VOLUME 28 - ARTICLE 35 | PAGES 995-1020

A dynamic birth-death model via Intrinsic Linkage

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DATE RECEIVED: 06 Mar 2012
DATE PUBLISHED: 16 May 2013
WORD COUNT: 6952
KEYWORDS: **birth-death models**, **cyclical stability**, **dynamic population models**, **Leslie matrices**, **metastable**
DOI: **10.4054/DemRes.2013.28.35**

Abstract

Background: Dynamic population models, or models with changing vital rates, are only beginning to receive serious attention from mathematical demographers. Despite considerable progress, there is still no general analytical solution for the size or composition of a population generated by an arbitrary sequence of vital rates.

Objective: The paper introduces a new approach, Intrinsic Linkage, that in many cases can analytically determine the birth trajectory of a dynamic birth-death population.

Methods: Intrinsic Linkage assumes a weighted linear relationship between (i) the time trajectory of proportional increases in births in a population and (ii) the trajectory of the intrinsic rates of growth of the projection matrices that move the population forward in time. Flexibility is provided through choice of the weighting parameter, *w*, that links these two trajectories.

Results: New relationships are found linking implied intrinsic and observed population patterns of growth. Past experience is "forgotten" through a process of simple exponential decay. When the intrinsic growth rate trajectory follows a polynomial, exponential, or cyclical pattern, the population birth trajectory can be expressed analytically in closed form. Numerical illustrations provide population values and relationships in metastable and cyclically stable models. Plausible projection matrices are typically found for a broad range of values of *w*, although *w* appears to vary greatly over time in actual populations.

Conclusions: The Intrinsic Linkage approach extends current techniques for dynamic modeling, revealing new relationships between population structures and the changing vital rates that generate them.

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