

Some proposals of corrective coefficients for a statistical evaluation of building vulnerability to seismic damage

Alcune proposte di coefficienti correttivi per la valutazione statistica della vulnerabilità degli edifici al danno sismico

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Riassunto: La Scala Europea Macrosismica EMS98, tramite la classificazione degli edifici in classi di vulnerabilità rispetto ad un progressivo livello decrescente di rischio sismico, fornisce un quadro concettuale coerente per una valutazione di larga scala della vulnerabilità sismica degli edifici. In questo lavoro da una scala di misura qualitativa viene derivata una misura quantitativa del grado di danno per ciascuna classe ed intensità macro-sismica. Il confronto ci consente di fornire alcune proposte di coefficienti correttivi, utilizzando la regressione lineare e la regressione robusta.

Keywords: robust regression, seismic risk.

1. Introduction

Two proposals are presented in Bernardini (2004) for the classification of residential buildings, identified respectively by means of a first level survey form (AeDES 05/2000) or simply using descriptive data obtained from national statistics (ISTAT 1991). These proposals satisfy a criterion of coherence between the obtained classification and the definitions of the European Macroseismic Scale EMS98, that provides a more precise evaluation of the seismic vulnerability of buildings and allows forecasts of the extent of damage. Using ISTAT 1991 data we can determine the number and volumes of buildings for “homogeneous” classes, in each census section, using several parameters; this will allow us to compare this population described by “poor” data taken from national statistics with the sample data taken from the AeDES survey of a sample of 46 census sections, that gives more accurate information on the EMS98 classification.

The main reason for this comparison is to evaluate the reliability of the data taken from ISTAT and to elaborate corrective coefficients that allow a more accurate EMS98 classification from the rough classification available for the entire population (of the census sections). Moreover, it will take into account the retrofitting building work and the construction of new residential buildings since 1991.

2. Comparison of EMS98 vulnerability classifications

We can consider the observations on Y as the “true” number of buildings, therefore we would estimate the actual values from those available for the entire population. In particular, in simple linear regression we have the following relationship:

$${}^gY_i = {}^g\beta_0 + {}^g\beta_1 {}^g x_i + {}^g\varepsilon_i \quad (1)$$

where the quantities ${}^g\beta_0$ and ${}^g\beta_1$, the intercept and the slope of the regression, are assumed to be fixed unknown parameters and ${}^g\varepsilon_i$ is a random variable. The main purpose of regression is to predict gY_i (the “true” number of buildings) from knowledge of ${}^g x_i$ (the “incorrect” number of buildings available for the entire population of the census section; we use ${}^g x_i$ instead of ${}^g X_i$ to highlight the fact that ${}^g x_i$ is fixed and known or that it is a realization of the observable random variable ${}^g X_i$), using a relationship such as (1). It seems from our analysis that the errors have a non-normal distribution. We might therefore consider a robust regression method (Draper and Smith, 1998; Maronna et al., 2006), particularly in cases where the error distribution is heavier-tailed than the normal distribution, i.e. when there is more probability in the tails than in the normal. Such heavier-tailed distributions are likely to generate more “large” errors than the normal. A least squares analysis weights each observation equally when getting parameters estimates. Robust methods enable the observations to be weighed unequally. Essentially, observations that produce large residuals are down-weighted by a robust estimation method. From the various weight functions given in the literature, we chose the bisquare weight function.

3. Conclusions

In this work several statistical methodologies have been compared to forecast, for every census section, actual frequencies of the number of residential buildings and their volumes in the EMS98 vulnerability classes, correcting preliminary classifications based on ISTAT 1991 statistic data. Because we are essentially interested in extrapolating our inference outside the sample, then the solution based on the linear regression is more appropriate than the one based on the ratio of the summations on the sample of census sections separately for each class (WM: Weighted mean solutions). Among the different solutions based on the linear regression, the choice should be based on “optimal” solution of the inner trade-off between the precision (R^2 values) of the estimates and the computational complexity to achieve it.

References

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