Baseline performance: 0.510 ± 0.052

RandomOver vs Baseline: p\_raw=0.0035, p\_corr=0.0173\* Δ=-0.205, d=-4.696 (large) [PRACTICAL]

SMOTE vs Baseline: p\_raw=0.0035, p\_corr=0.0173\* Δ=-0.185, d=-4.402 (large) [PRACTICAL]

BorderlineSMOTE vs Baseline: p\_raw=0.0044, p\_corr=0.0173\* Δ=-0.163, d=-3.682 (large) [PRACTICAL]

ADASYN vs Baseline: p\_raw=0.0048, p\_corr=0.0173\* Δ=-0.199, d=-4.478 (large) [PRACTICAL]

SMOTETomek vs Baseline: p\_raw=0.0035, p\_corr=0.0173\* Δ=-0.185, d=-4.402 (large) [PRACTICAL]

SMOTEENN vs Baseline: p\_raw=0.0025, p\_corr=0.0151\* Δ=-0.204, d=-4.792 (large) [PRACTICAL]

SVM - F1 Score Analysis:

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

Test type: Parametric

Baseline performance: 0.587 ± 0.099

RandomOver vs Baseline: p\_raw=0.0023, p\_corr=0.0137\* Δ=+0.180, d=1.961 (large) [PRACTICAL]

SMOTE vs Baseline: p\_raw=0.0075, p\_corr=0.0299\* Δ=+0.161, d=1.826 (large) [PRACTICAL]

BorderlineSMOTE vs Baseline: p\_raw=0.0034, p\_corr=0.0170\* Δ=+0.202, d=2.407 (large) [PRACTICAL]

ADASYN vs Baseline: p\_raw=0.0156, p\_corr=0.0299\* Δ=+0.146, d=1.759 (large) [PRACTICAL]

SMOTETomek vs Baseline: p\_raw=0.0075, p\_corr=0.0299\* Δ=+0.161, d=1.826 (large) [PRACTICAL]

SMOTEENN vs Baseline: p\_raw=0.0145, p\_corr=0.0299\* Δ=+0.126, d=1.342 (large) [PRACTICAL]

BalancedRF - F1 Score Analysis:

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

Test type: Non-parametric

Baseline performance: 0.054 ± 0.044

RandomOver vs Baseline: p\_raw=0.0625, p\_corr=0.3750 Δ=+0.248, d=3.564 (large) [PRACTICAL]

SMOTE vs Baseline: p\_raw=0.0625, p\_corr=0.3750 Δ=+0.499, d=7.523 (large) [PRACTICAL]

BorderlineSMOTE vs Baseline: p\_raw=0.0625, p\_corr=0.3750 Δ=+0.436, d=10.061 (large) [PRACTICAL]

ADASYN vs Baseline: p\_raw=0.0625, p\_corr=0.3750 Δ=+0.425, d=10.834 (large) [PRACTICAL]

SMOTETomek vs Baseline: p\_raw=0.0625, p\_corr=0.3750 Δ=+0.499, d=7.523 (large) [PRACTICAL]

SMOTEENN vs Baseline: p\_raw=0.0625, p\_corr=0.3750 Δ=+0.506, d=8.352 (large) [PRACTICAL]

MLP - F1 Score Analysis:

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

Test type: Parametric

Baseline performance: 0.742 ± 0.056

RandomOver vs Baseline: p\_raw=0.2715, p\_corr=1.0000 Δ=+0.018, d=0.354 (small)

SMOTE vs Baseline: p\_raw=0.4000, p\_corr=1.0000 Δ=-0.012, d=-0.178 (negligible)

BorderlineSMOTE vs Baseline: p\_raw=0.4221, p\_corr=1.0000 Δ=+0.017, d=0.293 (small)

ADASYN vs Baseline: p\_raw=0.4325, p\_corr=1.0000 Δ=-0.011, d=-0.186 (negligible)

SMOTETomek vs Baseline: p\_raw=0.4000, p\_corr=1.0000 Δ=-0.012, d=-0.178 (negligible)

SMOTEENN vs Baseline: p\_raw=0.3436, p\_corr=1.0000 Δ=-0.040, d=-0.677 (medium)

======================================================================

PROCESSING HighDim

======================================================================

============================================================

EVALUATING HIGHDIM DATASET

============================================================

Samples: 1500, Features: 100

Imbalance ratio: 7.62:1

Class distribution: {0: np.int64(1326), 1: np.int64(174)}

Effective dimensionality: 64

Class separability: 0.024

==================================================

K-NEIGHBORS SENSITIVITY ANALYSIS - HighDim

==================================================

k=3: F1 = 0.243 ± 0.072 (3 folds)

k=5: F1 = 0.291 ± 0.032 (3 folds)

k=7: F1 = 0.242 ± 0.037 (3 folds)

Testing No\_Oversampling...

