Predictive Modeling of Membership Patterns Across Health Insurance Segments

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Abstract

This study develops an open multi-state Markov framework to characterize and project membership dynamics in Indonesia's National Health Insurance Program (JKN). Monthly administrative data from 2020–2021 are used for estimation, with 2022 reserved for out-of-sample evaluation. The framework integrates a Genetic Algorithm for stock–flow reconciliation, Dirichlet distributions for transition uncertainty, and Monte Carlo simulation. The model achieves a total membership MAPE of 1.117%, compared with 6.208% for Auto-ARIMA. It also links membership projections to the contribution base and highlights the importance of active-member retention and reactivation.

Keywords: National Health Insurance, multi-state Markov model, open population, membership dynamics, stochastic projection, contribution projection.

Introduction

Indonesia's National Health Insurance Program (JKN), administered by BPJS Kesehatan, plays a crucial role in achieving Universal Health Coverage (UHC). However, aggregate enrollment alone does not adequately represent movements across membership segments, activity statuses, and service classes. These movements have financial implications because contribution rates and mechanisms differ across membership categories.

Existing studies generally examine membership transitions and aggregate forecasting as separate problems. An integrated framework is therefore needed to capture membership mobility, project future membership composition, and assess its contribution-side financial implications.

This study aims to develop a stochastic projection framework that incorporates new enrollment, demographic change, inter-state movements, activation and deactivation, and deaths. The framework supports membership monitoring and financial planning within large-scale social health insurance systems.

Research Method

This study uses monthly administrative data from BPJS Kesehatan and demographic data from Statistics Indonesia (BPS). Seven segments, two activity statuses and valid service classes form 28 registered membership states. The unregistered population and death are added, yielding a 30-state model.

A Genetic Algorithm reconciles recorded membership flows with observed membership stocks under feasibility constraints. Reconciled flows are used to estimate monthly transition probabilities within an open multi-state Markov model. Demographic changes enter the state update as exogenous inflows.

$$z_{t+1} = z_t P_t + u_t$$

Population vector × transition matrix + inflow

Dirichlet distributions represent uncertainty in transition probabilities, propagated through Monte Carlo simulation to generate stochastic projections. Model performance is evaluated using 2022 observations and an Auto-ARIMA benchmark. Projected active membership is combined with category-specific monthly contribution rates to estimate contributions and analyze alternative transition scenarios.

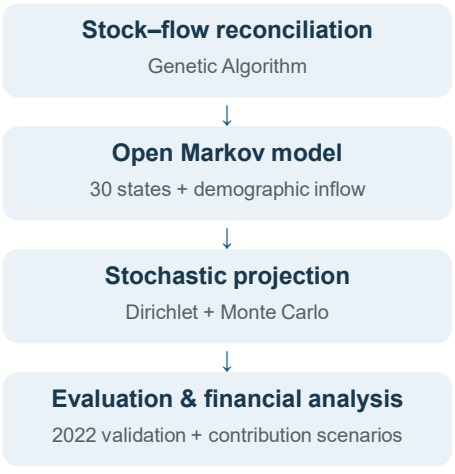


Figure 1. Proposed membership projection framework.

Discussion & Result

The estimated transition structure shows high membership-state persistence and heterogeneous mobility. In the 2022 evaluation, the Markov model achieves an aggregate MAPE of 1.117%, compared with 6.208% for Auto-ARIMA. Segment-level MAPE ranges from 0.878% (PBPU) to 9.568% (BP NP).

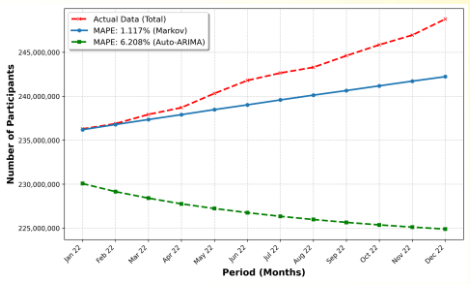


Figure 2. Observed and projected membership.

The annual contribution amount implied by projected active membership is IDR 139.740 trillion, versus IDR 140.891 trillion based on observed membership. Retention and reactivation have greater modeled effects than shifts across active segments: preventing deactivation increases the estimate to IDR 153.738 trillion, while PBPU reactivation at 30% raises it to IDR 146.885 trillion.

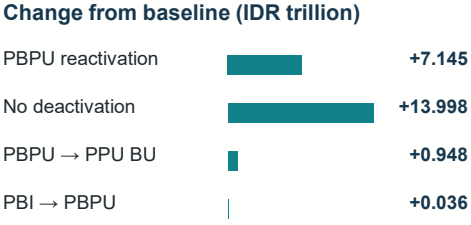


Figure 3. Sensitivity scenarios.

Conclusion

The open multi-state Markov framework integrates membership mobility with stochastic projections and contribution-side analysis. Results emphasize the role of activity status, retention and reactivation in financial planning. Scenario results are illustrative, not causal policy estimates or actual collections. Further validation is required before operational implementation.