

Semiparametric robust mean estimations based on the orderliness of quantile averages

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| Hodges–Lehmann estimator

Hodges–Lehmann inequality and γ - U -orderliness

The Hodges–Lehmann estimator stands out as a unique robust location estimator due to its definition being substantially dissimilar from conventional L -estimators, R -estimators, and M -estimators. In their landmark paper, *Estimates of location based on rank tests*, Hodges and Lehmann (1) proposed two methods for computing the H-L estimator: the Wilcoxon score R -estimator and the median of pairwise means. The Wilcoxon score R -estimator is a location estimator based on signed-rank test, or R -estimator, (1) and was later independently discovered by Sen (1963) (2, 3). However, the median of pairwise means is a generalized L -statistic and a trimmed U -statistic, as classified by Serfling in his novel conceptualized study in 1984 (4). Serfling further advanced the understanding by generalizing the H-L kernel as $hl_k(x_1, \dots, x_k) = \frac{1}{k} \sum_{i=1}^k x_i$, where $k \in \mathbb{N}$ (4). Here, the weighted H-L kernel is defined as $whl_k(x_1, \dots, x_k) = \frac{\sum_{i=1}^k x_i \mathbf{w}_i}{\sum_{i=1}^k \mathbf{w}_i}$, where \mathbf{w}_i s are the weights applied to each element.

By using the weighted H-L kernel and the L -estimator, it is now clear that the Hodges–Lehmann estimator is an LL -statistic, the definition of which is provided as follows:

$$LL_{k,\epsilon,\gamma,n} := L_{\epsilon_0,\gamma,n} \left(\text{sort} \left((whl_k(X_{N_1}, \dots, X_{N_k}))_{N=1}^{\binom{n}{k}} \right) \right),$$

where $L_{\epsilon_0,\gamma,n}(Y)$ represents the ϵ,γ - L -estimator that uses the sorted sequence, $\text{sort}(whl_k(X_{N_1}, \dots, X_{N_k}))_{N=1}^{\binom{n}{k}}$, as input, the upper asymptotic breakdown point of the L -estimator is ϵ_0 , the lower asymptotic breakdown point is $\gamma\epsilon_0$.

Data Availability. Data for Figure ?? are given in SI Dataset S1. All codes have been deposited in [GitHub](#).

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