Progress: 1/35 - RandomForest

RandomForest: 5/5 successful folds

Progress: 2/35 - LogisticRegression

LogisticRegression: 5/5 successful folds

Progress: 3/35 - SVM

SVM: 5/5 successful folds

Progress: 4/35 - BalancedRF

BalancedRF: 5/5 successful folds

Progress: 5/35 - MLP

MLP: 5/5 successful folds

Testing RandomOver...

Progress: 6/35 - RandomForest

RandomForest: 5/5 successful folds

Progress: 7/35 - LogisticRegression

LogisticRegression: 5/5 successful folds

Progress: 8/35 - SVM

SVM: 5/5 successful folds

Progress: 9/35 - BalancedRF

BalancedRF: 5/5 successful folds

Progress: 10/35 - MLP

MLP: 5/5 successful folds

Testing SMOTE...

Progress: 11/35 - RandomForest

RandomForest: 5/5 successful folds

Progress: 12/35 - LogisticRegression

LogisticRegression: 5/5 successful folds

Progress: 13/35 - SVM

SVM: 5/5 successful folds

Progress: 14/35 - BalancedRF

BalancedRF: 5/5 successful folds

Progress: 15/35 - MLP

MLP: 5/5 successful folds

Testing BorderlineSMOTE...

Progress: 16/35 - RandomForest

RandomForest: 5/5 successful folds

Progress: 17/35 - LogisticRegression

LogisticRegression: 5/5 successful folds

Progress: 18/35 - SVM

SVM: 5/5 successful folds

Progress: 19/35 - BalancedRF

BalancedRF: 5/5 successful folds

Progress: 20/35 - MLP

MLP: 5/5 successful folds

Testing ADASYN...

Progress: 21/35 - RandomForest

RandomForest: 5/5 successful folds

Progress: 22/35 - LogisticRegression

LogisticRegression: 5/5 successful folds

Progress: 23/35 - SVM

SVM: 5/5 successful folds

Progress: 24/35 - BalancedRF

BalancedRF: 5/5 successful folds

Progress: 25/35 - MLP

MLP: 5/5 successful folds

Testing SMOTETomek...

Progress: 26/35 - RandomForest

RandomForest: 5/5 successful folds

Progress: 27/35 - LogisticRegression

LogisticRegression: 5/5 successful folds

Progress: 28/35 - SVM

SVM: 5/5 successful folds

Progress: 29/35 - BalancedRF

BalancedRF: 5/5 successful folds

Progress: 30/35 - MLP

MLP: 5/5 successful folds

Testing SMOTEENN...

Progress: 31/35 - RandomForest

RandomForest: 5/5 successful folds

Progress: 32/35 - LogisticRegression

LogisticRegression: 5/5 successful folds

Progress: 33/35 - SVM

SVM: 5/5 successful folds

Progress: 34/35 - BalancedRF

BalancedRF: 5/5 successful folds

Progress: 35/35 - MLP

MLP: 5/5 successful folds

======================================================================

ENHANCED STATISTICAL ANALYSIS - HighDim

======================================================================

RandomForest - F1 Score Analysis:

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

Test type: Parametric

Baseline performance: 0.000 ± 0.000

RandomOver vs Baseline: p\_raw=0.0705, p\_corr=0.0705 Δ=+0.034, d=1.549 (large)

SMOTE vs Baseline: p\_raw=0.0003, p\_corr=0.0014\*\* Δ=+0.260, d=7.529 (large) [PRACTICAL]

BorderlineSMOTE vs Baseline: p\_raw=0.0012, p\_corr=0.0035\*\* Δ=+0.244, d=5.248 (large) [PRACTICAL]

ADASYN vs Baseline: p\_raw=0.0020, p\_corr=0.0041\*\* Δ=+0.297, d=4.510 (large) [PRACTICAL]

SMOTETomek vs Baseline: p\_raw=0.0003, p\_corr=0.0014\*\* Δ=+0.260, d=7.529 (large) [PRACTICAL]

SMOTEENN vs Baseline: p\_raw=0.0000, p\_corr=0.0002\*\*\* Δ=+0.420, d=12.735 (large) [PRACTICAL]

