Chapter LVII
Multi-Objective Optimization Evolutionary Algorithms in Insurance-Linked Derivatives

M. J. Pérez
Universidad Carlos III de Madrid, Spain

J. García
Universidad Carlos III de Madrid, Spain

L. Martí
Universidad Carlos III de Madrid, Spain

J. M. Molina
Universidad Carlos III de Madrid, Spain

ABSTRACT

This work addresses a real-world adjustment of economic models where the application of robust and global optimization techniques is required. The problem dealt with is the search for a set of parameters to calculate the reported claim amount. Several functions are proposed to obtain the reported claim amount, and a multi-objective optimization procedure is used to obtain parameters using real data and to decide the best function to approximate the reported claim amount. Using this function, insurance companies negotiate the underlying contract—that is, the catastrophic loss ratio defined from the total reported claim amount. They are associated with catastrophes that occurred during the loss period and declared until the development period expired. The suitability of different techniques coming from evolutionary computation (EC) to solve this problem is explored, contrasting the performance achieved with recent proposals of multi-objective evolutionary algorithms (MOEAs). Results show the advantages of MOEAs in the proposal in terms of effectiveness and completeness in searching for solutions, compared with particular solutions of classical EC approaches (using an aggregation operator) in problems with real data.

INTRODUCTION

The search for models explaining a database representing different real situations is common in many practical applications. Usually, real data represent opposite behaviors so that the acceptable model should achieve a certain level of performance with each situation. This problem can be generally transformed into a multi-objective optimization, attaining an appropriate trade-off to cover all cases. This field has been extensively studied in past years by evolutionary computation (ECs) researchers (Deb, 2001), defining the properties and advantages for different families of algorithms. Two basic types of approaches are distinguished: on the one hand the aggregation of all objectives into a single scalar function to apply standard optimization methods, and on the other hand the use of specific multi-objective evolutionary algorithms (MOEAs), exploiting the concept of multi-objective domination. In this second case, the algorithms preserving dominance are intended to maintain diverse population and provide a representation of the whole Pareto-optimal front after a single optimization run. In this chapter we propose the application of these techniques to search for the most appropriate model for the underlying loss ratio of catastrophic contract of capital markets, considering at the same time different cases covered in the available data set.

The frequency and intensity of catastrophe damages have grown severely in past years, and this tendency is expected to be continued in the future (Sigma, 2003, 2005). Insurance companies increase costs to cover these events, and they need new methods to guarantee the viability of their business activity with reasonable economic yield. The expert opinion about catastrophes shows a high probability of hurricanes like Andrew and earthquakes on the West Coast. Concurrently with these phenomena, zones with a higher risk of hurricanes and earthquakes experience great demographic growth. Following *NPA Data Services*, the population growth, until 2025, in these areas (California, Florida, and Texas) will be higher (up 36.6%) than other areas.

Some insurance companies and financial engineers have designed new ways to assume catastrophic risk through the interchange in financial markets, known as securitization (Sigma, 2001). Securitization means to trade with derivatives whose underlying assets are usually non-negotiated. The securitization allows insurance companies risk reduction and diversification.

Until today, principal catastrophe risk securitizations are catastrophe options and bonds. In this way, the Chicago Board of Trade (CBOT) begins to trade the first derivative specifically designed to insurers in December 1992: CAT-futures and CAT-options. Limitations in these products carried that, in September 1995, these contracts were changed by PCS options. Around the same time (1993), the first catastrophe bonds, CAT-bonds (Mueller, 2002; Cox, 1997), were issued, presenting a high-yield restricted loss to the principal and interest if a catastrophe occurs during the bond life. Actually, the usual catastrophe bonds and options are based on indexes to trigger the contract payment (Loubergé, Kellezi, & Gilli 1999; Muermann, 2003).

The underlying contract is the catastrophic loss ratio $LR = \frac{L(T_2)}{cte}$, defined from the total reported claim amount $L(T_2) = \sum S(t)$, associated to occurred catastrophes during the loss period, and declared until the development period expired.

LR is a random variable because the incurred total loss amount $L(T_2)$ is an unknown value during the contract life; the number of catastrophes, their severity, and the occurrence moment, as well as their reported claim intensity, are all unknown.

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