

Overview of ROC Curves in SAS PROC LOGISTIC

Paul Constantin and Sue McKendrick



Introduction

There is interest in developing new biomarkers (BM) that are more specific in detecting drug induced liver injury (DILI) than the commonly used tests [e.g. elevated Alanine Transaminase (ALT) and total bilirubin]. We use simulated data from 100 healthy and 100 DILI patients to demonstrate receiver operating characteristic (ROC) enhancements made to PROC LOGISTIC in SAS Version (v) 9.2. In particular, different BMs can be compared using the area under the ROC curve (AUROC). Further details can be found in Gonen (2007)^[1].

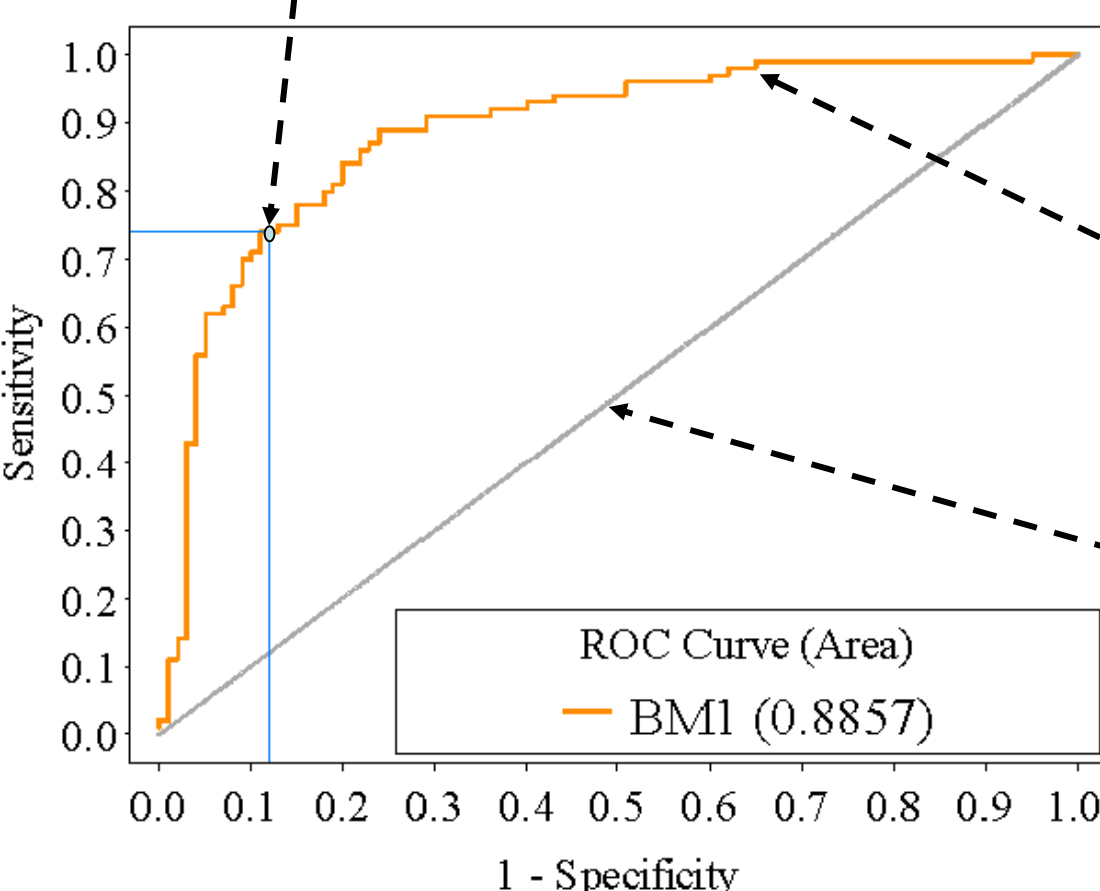
Derivation of the ROC Curve

Step 1:
Choose threshold (t)=8 and classify subject's diagnosis as 'DILI' if BM1 > t and 'clear' if BM1 < t.

		Diagnosis (based on BM1 threshold of 8)		Total
		Clear	DILI	
True Status	Healthy	88 (TN)	12 (FP)	100 (N)
	DILI	26 (FN)	74 (TP)	100 (P)

T = True; F=False; N=Negative; P=Positive.

Step 2:
Plot the true positive rate, TP/P = 0.74 (sensitivity) against the false positive rate, FP/N=0.12 (1 - specificity).