LogisticRegression - F1 Score Analysis:

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

Test type: Parametric

Baseline performance: 0.640 ± 0.074

RandomOver vs Baseline: p\_raw=0.0351, p\_corr=0.1753 Δ=-0.091, d=-1.510 (large) [PRACTICAL]

SMOTE vs Baseline: p\_raw=0.1339, p\_corr=0.4016 Δ=-0.061, d=-0.987 (large) [PRACTICAL]

BorderlineSMOTE vs Baseline: p\_raw=0.1991, p\_corr=0.4016 Δ=-0.054, d=-0.872 (large) [PRACTICAL]

ADASYN vs Baseline: p\_raw=0.0592, p\_corr=0.2366 Δ=-0.085, d=-1.377 (large) [PRACTICAL]

SMOTETomek vs Baseline: p\_raw=0.1339, p\_corr=0.4016 Δ=-0.061, d=-0.987 (large) [PRACTICAL]

SMOTEENN vs Baseline: p\_raw=0.0059, p\_corr=0.0356\* Δ=-0.189, d=-3.028 (large) [PRACTICAL]

SVM - F1 Score Analysis:

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

Test type: Parametric

Baseline performance: 0.582 ± 0.061

RandomOver vs Baseline: p\_raw=0.0060, p\_corr=0.0358\* Δ=+0.193, d=2.888 (large) [PRACTICAL]

SMOTE vs Baseline: p\_raw=0.0106, p\_corr=0.0531 Δ=+0.148, d=2.268 (large) [PRACTICAL]

BorderlineSMOTE vs Baseline: p\_raw=0.0220, p\_corr=0.0660 Δ=+0.145, d=1.959 (large) [PRACTICAL]

ADASYN vs Baseline: p\_raw=0.0261, p\_corr=0.0660 Δ=+0.136, d=1.886 (large) [PRACTICAL]

SMOTETomek vs Baseline: p\_raw=0.0106, p\_corr=0.0531 Δ=+0.148, d=2.268 (large) [PRACTICAL]

SMOTEENN vs Baseline: p\_raw=0.0682, p\_corr=0.0682 Δ=+0.120, d=1.894 (large) [PRACTICAL]

BalancedRF - F1 Score Analysis:

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

Test type: Parametric

Baseline performance: 0.000 ± 0.000

RandomOver vs Baseline: p\_raw=0.0705, p\_corr=0.0705 Δ=+0.034, d=1.549 (large)

SMOTE vs Baseline: p\_raw=0.0003, p\_corr=0.0014\*\* Δ=+0.260, d=7.529 (large) [PRACTICAL]

BorderlineSMOTE vs Baseline: p\_raw=0.0012, p\_corr=0.0023\*\* Δ=+0.244, d=5.248 (large) [PRACTICAL]

ADASYN vs Baseline: p\_raw=0.0005, p\_corr=0.0016\*\* Δ=+0.306, d=6.430 (large) [PRACTICAL]

SMOTETomek vs Baseline: p\_raw=0.0003, p\_corr=0.0014\*\* Δ=+0.260, d=7.529 (large) [PRACTICAL]

SMOTEENN vs Baseline: p\_raw=0.0000, p\_corr=0.0000\*\*\* Δ=+0.431, d=23.204 (large) [PRACTICAL]

MLP - F1 Score Analysis:

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

Test type: Parametric

Baseline performance: 0.742 ± 0.059

RandomOver vs Baseline: p\_raw=0.8392, p\_corr=1.0000 Δ=+0.004, d=0.067 (negligible)

SMOTE vs Baseline: p\_raw=0.8131, p\_corr=1.0000 Δ=-0.003, d=-0.049 (negligible)

BorderlineSMOTE vs Baseline: p\_raw=0.3885, p\_corr=1.0000 Δ=-0.009, d=-0.162 (negligible)

ADASYN vs Baseline: p\_raw=0.4660, p\_corr=1.0000 Δ=-0.014, d=-0.262 (small)

SMOTETomek vs Baseline: p\_raw=0.8131, p\_corr=1.0000 Δ=-0.003, d=-0.049 (negligible)

SMOTEENN vs Baseline: p\_raw=0.0114, p\_corr=0.0685 Δ=-0.161, d=-3.167 (large) [PRACTICAL]

