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Research Article

Bayesian analysis of the Xgamma distribution under type II censored accelerated life testing: Simulation-based insights and reliability applications

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Abstract

This study introduces a robust Bayesian framework for simple-step stress accelerated life testing. For modeling lifetime characteristics, this study adopts the Xgamma distribution as the principal life model. Bayesian parameter estimation is conducted using the Markov Chain Monte Carlo method under three distinct loss functions: the squared error loss function, generalized entropy loss function, and linear exponential loss function. The resulting Bayesian estimators are analyzed and compared with those obtained through the classical maximum likelihood estimation method. Finally, the proposed methods are illustrated with the analysis of two real data sets.

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Keywords. Accelerated life testing, Bayesian estimation, Xgamma distribution, type-II censoring

1. Introduction

In reliability engineering, accelerated life testing (ALT) plays a pivotal role in efficiently obtaining failure data for highly durable products. Under normal usage conditions, collecting sufficient failure information can be prohibitively time-consuming and costly, particularly for components with extended lifespans. To address this challenge, ALT involves subjecting products to elevated stress levels—such as increased temperature, pressure, or voltage—using one or more stressors to induce early failures. These accelerated conditions allow engineers to gather meaningful reliability data within a shortened timeframe. The resulting failure data are then extrapolated to estimate the reliability characteristics in standard operating environments, making ALT an indispensable tool for contemporary reliability assessment and product enhancement.

The Xgamma distribution is used in lifetime data analysis to address limitations of the exponential distribution, which assumes a constant failure rate. Real-world scenarios often exhibit non-monotonic failure rates—initially high, then decreasing, stabilizing, and eventually rising again. Traditional exponential based mixtures like exponential-Poisson or

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