Descriptive statistics for semiparametric models. ii. moments

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This manuscript was compiled on June 10, 2023

A. Robust Estimations of the Central Moments. In 1976, Bickel and Lehmann (1), in their third paper of the landmark series *Descriptive Statistics for Nonparametric Models*, generalized nearly all robust scale estimators of that time as measures of the dispersion of a symmetric distribution around its center of symmetry. In 1979, the same series, they (2) proposed a class of estimators referred to as measures of spread, which consider the pairwise differences of a random variable, irrespective of its symmetry, throughout its distribution, rather than focusing on dispersion relative to a fixed point. While they had already considered one version of the trimmed standard deviation, which is essentially a trimmed second raw moment, in the third paper of that series (1); in the final section of the fourth paper (2), they explored another two versions of the trimmed standard deviation based on symmetric differences and pairwise differences, the latter is modified here for comparison,

$$\left[\binom{n}{2}\left(1-\epsilon-\gamma\epsilon\right)\right]^{-\frac{1}{2}}\left[\sum_{i=\binom{n}{2}\gamma\epsilon}^{\binom{n}{2}(1-\epsilon)}\left(X-X'\right)_i^{2}\right]^{\frac{1}{2}}, \qquad [1]$$

where $(X-X')_1 \leq \ldots \leq (X-X')_{\binom{n}{2}}$ are the order statistics of the pairwise differences, $X_{\mathbf{i}}-X_{\mathbf{j}}$, $\mathbf{i}<\mathbf{j}$, provided that $\binom{n}{2}\gamma\epsilon \in \mathbb{N}$ and $\binom{n}{2}(1-\epsilon) \in \mathbb{N}$. They showed that, when $\epsilon=0$, the result obtained using [1] is equal to $\sqrt{2}$ times the sample standard deviation. The paper ended with, "We do not know a fortiori which of the measures is preferable and leave these interesting questions open."

Two examples of the impacts of this series are as follows. Oja (1981, 1983) (3, 4) provided a more comprehensive and generalized examination of these concepts, and integrated the measures of location, dispersion, and spread as proposed by Bickel and Lehmann (1, 2, 5), along with van Zwet's convex transformation order of skewness and kurtosis (1964) (6) for univariate and multivariate distributions, resulting a greater degree of generality and a broader perspective on these statistical constructs. Rousseeuw and Croux proposed a popular efficient scale estimator based on separate medians of pairwise differences taken over $\mathbf{i}$ and $\mathbf{j}$ (7) in 1993. However the importance of tackling the symmetry assumption has been greatly underestimated, as will be discussed later.

Theorem A.1.

Proof. □

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7. PJ Rousseeuw, C Croux, Alternatives to the median absolute deviation. *J. Am. Stat. association* **88**, 1273–1283 (1993).

T.L. designed research, performed research, analyzed data, and wrote the paper.

The author declares no competing interest.

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