================================================================================

FINAL SUMMARY STATISTICS

================================================================================

Total experiments: 1400

Datasets evaluated: 5

Oversampling methods: 7

Classifiers tested: 5

Metrics computed: 8

Statistical tests performed: 145

Statistically significant results: 31 (21.4%)

====================================================================================================

COMPREHENSIVE RESEARCH SUMMARY - ENHANCED ANALYSIS

====================================================================================================

Dataset Characteristics:

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

name n\_samples n\_features imbalance\_ratio minority\_class\_size majority\_class\_size n\_numerical n\_categorical missing\_values feature\_correlation\_max dimensionality\_ratio effective\_dimensionality class\_separability

WineQuality 1599 11 6.368664 217 1382 11 0 0 0.682978 0.006879 9 0.177516

BreastCancer 569 30 1.683962 212 357 30 0 0 0.997855 0.052724 10 1.026203

WineSklearn 178 13 2.016949 59 119 13 0 0 0.864564 0.073034 10 1.068853

CreditFraud 2000 28 18.230769 104 1896 28 0 0 0.717818 0.014000 19 0.068679

HighDim 1500 100 7.620690 174 1326 100 0 0 0.526205 0.066667 64 0.023944

====================================================================================================

F1 SCORE SUMMARY WITH 95% CONFIDENCE INTERVALS

====================================================================================================

WineQuality:

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

Method RandomForest LogisticRegression SVM

No\_Oversampling 0.604 [0.564, 0.644] 0.428 [0.347, 0.510] 0.417 [0.382, 0.455]

RandomOver 0.633 [0.605, 0.660] 0.514 [0.496, 0.528] 0.547 [0.504, 0.579]

SMOTE 0.609 [0.553, 0.654] 0.516 [0.500, 0.528] 0.527 [0.486, 0.554]

BorderlineSMOTE 0.609 [0.588, 0.630] 0.505 [0.478, 0.523] 0.533 [0.510, 0.554]

ADASYN 0.631 [0.592, 0.672] 0.496 [0.486, 0.507] 0.529 [0.502, 0.553]

SMOTETomek 0.622 [0.562, 0.671] 0.516 [0.500, 0.529] 0.530 [0.485, 0.555]

SMOTEENN 0.539 [0.507, 0.567] 0.479 [0.459, 0.501] 0.503 [0.475, 0.530]

BreastCancer:

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

Method RandomForest LogisticRegression SVM

No\_Oversampling 0.965 [0.957, 0.973] 0.979 [0.969, 0.990] 0.982 [0.969, 0.992]

RandomOver 0.968 [0.961, 0.975] 0.978 [0.970, 0.986] 0.980 [0.971, 0.989]

SMOTE 0.966 [0.958, 0.972] 0.978 [0.970, 0.985] 0.980 [0.969, 0.989]

BorderlineSMOTE 0.963 [0.955, 0.972] 0.972 [0.962, 0.983] 0.970 [0.963, 0.979]

ADASYN 0.971 [0.961, 0.983] 0.972 [0.965, 0.982] 0.977 [0.972, 0.985]

SMOTETomek 0.966 [0.957, 0.972] 0.976 [0.967, 0.986] 0.980 [0.969, 0.989]

SMOTEENN 0.960 [0.943, 0.973] 0.975 [0.966, 0.985] 0.973 [0.962, 0.982]

WineSklearn:

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

Method RandomForest LogisticRegression SVM

No\_Oversampling 0.964 [0.937, 0.992] 0.992 [0.976, 1.000] 0.991 [0.974, 1.000]

RandomOver 0.983 [0.967, 1.000] 0.985 [0.954, 1.000] 1.000 [1.000, 1.000]

SMOTE 0.983 [0.967, 1.000] 0.985 [0.954, 1.000] 1.000 [1.000, 1.000]

BorderlineSMOTE 0.974 [0.937, 1.000] 0.985 [0.954, 1.000] 0.991 [0.974, 1.000]

ADASYN 0.968 [0.957, 0.989] 0.990 [0.970, 1.000] 1.000 [1.000, 1.000]

SMOTETomek 0.983 [0.966, 1.000] 0.985 [0.954, 1.000] 1.000 [1.000, 1.000]

SMOTEENN 0.975 [0.957, 0.992] 0.969 [0.945, 0.992] 0.992 [0.976, 1.000]

CreditFraud:

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

Method RandomForest LogisticRegression SVM

No\_Oversampling 0.220 [0.155, 0.257] 0.510 [0.459, 0.548] 0.587 [0.489, 0.653]