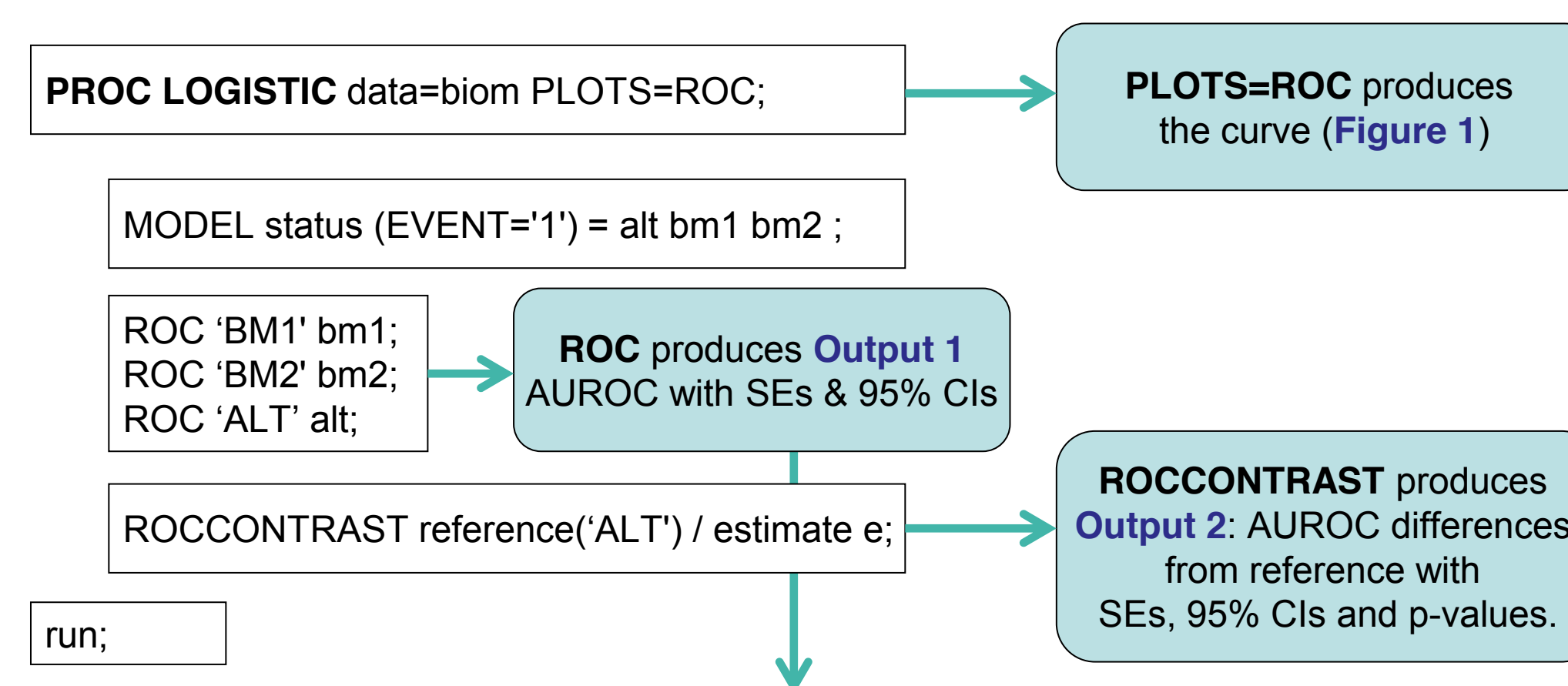


Step 3:
Repeat Steps 1 and Step 2 for all possible thresholds and plot all points on the same plot to produce the ROC Curve.

Chance Diagonal (AUROC=0.5)
(represents no discriminating ability).

New Features in PROC LOGISTIC

The ability to estimate AUROC and AUROC differences with standard errors (SEs) and 95% Confidence Intervals (CIs), and plot the associated curve(s) in PROC LOGISTIC was new in SAS v9.2. This is an improvement over SAS v9.1 where the 'c' statistic gave an unintuitive estimate of the AUROC without SE or CI.



