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Claim reserving with fuzzy regression and Taylor's geometric separation method[☆]

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Abstract

Claim provisions are crucial for the financial stability of insurance companies. This is why actuarial literature has proposed several claim reserving methods, which are usually based on statistical concepts. However, the mutant and uncertain behaviour of insurance environments does not make it advisable to use a wide database when calculating claim reserves, and so it in fact makes the use of Fuzzy Set Theory very attractive. This paper develops a claim reserving method that combines Ishibuchi and Nii's extension [Ishibuchi, H., Nii, M., 2001. Fuzzy regression using asymmetric fuzzy coefficients and fuzzified neural networks. Fuzzy Sets and Systems 119, 273–290] to the fuzzy regression methods described by Tanaka et al. [Tanaka, H., Uejima, S., Asai, K., 1982. Linear regression analysis with fuzzy model. IEEE Trans. Man Cybernetics 41, 389–396], Tanaka [Tanaka, H., 1987. Fuzzy data analysis by possibilistic linear models. Fuzzy Sets and Systems 24, 363–375], Savic and Pedrycz [Savic, D., Predrycz, W., 1992. Fuzzy linear models: construction and evaluation. In: Fuzzy Regression Analysis. Physica-Verlag, Heidelberg, pp. 91–100] and Tanaka and Ishibuchi (1992) [Tanaka, H., Ishibuchi, H., 1992. A possibilistic regression analysis based on linear programming. In: Fuzzy Regression Analysis. Physica-Verlag, Heidelberg, pp. 47–60] with the scheme for claim reserving proposed by Taylor (1978) [Taylor, G., 1978. Statistical testing of a non-life insurance run-off model. In: Proceedings of the First Meeting of the Contact Group Actuarial Sciences, pp. 37–64].

IMA codes: IM40; IM42

JEL classification: C29; C53; G22

Keywords: Claim provisions; Run-off triangle; Taylor's separation method; Fuzzy logic; Fuzzy numbers; Fuzzy regression

1. Introduction

Determining the fair value of claim provisions (i.e. the value of the future claims from the portfolio of insurance contracts) is crucial if insurance companies are to perform well. Neither under-reserving nor over-reserving is advisable. This is why the estimation of claim provisions is a classic topic in actuarial literature, which usually focuses

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on the problem from a statistical point of view. We can distinguish two sets of methods for calculating claim reserves. The first can be labelled as "classical" and adopts a deterministic perspective. The second set is commonly known as "stochastic" and provides predictions that are more complete than "classical" methods.

Classical methods only provide crisp predictions for reserves: that is to say, they obtain only a fair value for future claims. In Van Eeghen (1981), Taylor (1986) and Institute Of Actuaries (1989) a wide survey of these methods can be consulted. According to Taylor et al. (2003), stochastic methods date back to the mid-1970s. They are more complete and sophisticated than classical methods because, as England and Verrall point out (2002), they provide not only a fair value for the reserves but also their variability (i.e. their uncertainty). Given that the central hypothesis of these methods is that the evolution of claims is random, an ideal method must determinate the value of claim provisions by a random variable completely described by their distribution function.

To be completely effective, stochastic methods need to use considerable empirical experience but, unfortunately, this is not advisable in our context. Straub (1997) states that experiences that are too far from the present can lead to unrealistic estimates. For example, if claims are related to bodily injuries, the future losses for the company will depend on the growth of the wage index (which will be used to determine the amount of indemnification due), changes in court practices and public awareness of liability matters. When information is scanty or vague, instruments derived from Fuzzy Sets Theory (FST) such as Fuzzy Regression (FR) are suitable alternatives, as is shown, for example, by Watada (1992) and Tseng et al. (2001) in the field of univariate time series. The present paper, therefore, proposes a claim reserving method that combines the use of FR with Taylor's geometric separation method exposed in Taylor (1978) which is based on Taylor (1977).

In our context, FR has another advantage over traditional regression techniques. The estimates obtained after the coefficients have been adjusted are not random variables, which are difficult to use in arithmetical operations, but fuzzy numbers (FNs) are easier to handle arithmetically. So, when starting from magnitudes estimated by random variables (e.g. which have been predicted by statistical regression) these random variables are often reduced to their mathematical expectation so that they are easier to handle. If FNs are used, this loss of information is not needed since arithmetical operations with FNs are easy to compute. We think that the reasons mentioned above explain why papers such as Ramenazi and Duckstein (1992), Fedrizzi et al. (1993), Profillidis et al. (1999), Lee and Chen (2001), Yen and Goshray (1999) and Andrés and Terceño (2003b) suggest using FR to analyse several economic problems.

In the actuarial field, FST is used to model problems that require a great deal of actuarial subjective judgement and problems for which the information available is scarce or vague. Some surveys of FST applications in Actuarial Science are Ostaszewski (1993), Derrig and Ostaszewski (1998), Yakoubov and Haberman (1998), Andrés and Terceño (2003a) and Shapiro (2004a). Although actuarial quantitative analysis is essentially based on statistical methods, academics and practitioners now tend to believe that FST is a useful complement to statistics, as is recognised in Brockett and Xia (1995). So, in the recently published Encyclopaedia of Actuarial Science, which deals with fundamental topics in Actuarial Science, Derrig and Ostaszewski (2004) dedicate a chapter to FST. Below we list some of the leading applications of FST in actuarial science:

- Underwriting and reinsurance decisions: de Wit (1982), Lemaire (1990), Jablonowski (1991), Young (1993), Babad and Berliner (1995) and Horgby et al. (1997).
- Evaluating the goodness of several econometric methods to claim prediction by using the paradigm of decision in a fuzzy environment by Bellman and Zadeh (1970): Cummins and Derrig (1993)
- Ratemaking and risk clustering: Ebanks et al. (1992), Derrig and Ostaszewski (1995), Young (1996), Horgby (1998), Verrall and Yakoubov (1999), Caro (2000) and Caro and Sarabia (2000)
- Insurance pricing: Lemaire (1990), Karkowski and Ostaszewski (1992), Berliner and Buehlmann (1993), Babad and Berliner (1994), Terceño et al. (1996), Cummins and Derrig (1997), Derrig and Ostaszewski (1997) and Simonelli (1999)
- Calculating incurred but not reported reserves in Andrés and Terceño (2003a). Here Benjamin and Eagles' method (1986) is extended to the use of FR. We also develop a claim reserving method from a fuzzy logic perspective but it has two main differences with respect to that by Andrés and Terceño (2003a). Firstly, we use the FR model by Ishibuchi and Nii (2001) instead of the method proposed in Tanaka and Ishibuchi (1992), and so some problems of the second model are avoided. Moreover, our claim reserving scheme is based on Taylor's (1978) geometric method instead Benjamin and Eagles' (1986) approach. So, the proposed claim reserving method can fit, of course, the development of claims throughout time but also the impact of inflation in these claims.