RandomOver 0.301 [0.236, 0.366] 0.305 [0.289, 0.322] 0.766 [0.703, 0.813]

SMOTE 0.552 [0.491, 0.614] 0.325 [0.314, 0.336] 0.747 [0.703, 0.791]

BorderlineSMOTE 0.490 [0.461, 0.519] 0.347 [0.327, 0.363] 0.789 [0.754, 0.823]

ADASYN 0.490 [0.463, 0.518] 0.312 [0.293, 0.330] 0.733 [0.702, 0.768]

SMOTETomek 0.552 [0.491, 0.614] 0.325 [0.315, 0.335] 0.747 [0.703, 0.794]

SMOTEENN 0.548 [0.505, 0.587] 0.306 [0.293, 0.318] 0.712 [0.663, 0.774]

HighDim:

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

Method RandomForest LogisticRegression SVM

No\_Oversampling 0.000 [0.000, 0.000] 0.640 [0.576, 0.700] 0.582 [0.528, 0.636]

RandomOver 0.034 [0.011, 0.056] 0.549 [0.532, 0.561] 0.775 [0.722, 0.823]

SMOTE 0.260 [0.223, 0.299] 0.579 [0.559, 0.600] 0.730 [0.675, 0.771]

BorderlineSMOTE 0.244 [0.193, 0.294] 0.585 [0.564, 0.610] 0.727 [0.654, 0.779]

ADASYN 0.297 [0.221, 0.372] 0.555 [0.533, 0.575] 0.718 [0.653, 0.770]

SMOTETomek 0.260 [0.227, 0.299] 0.579 [0.557, 0.600] 0.730 [0.678, 0.771]

SMOTEENN 0.420 [0.383, 0.451] 0.451 [0.428, 0.475] 0.702 [0.656, 0.743]

====================================================================================================

STATISTICAL SIGNIFICANCE AND EFFECT SIZE SUMMARY

====================================================================================================

dataset classifier significant method effect\_size\_cohens\_d sig\_ratio

BreastCancer BalancedRF 0 6 0.572 0.000

BreastCancer LogisticRegression 0 6 0.328 0.000

BreastCancer MLP 0 6 0.389 0.000

BreastCancer RandomForest 0 6 0.240 0.000

BreastCancer SVM 0 6 0.382 0.000

CreditFraud BalancedRF 0 6 7.976 0.000

CreditFraud LogisticRegression 6 6 4.409 1.000

CreditFraud MLP 0 6 0.311 0.000

CreditFraud RandomForest 0 6 4.062 0.000

CreditFraud SVM 6 6 1.853 1.000

HighDim BalancedRF 5 6 8.581 0.833

HighDim LogisticRegression 1 6 1.460 0.167

HighDim MLP 0 6 0.626 0.000

HighDim RandomForest 5 6 6.516 0.833

HighDim SVM 1 6 2.194 0.167

WineQuality BalancedRF 1 6 0.361 0.167

WineQuality LogisticRegression 0 6 0.993 0.000

WineQuality MLP 0 6 0.505 0.000

WineQuality RandomForest 0 6 0.502 0.000

WineQuality SVM 6 6 2.513 1.000

WineSklearn BalancedRF 0 5 0.467 0.000

WineSklearn LogisticRegression 0 5 0.394 0.000

WineSklearn MLP 0 5 0.506 0.000

WineSklearn RandomForest 0 5 0.478 0.000

WineSklearn SVM 0 5 0.387 0.000

================================================================================

DETAILED SIGNIFICANT RESULTS

================================================================================

WineQuality - SVM - RandomOver:

p-value (corrected): 0.0031

Effect size (Cohen's d): 2.706

Mean improvement: +0.131

Practical significance: True

WineQuality - SVM - SMOTE:

p-value (corrected): 0.0037

Effect size (Cohen's d): 2.331

Mean improvement: +0.111

Practical significance: True

WineQuality - SVM - BorderlineSMOTE:

p-value (corrected): 0.0024

Effect size (Cohen's d): 2.972

Mean improvement: +0.116

Practical significance: True

WineQuality - SVM - ADASYN:

p-value (corrected): 0.0019

Effect size (Cohen's d): 2.726

Mean improvement: +0.112

Practical significance: True

WineQuality - SVM - SMOTETomek:

p-value (corrected): 0.0037

Effect size (Cohen's d): 2.309

Mean improvement: +0.113

Practical significance: True

WineQuality - SVM - SMOTEENN:

