26th International Congress on Modelling and Simulation, Adelaide, SA, Australia, 30 Nov–4 Dec 2025
mssanz.org.au/modsim2025

Factor Models in Housing Research: Addressing Methodological Gaps for Enhanced Policy Decision-Making

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Abstract: Factor models serve as powerful tools used to simplify and explain the variation in large datasets by capturing the influence of a relatively small number of underlying common, unobserved factors. Mathematically, a factor model can be expressed as $\mathbf{X} = \mathbf{\Lambda F} + \mathbf{E}$ where $\mathbf{X}$ is an $N \times T$ matrix of observed variables, $\mathbf{\Lambda}$ is an $N \times K$ matrix of factor loadings, and $\mathbf{F}$ is a $K \times T$ matrix of common factors and $\mathbf{E}$ is an $N \times T$ matrix of idiosyncratic errors.

In housing research, factor models currently address price forecasting through macroeconomic factor extraction, spatial dynamics via Principal Component Analysis of regional price indices, and commercial real estate valuation using style factors beyond traditional property characteristics. Current housing factor models explain approximately 50% of quarterly price variation but fail to capture complex interactions between physical housing conditions, neighborhood characteristics, and resident outcomes. However, existing applications face critical limitations: (1) unobserved heterogeneity in property and household characteristics leading to biased parameter estimates, (2) inadequate integration of social determinants of health with economic housing factors, (3) limited temporal modeling of adaptive learning and structural breaks in housing markets, and (4) insufficient cross-sectional analysis of multi-dimensional housing outcomes including health, social, and environmental impacts.

This research investigates various methodological approaches to address these gaps through: factor decomposition $\mathbf{Y} = \mathbf{\Lambda}_c\mathbf{F}_c + \mathbf{\Lambda}_s\mathbf{F}_s + \mathbf{\Lambda}_r\mathbf{F}_r + \mathbf{E}$, sparse regularized estimation $\min_{\mathbf{\Lambda},\mathbf{F}} \|\mathbf{Y} - \mathbf{\Lambda F}\|_F^2 + \lambda_1\|\mathbf{\Lambda}\|_1 + \lambda_2\|\mathbf{F}\|_1$ and dynamic models $h_{t+1} = \rho h_t + \lambda f_t + \varepsilon_t$. The integrated framework enables policy-relevant decomposition of housing outcomes into economic factors ($\mathbf{f}_{\text{econ}}$), social determinants ($\mathbf{f}_{\text{social}}$), environmental conditions ($\mathbf{f}_{\text{env}}$), and/or health impacts ($\mathbf{f}_{\text{health}}$). By addressing current methodological limitations, this framework enhances evidence-based housing policy development and supports more effective resource allocation for addressing housing challenges.

Keywords: *Factor models, Housing research, Policy decision-making*