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Exact inference for a simple step-stress model from the exponential distribution under time constraint

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Abstract In reliability and life-testing experiments, the researcher is often interested in the effects of extreme or varying stress factors such as temperature, voltage and load on the lifetimes of experimental units. Step-stress test, which is a special class of accelerated life-tests, allows the experimenter to increase the stress levels at fixed times during the experiment in order to obtain information on the parameters of the life distributions more quickly than under normal operating conditions. In this paper, we consider the simple step-stress model from the exponential distribution when there is time constraint on the duration of the experiment. We derive the maximum likelihood estimators (MLEs) of the parameters assuming a cumulative exposure model with lifetimes being exponentially distributed. The exact distributions of the MLEs of parameters are obtained through the use of conditional moment generating functions. We also derive confidence intervals for the parameters using these exact distributions, asymptotic distributions of the MLEs and the parametric bootstrap methods, and assess their performance through a Monte Carlo simulation study. Finally, we present two examples to illustrate all the methods of inference discussed here.

Keywords Accelerated testing · Bootstrap method · Conditional moment generating function · Coverage probability · Cumulative exposure model · Exponential distribution · Maximum likelihood estimation · Order statistics · Step-stress models · Tail probability · Type-I censoring