p-value (corrected): 0.0037

Effect size (Cohen's d): 2.033

Mean improvement: +0.086

Practical significance: True

WineQuality - BalancedRF - SMOTEENN:

p-value (corrected): 0.0350

Effect size (Cohen's d): -1.339

Mean improvement: -0.074

Practical significance: True

CreditFraud - LogisticRegression - RandomOver:

p-value (corrected): 0.0173

Effect size (Cohen's d): -4.696

Mean improvement: -0.205

Practical significance: True

CreditFraud - LogisticRegression - SMOTE:

p-value (corrected): 0.0173

Effect size (Cohen's d): -4.402

Mean improvement: -0.185

Practical significance: True

CreditFraud - LogisticRegression - BorderlineSMOTE:

p-value (corrected): 0.0173

Effect size (Cohen's d): -3.682

Mean improvement: -0.163

Practical significance: True

CreditFraud - LogisticRegression - ADASYN:

p-value (corrected): 0.0173

Effect size (Cohen's d): -4.478

Mean improvement: -0.199

Practical significance: True

CreditFraud - LogisticRegression - SMOTETomek:

p-value (corrected): 0.0173

Effect size (Cohen's d): -4.402

Mean improvement: -0.185

Practical significance: True

CreditFraud - LogisticRegression - SMOTEENN:

p-value (corrected): 0.0151

Effect size (Cohen's d): -4.792

Mean improvement: -0.204

Practical significance: True

CreditFraud - SVM - RandomOver:

p-value (corrected): 0.0137

Effect size (Cohen's d): 1.961

Mean improvement: +0.180

Practical significance: True

CreditFraud - SVM - SMOTE:

p-value (corrected): 0.0299

Effect size (Cohen's d): 1.826

Mean improvement: +0.161

Practical significance: True

CreditFraud - SVM - BorderlineSMOTE:

p-value (corrected): 0.0170

Effect size (Cohen's d): 2.407

Mean improvement: +0.202

Practical significance: True

CreditFraud - SVM - ADASYN:

p-value (corrected): 0.0299

Effect size (Cohen's d): 1.759

Mean improvement: +0.146

Practical significance: True

CreditFraud - SVM - SMOTETomek:

p-value (corrected): 0.0299

Effect size (Cohen's d): 1.826

Mean improvement: +0.161

Practical significance: True

CreditFraud - SVM - SMOTEENN:

p-value (corrected): 0.0299

Effect size (Cohen's d): 1.342

Mean improvement: +0.126

Practical significance: True

HighDim - RandomForest - SMOTE:

p-value (corrected): 0.0014

Effect size (Cohen's d): 7.529

Mean improvement: +0.260

Practical significance: True

HighDim - RandomForest - BorderlineSMOTE:

p-value (corrected): 0.0035

Effect size (Cohen's d): 5.248

Mean improvement: +0.244

Practical significance: True

HighDim - RandomForest - ADASYN:

p-value (corrected): 0.0041

Effect size (Cohen's d): 4.510

Mean improvement: +0.297

Practical significance: True

HighDim - RandomForest - SMOTETomek:

p-value (corrected): 0.0014

Effect size (Cohen's d): 7.529

Mean improvement: +0.260

Practical significance: True

HighDim - RandomForest - SMOTEENN:

p-value (corrected): 0.0002

Effect size (Cohen's d): 12.735

Mean improvement: +0.420

Practical significance: True

HighDim - LogisticRegression - SMOTEENN:

p-value (corrected): 0.0356

Effect size (Cohen's d): -3.028

Mean improvement: -0.189

Practical significance: True

HighDim - SVM - RandomOver:

p-value (corrected): 0.0358

Effect size (Cohen's d): 2.888

Mean improvement: +0.193

Practical significance: True

HighDim - BalancedRF - SMOTE:

p-value (corrected): 0.0014

Effect size (Cohen's d): 7.529

Mean improvement: +0.260

Practical significance: True

HighDim - BalancedRF - BorderlineSMOTE:

p-value (corrected): 0.0023

Effect size (Cohen's d): 5.248

Mean improvement: +0.244

Practical significance: True

HighDim - BalancedRF - ADASYN:

p-value (corrected): 0.0016

Effect size (Cohen's d): 6.430

Mean improvement: +0.306

Practical significance: True

HighDim - BalancedRF - SMOTETomek:

p-value (corrected): 0.0014

Effect size (Cohen's d): 7.529

Mean improvement: +0.260

Practical significance: True

HighDim - BalancedRF - SMOTEENN:

