

# Semiparametric robust mean estimations based on the orderliness of quantile averages

Tuban Lee

This manuscript was compiled on June 10, 2023

semiparametric | mean-median-mode inequality | asymptotic | unimodal  
| Hodges–Lehmann estimator

## Inequalities related to weighted averages

So far, it is quite natural to hypothesize that the value of  $\epsilon, \gamma$ -trimmed mean should be monotonically related to the breakdown point in a semiparametric distribution, since it is a linear combination of quantile averages as shown in Section ???. Analogous to the  $\gamma$ -orderliness, the  $\gamma$ -trimming inequality for a right-skewed distribution is defined as  $\forall 0 \leq \epsilon_1 \leq \epsilon_2 \leq \frac{1}{1+\gamma}$ ,  $\text{TM}_{\epsilon_1, \gamma} \geq \text{TM}_{\epsilon_2, \gamma}$ .  $\gamma$ -orderliness is a sufficient condition for the  $\gamma$ -trimming inequality, as proven in the SI Text. The next theorem shows a relation between the  $\epsilon, \gamma$ -quantile average and the  $\epsilon, \gamma$ -trimmed mean under the  $\gamma$ -trimming inequality, suggesting the  $\gamma$ -orderliness is not a necessary condition for the  $\gamma$ -trimming inequality.

**Theorem .1.** *For a distribution that is right-skewed and follows the  $\gamma$ -trimming inequality, it is asymptotically true that the quantile average is always greater or equal to the corresponding trimmed mean with the same  $\epsilon$  and  $\gamma$ ,  $0 \leq \epsilon \leq \frac{1}{1+\gamma}$ .*

*Proof.* According to the definition of the  $\gamma$ -trimming inequality:  $\forall 0 \leq \epsilon \leq \frac{1}{1+\gamma}$ ,  $\frac{1}{1-\epsilon-\gamma\epsilon+2\delta} \int_{\gamma\epsilon-\delta}^{1-\epsilon+\delta} Q(u) du \geq \frac{1}{1-\epsilon-\gamma\epsilon} \int_{\gamma\epsilon}^{1-\epsilon} Q(u) du$ , where  $\delta$  is an infinitesimal positive quantity. Subsequently, rewriting the inequality gives  $\int_{\gamma\epsilon-\delta}^{1-\epsilon+\delta} Q(u) du - \frac{1-\epsilon-\gamma\epsilon+2\delta}{1-\epsilon-\gamma\epsilon} \int_{\gamma\epsilon}^{1-\epsilon} Q(u) du \geq 0 \Leftrightarrow \int_{1-\epsilon}^{1-\epsilon+\delta} Q(u) du + \int_{\gamma\epsilon-\delta}^{\gamma\epsilon} Q(u) du - \frac{2\delta}{1-\epsilon-\gamma\epsilon} \int_{\gamma\epsilon}^{1-\epsilon} Q(u) du \geq 0$ . Since  $\delta \rightarrow 0^+$ ,  $\frac{1}{2\delta} \left( \int_{1-\epsilon}^{1-\epsilon+\delta} Q(u) du + \int_{\gamma\epsilon-\delta}^{\gamma\epsilon} Q(u) du \right) = \frac{Q(\gamma\epsilon)+Q(1-\epsilon)}{2} \geq \frac{1}{1-\epsilon-\gamma\epsilon} \int_{\gamma\epsilon}^{1-\epsilon} Q(u) du$ , the proof is complete.  $\square$

An analogous result about the relation between the  $\epsilon, \gamma$ -trimmed mean and the  $\epsilon, \gamma$ -Winsorized mean can be obtained in the following theorem.

**Theorem .2.** *For a right-skewed distribution following the  $\gamma$ -trimming inequality, asymptotically, the Winsorized mean is always greater or equal to the corresponding trimmed mean with the same  $\epsilon$  and  $\gamma$ , provided that  $0 \leq \gamma \leq 1$ . If assuming  $\gamma$ -orderliness, the inequality is valid for any non-negative  $\gamma$ .*

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

**ACKNOWLEDGMENTS.** I sincerely acknowledge the insightful comments from the editor which considerably elevated the lucidity and merit of this paper.