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# Forecasting Urban Residential Stock Turnover Dynamics using System Dynamics and Bayesian Model Averaging

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**Abstract** Knowing the size of the building stock is perhaps the most basic determinant in assessing energy use in buildings. However, official statistics on urban residential stock for many countries are piecemeal at best. Previous studies estimating stock size and energy use make various debateable methodological assumptions and only produce deterministic results. We present a Bayesian approach to characterise stock turnover dynamics and estimate stock size uncertainties, applied here to the case of China. Firstly, a probabilistic dynamic building stock turnover model is developed to describe the building aging and demolition process, governed by a hazard function specified by a parametric survival model. Secondly, using five candidate parametric survival models, the building stock turnover model is simulated through Markov Chain Monte Carlo to obtain posterior distributions of model-specific parameters, estimate marginal likelihood, and make predictions of stock size. Thirdly, Bayesian Model Averaging is applied to create a model ensemble that combines model-specific posterior predictive distributions of the recent historical stock evolution pathway in proportion to posterior model probabilities. Finally, the Bayesian Model Averaging model ensemble is extended to forecast future trajectories of residential stock development through 2100. The modelling results suggest that the total stock in China will peak around 2065, at between 42.4 and 50.1 billion $m^2$. This Bayesian modelling framework produces probability distributions of annual total stock, age-specific substocks, annual new buildings and annual demolition rates. This can support future analysis of policy trade-offs across embodied-versus-operational energy consumption, in the context of sector-wide decarbonisation.

**Keywords** building stock; lifetime distribution; System Dynamics; Bayesian Model Averaging, Markov Chain Monte Carlo, embodied energy, operational energy; China

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