

Statistical Methods for Order Spike Detection: Comparative Analysis

Model Performance Comparison

Metric	Negative Binomial	Zero-Inflated NB	Improvement
Pseudo R² Model Fit Quality	0.059	0.079 Superior fit	+33.9% Substantial gain
Log-Likelihood Model Performance	Not specified	-305.63 Quantified	- N/A
LLR Test p-value Statistical Significance	-	0.0008 p < 0.001	Significant Highly significant
Spikes Detected False Positive Rate	2 false positives Poor specificity	0 Perfect detection	Eliminated 100% reduction
Overdispersion () Variance Parameter	Not specified	0.158 Controlled	Well-controlled Appropriate level

Statistical Methods Evaluation by Condition

Condition	PMF/CDF	Z-Score	GLM Poisson			GLM Negative
	Method (Poisson-based)	Method (vs mean/std)	Z-Score	Absolute Threshold	Relative Threshold	Binomial
$\lambda < 5$ Highly Discrete	Cautious Too sensitive	Invalid Skewed data	Invalid Biased residuals	Valid Needs tuning	Valid Better choice	Best Handles skew
$\lambda \geq 10$ Near-Normal	Valid	Valid	Valid	Valid	Valid	Best Generalizes well
Overdispersion $\text{Var}(Y) > \mu$	Invalid Fixed lambda	Invalid Underestimates	Invalid Biased results	Cautious May misfire	Cautious Arbitrary scale	Best Accounts variance
No Overdispersion $\text{Var}(Y) = \mu$	Valid	Valid	Valid	Valid	Valid	Valid Equal performance

Method Evaluation Legend

Category	Description
Best	Optimal method for the condition. Provides most reliable and accurate results with robust statistical properties.
Valid	Statistically appropriate and reliable method. Can be used confidently with standard implementation.
Cautious	Method has limitations or requires careful tuning. Use with additional validation and expert oversight.
Invalid	Statistically inappropriate method that produces unreliable or biased results. Should be avoided.
Improvement	Shows significant enhancement or positive change compared to baseline method.