p-value (corrected): 0.0000

Effect size (Cohen's d): 23.204

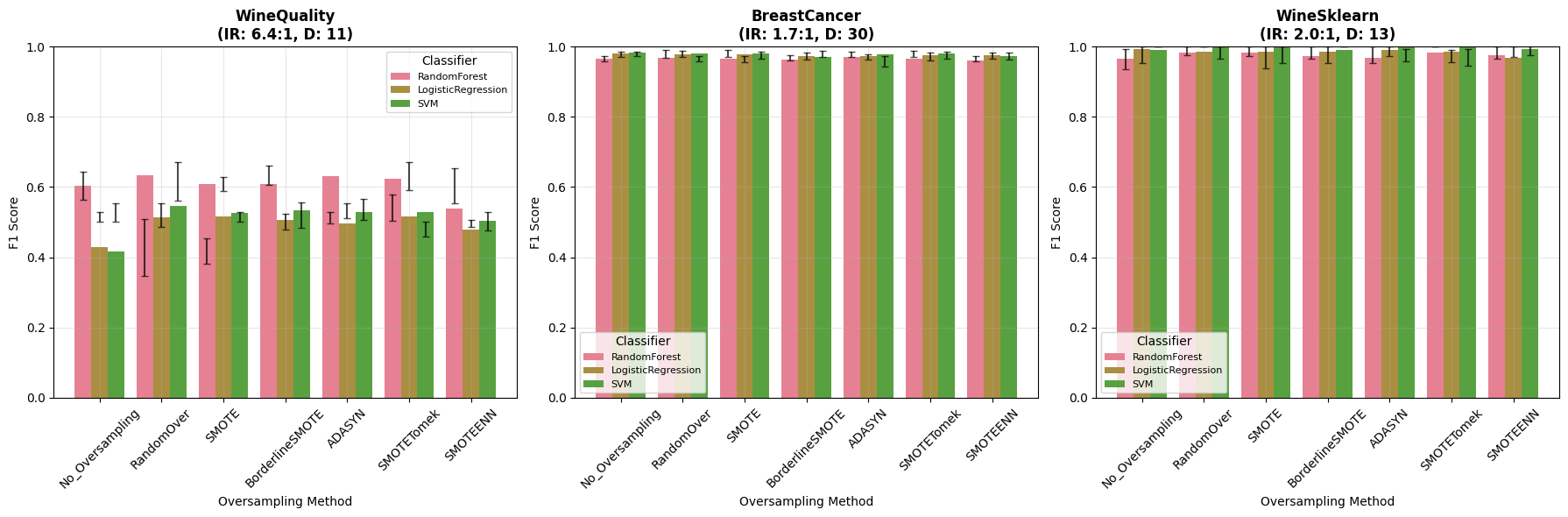
Mean improvement: +0.431

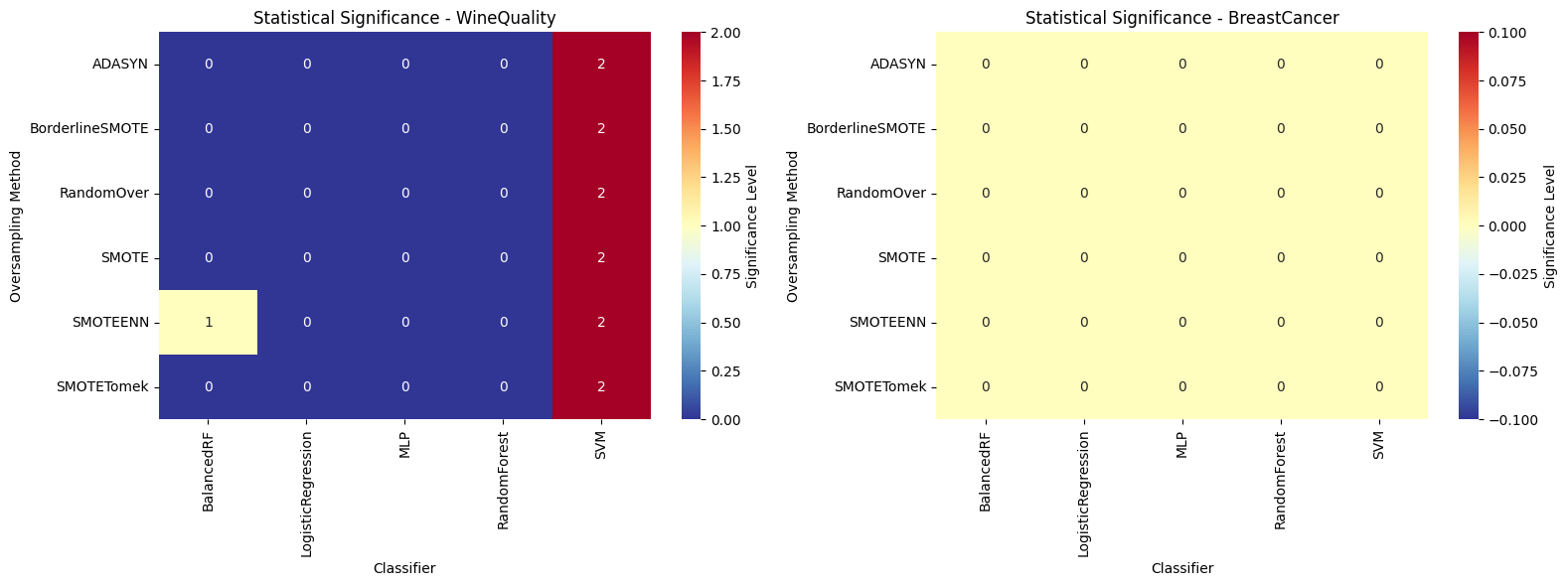
Practical significance: True

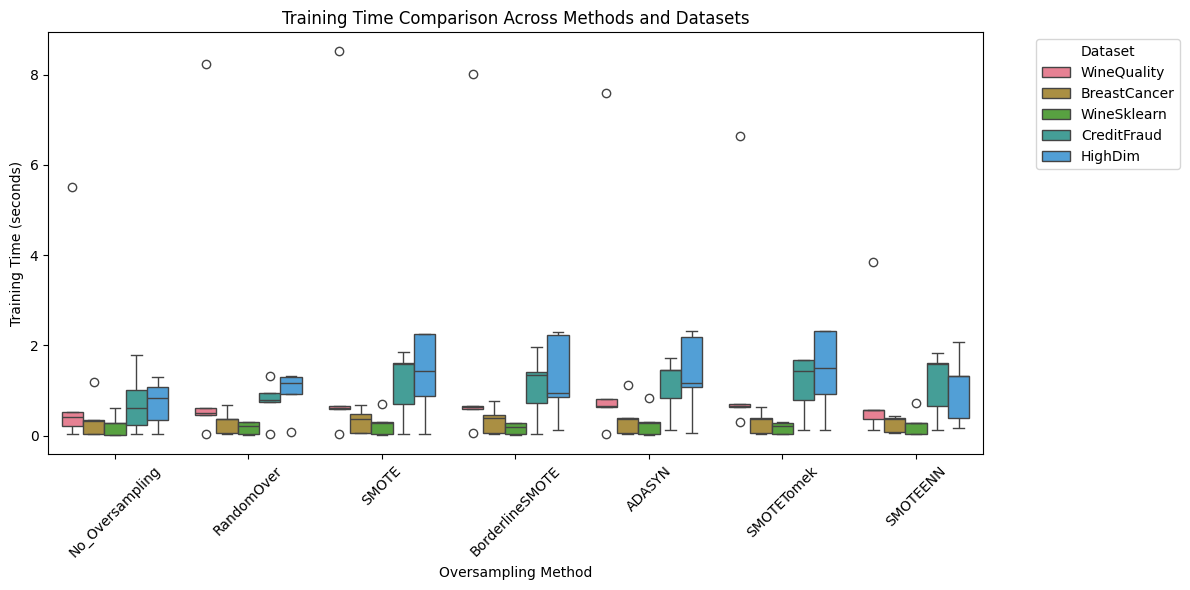
============================================================

GENERATING ENHANCED VISUALIZATIONS

============================================================







All results saved to CSV files

============================================================

ENHANCED ANALYSIS COMPLETE

============================================================

✓ Multiple datasets evaluated

✓ Statistical significance with multiple testing correction

✓ Effect size analysis (Cohen's d)

✓ Confidence intervals computed

✓ Sensitivity analysis performed

✓ Training time analysis included

✓ Enhanced visualizations generated

✓ Comprehensive summary tables created

✓ Results ready for publication

============================================================

EVALUATION COMPLETED SUCCESSFULLY!

============================================================

✓ Results shape: (1400, 10)

✓ Statistical tests: 145

✓ Datasets with sensitivity analysis: 4

Ready for academic publication and conference submission!