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*Research article*

## **Mitigation effect on the efficiency mismeasurement of deterministic data envelopment analysis through statistical noise correction**

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### **Appendix A. Exploratory simulation under variable returns to scale**

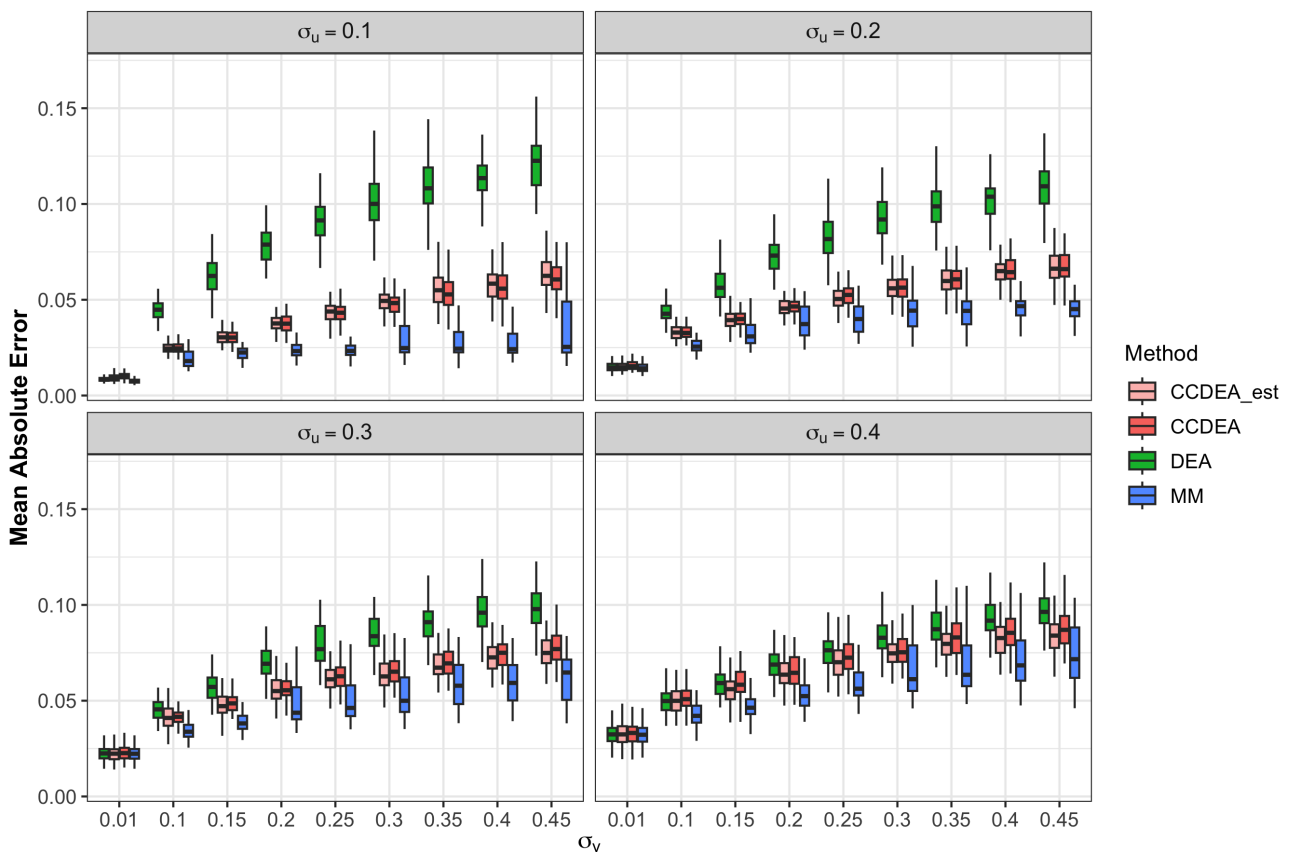
Although the theoretical motivation in Section 3 relies on the CRS assumption, we conducted an exploratory simulation to observe the empirical performance of the proposed MM method under a VRS setting.

The true production data is generated from a Cobb–Douglas function exhibiting increasing returns to scale,

$$\log y_i = \log 2 + 0.5 \log x_{i1} + 0.7 \log x_{i2} - u_i + v_i, \quad i = 1, 2, \dots, N.$$

The input variables, inefficiency  $u_i$  and statistical noise  $v_i$ , are generated using the same distributions and parameters as in Section 4. To evaluate efficiency under the VRS assumption, the standard convexity constraint is added to the linear programming models for classical DEA, CCDEA, CCDEA\_est, and the proposed MM method. As in the main CRS simulations, CCDEA uses the true noise variance, whereas CCDEA\_est uses the SFA-estimated noise variance.

Figure A1 presents the MAEs for the VRS experiment. Since this VRS analysis is exploratory and the main correction is developed under the CRS radial framework, no formal significance tests are reported. Consistent with the CRS results, the proposed MM method reduces mismeasurement relative to classical DEA as the noise variance  $\sigma_v^2$  increases. While a formal theoretical justification for the approach under VRS remains a subject for future research, this exploratory result suggests that the SFA-based noise correction retains practical utility in VRS applications.



**Figure A1.** Boxplots of MAEs under an exploratory VRS setting. The true data is generated from an increasing returns to scale Cobb–Douglas function, and the DEA models incorporate the convexity constraint.



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