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# A Novel Alpha-Power X Family: A Flexible Framework for Distribution Generation with Focus on the Half-Logistic Model

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**Abstract:** This study introduces a new and flexible class of probability distributions known as the novel alpha-power X (NAP-X) family. A key development within this framework is the novel alpha-power half-logistic (NAP-HL) distribution, which extends the classical half-logistic model through an alpha-power transformation, allowing for greater adaptability to various data shapes. The paper explores several theoretical aspects of the proposed model, including its moments, quantile function and hazard rate. To assess the effectiveness of parameter estimation, a detailed simulation study is conducted using seven estimation techniques: Maximum likelihood estimation (MLE), Cramér–von Mises estimation (CVME), maximum product of spacings estimation (MPSE), least squares estimation (LSE), weighted least squares estimation (WLSE), Anderson–Darling estimation (ADE) and a right-tailed version of Anderson–Darling estimation (RTADE). The results offer comparative insights into the performance of each method across different sample sizes. The practical value of the NAP-HL distribution is demonstrated using two real datasets from the metrology and engineering domains. In both cases, the proposed model provides a better fit than the traditional half-logistic and related distributions, as shown by lower values of standard model selection criteria. Graphical tools such as fitted density curves, Q–Q and P–P plots, survival functions and box plots further support the suitability of the model for real-world data analysis.

**Keywords:** novel alpha-power X family; statistical model; statistical characterization; half-logistic distribution; estimation approaches; simulation; real-world applications



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## 1. Introduction

In the field of statistical distribution theory, the practice of introducing additional parameters to existing distribution families has become widespread and highly valuable. By adding an extra parameter, statisticians are able to significantly enhance the flexibility of the underlying models, allowing them to better capture complex data patterns and provide improved fits to a variety of real-world phenomena. This approach not only enriches the mathematical structure of distributions but also extends their practical applications across numerous scientific and engineering disciplines.