



RESEARCH PAPER

A New Generalization of the Gompertz Makeham Distribution: Theory and Application in Reliability

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ABSTRACT

In this paper, a new five-parameter distribution called Marshall-Olkin Gompertz Makeham Distribution (MOGM) is proposed. This new model can be applied to the analysis of lifetime data, engineering, and actuarial. In addition, several properties of the proposed model such as mode, moment, Renyi entropy, Tsallis entropy, quantile function, and decreasing and unimodal hazard rate function were also investigated. The unknown parameters of MOGM distribution were estimated using Maximum Likelihood Estimation (MLE) and Bayes methods. Then, these methods were compared using Monte Carlo simulation and the best estimator was introduced accordingly. Finally, some other applications of the proposed model were illustrated to show its usefulness and efficiency.

KEYWORDS: Gompertz makeham distribution; Reliability; Estimation parameters; Simulation.
Mathematics Subject Classification (2010):62Fxx, 62N02, 62F10, 62F15, 54C70, 37M05.

1. Introduction

Gompertz distribution (G), introduced by Gompertz in 1825 ([21] and [10]), is one of the significant distributions in reliability, lifetime data analysis [15], and human mortality studies [22], especially in growth modeling and actuarial tables. Generalization of Gompertz distribution based on the idea given in [3] was proposed by El-Gohary et al. (2013) [8]. This new distribution is known as Generalized Gompertz (GG) distribution and it includes the Exponential (E), Generalized Exponential (GE), and Gompertz (G) distributions. Jafari et al. (2014) [13] proposed a new generalization of Gompertz (G) distribution called Beta-Gompertz (BG) distribution which was the result of the application of the Gompertz distribution to the Beta generator [9]. Back in 1860, Makeham introduced Gompertz Makeham (GM) distribution as a different version of G distribution [16] which was more compatible than G for modeling lifetime data

([4], [19], etc.). Moreover, Jorda [14] studied this family in terms of statistical properties using the Lambert W function. This function proposes a closed-form expression for the quantile function that is one of the remarkable features for GM.

Statistical theories can provide a new distribution by means of some transformations such as methods introduced by Shaw and Buckley (2009) [18]. These transformations have also been applied to introduce a new GM distribution [1], [2], [23].

This study introduces a new extended form of Gompertz Makeham distribution (MOGM) by applying the Marshall-Olkin transformation. First, several statistical properties including hazard rate function, Laplace transform of a probability density function, Renyi and Tsallis entropies, residual life, reversed residual life functions, and the density of order statistics are carefully investigated. Then, in Section 2, the maximum likelihood and Bayes methods are presented to estimate the parameters of MOGM. In Section 3, by applying the Monte Carlo simulation, a sample random variable is generated from MOGM. In addition, those two methods mentioned in Section 2 are compared to find out which method is more compatible with the estimation of unknown parameters. Finally, to illustrate how this new distribution functions successfully, a real data set is used for comparing MOGM with some other well-known

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