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Dynamic Modeling and Multi-Objective Optimization of Takaful Insurance System

Communication Info

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Abstract

This paper proposes a novel dynamical systems approach to model and optimize Takaful insurance operations, contributing to the growing body of research in Islamic finance [1]. It formalizes, for the first time the interactions between the three core components of Takaful [2] — participants, claims, and the mutual fund—within a continuous-time dynamical framework. The model integrates key operational parameters such as enrollment and attrition rates, claim frequency, contribution levels, and profit-and-loss sharing mechanisms. The study proves the mathematical well-posedness and stability of the system and supports the analysis with numerical simulations. It then formulates a multi-objective optimization problem [3] aimed at maximizing participant retention, minimizing claim incidence, and ensuring the stability of funds within operational constraints. The problem is solved using an integrated NSGA-II [4] and entropy weighting approach [5], providing a robust decision support tool for sustainable and Sharia-compliant Takaful management.

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