Pricing index-based catastrophe bonds: bridging the gap between geological and financial engineering.

A.J.A. Unger

Department of Earth Sciences, University of Waterloo, Waterloo, Ontario, Canada
(aunger@uwaterloo.ca / Fax: 519-746-7484 / Phone: 519-746-7484)

Earthquakes and hurricanes routinely create large-scale property damage in North American cities, with clean-up costs in the range of tens-of-billions of dollars annually. Insurance companies often require reinsurance to limit their liabilities given the large capital requirements required to cover this damage. Unfortunately, the reinsurance industry is also limit in size relative to the magnitude of these damages, creating large fluctuations in the price and availability of reinsurance during years when multiple catastrophes occur. In response, reinsurance companies have recently turned to the capital markets by issuing Catastrophe Bonds (CAT Bonds) to provide the collateral necessary to provide reinsurance. If no catastrophe occurs before the maturity date of the bond, the investors get the full face value of the bond plus coupon payments. If a catastrophe occurs before the maturity date, the bond defaults resulting in either a partial or no payment to investors. Fortunately, the capital markets are extremely large and can readily absorb this risk.

In the case of earthquake or hurricane (natural disasters) damages, the first step in pricing CAT bonds requires a detailed geological engineering analysis on the frequency and magnitude at which these natural disasters are expected to occur within a given metropolitan area. This step results in the construction of hazard map. The second step requires an analysis of the response of buildings within the hazard zones to these natural disasters, with insured costs required to cover damages yielding a risk analysis. Any given insurer can examine their portfolio of policies within the metropolitan area to estimate their liabilities. The resulting costs will follow a continuous probability distribution scaled by the value of their liabilities. The second step in pricing CAT bonds involves using financial engineering to provide a no-arbitrage based approach for pricing the bond (and solved using a control volume finite difference/element method)

given two underlying stochastic variables. The first variable is the interest rate, which is assumed to follow a CIR process. The second variable is the PCS index, which is posted each quarter by Property Claims Services and represents the losses claimed by a survey of insurers within specific geographic regions. Catastrophes cause a spike in the PCS index which is valued using a jump diffusion process. The bond principal is structured in an identical manner to standard reinsurance, and is based on the aggregate number of claims up to the maturity date thereby providing a "layer" of reinsurance coverage. Therefore, the bond can be valued in a manner identical to a discrete Asian option on the PCS index.

The purpose of this talk to introduce collaborate geological engineering work which provides the foundation of this analysis, and to present the completed financial engineering model along with preliminary results.