A multilevel approach to model spatial correlation in disaster insurance losses in New Zealand

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Abstract In this paper we present a multilevel mixed effects model to describe earthquake losses in New Zealand. To this end we consider insured losses at the ward level and, to capture the correlation between wards, a second level of aggregation defined by the 16 regions of New Zealand. We analyze total building losses reported over 2000-2018 by assuming that wards in the same region are correlated. We model the within-region correlation as a function of the distance between the centroids of two wards and the distance where the variogram reaches the sill. This approach allows us to capture the spatial correlation between neighboring areas and to predict the insured losses on the basis of geographical and demographic characteristics as well as peculiarities of insured buildings. We find that the number of usual residents, the real estate value, the inhabited density and the risk index CRESTA zone are good predictors of wards' earthquake losses. The data show heteroscedasticity that is explained by spatial characteristics of the data, such as the number of neighboring regions and the north-south location of the ward. We found that introducing heteroscedasticity and spatially correlated random effects significantly improves the ability of the model in capturing the wards' losses. We also show that our model successfully represents losses of the Christchurch earthquake sequence, thus proving effective in capturing extreme events. The proposed model might support the insurers in the definition of risk-based premiums adequate to prevent extreme losses that may challenge the business.

Key words: Earthquake insurance losses, mixed effects, multilevel model, spatial correlation.

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