Output 1: ROC Association Statistics

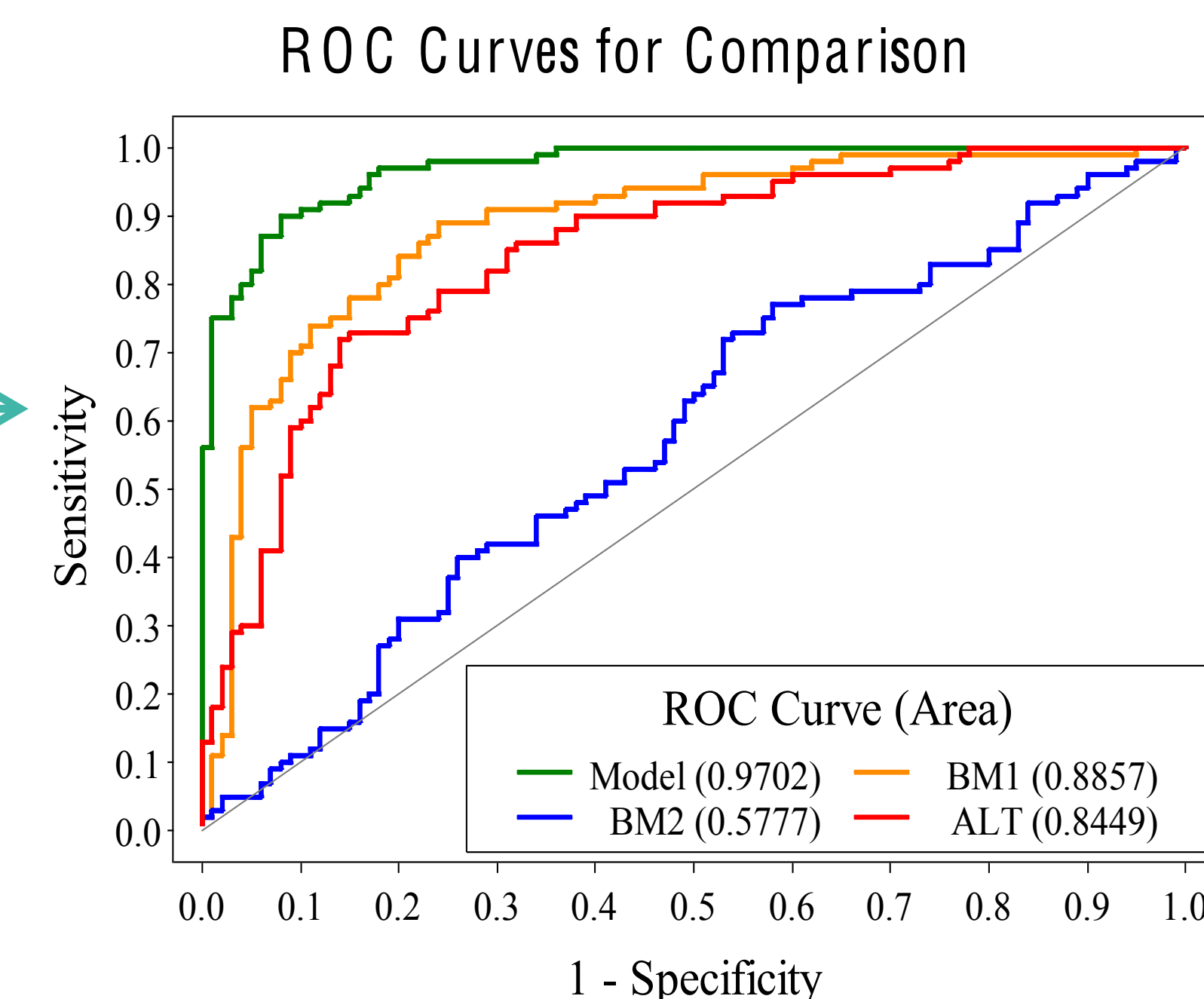
Model	AUROC	Standard Error	95% CI	
			Lower Limit	Upper Limit
Model	0.9702	0.00943	0.9517	0.9887
ALT	0.8449	0.0276	0.7909	0.8989
BM1	0.8857	0.0243	0.8380	0.9334
BM2	0.5777	0.0406	0.4981	0.6573

The 'Model' results includes all terms. The BM with AUROC closest to one has the best classification ability. The AUROC can be interpreted as the probability that the BM for a randomly selected DILI patient has a higher value than for a randomly selected healthy subject.

Reference

1. Gonen, Mithat. 2007. *Analyzing Receiver Operating Characteristic Curves with SAS*. Cary, NC: SAS Institute Inc.

Figure 1: Comparison of ROC Curves



Output 2: ROC Contrast Estimation

Model Comparison	AUROC Difference	Standard Error	95% CI		Prob
			Lower Limit	Upper Limit	
Model - ALT	0.1253	0.0250	0.0762	0.1744	<.0001
BM1 - ALT	0.0408	0.0200	0.00169	0.0799	0.0409
BM2 - ALT	-0.2672	0.0301	-0.3263	-0.2081	<.0001

Conclusion

PROC LOGISTIC in SAS v9.2 was improved with these features:

- AUROC estimates with SEs and 95% CIs (ROC statement);
- AUROC comparisons with 95% CIs (ROCCONTRAST statement);
- Easy plots of ROC curves (PLOTS=ROC option).

Further improvements could include derivation of the "best" threshold, estimation of partial AUROCs and validation tools.