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Catastrophe risk management with counterparty risk using alternative instruments

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ABSTRACT

Since weather-related disasters have an upward trend-cycle movement and the global financial crisis has revealed the severity of counterparty risk, this study reinvestigates and incorporates the catastrophe characteristics and counterparty risk into the valuation of catastrophe products. First, the excess of loss reinsurance is traditionally used to reduce catastrophe risk. Its premium is estimated under these catastrophe characteristics. Second, this paper looks into the price of catastrophe futures and spread option contracts that are based on a catastrophe index. The (re)insurer can apply these exchange-traded derivatives to reduce catastrophe risk without counterparty risk. Third, this paper takes counterparty risk into account to value catastrophe bonds and catastrophe equity puts. Thus, the fair valuations of these two instruments are revealed to the buyer.

1. Introduction

Catastrophicevents (CATs) have a low frequency of occurrence but generally high loss severity. Different types of CATS have different characteristics of occurrence and impacts on human lives and properties. As shown in Fig. 1, the fitting-lines of occurrence numbers are plotted by a sixth-order polynomial. Weather-related disasters, such as storms and floods (often arose from storms), have an upward trend-cycle movement. The reason is that abnormal weather changes have a close relationship with El Niño events, which historically seem to have occurred at irregular intervals of 2–7 years, usually lasting 1–2 years, for at least the last 300 years. Additionally, global warming is causing weather-related disasters to become more frequent and intense (published in the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report 2007). However, the occurrence of earthquakes, tsunamis, or volcanic eruptions does not appear to have an obvious period or trend as time passes. The most costly insured CAT losses in Table 1 come from weather-related CATs and vary from low to high. Thus, describing different types of CAT loss processes needs a quite flexible model. Poisson processes are traditionally used to model the arrival of CATs resulting in insurance claims, but this is an inadequate approach due to its determined intensity (Seal, 1983; Beard et al., 1984). A doubly stochastic Poisson process provides more flexibility than a pure Poisson process by assuming that the intensity not only depends on time but is also a stochastic process. Moreover, CAT loss distributions in this process can be described by any positive random variable.

The global financial crisis of 2007 and 2008 is a multifaceted process. The counterparty risk caused by Northern Rock, Bear Stearns and Lehman Brothers has effects on other financial institutions. The contagion effects of credit risk aggravate counterparty default. Increased counterparty risk aversion results in significantly higher risk pricing. As most CAT risk instruments do not belong to exchange-traded products, fair values of CAT risk instruments may require reassessment.

In recessions or industry downturns, the number of defaulting firms rises, counterparty risk also increase, and at the same time, the resale price of real assets or financial assets (the defaulted bond) of defaulting firms is depressed (Altman et al., 2005; Acharya et al., 2007). Thus, the default probabilities (default or hazard rates) are high, and recovery rates are low. Conversely, in expansions, the default probabilities (default or hazard rates) are low, and recovery rates are high. Both variables are negatively correlated and are clearly related to the business cycle (Nickell et al., 2000; Bangia et al., 2002; Bruche and González, 2008). Thus, the counterparty default loss process must present two empirical characteristics of mean reversion and credit contagion.

This study attempts to empirically characterize the mean-reverting and credit contagious behavior of default probabilities and recovery rates. In contrast to related literature which does not involve the two empirical characteristics (Chava et al., 2008), a

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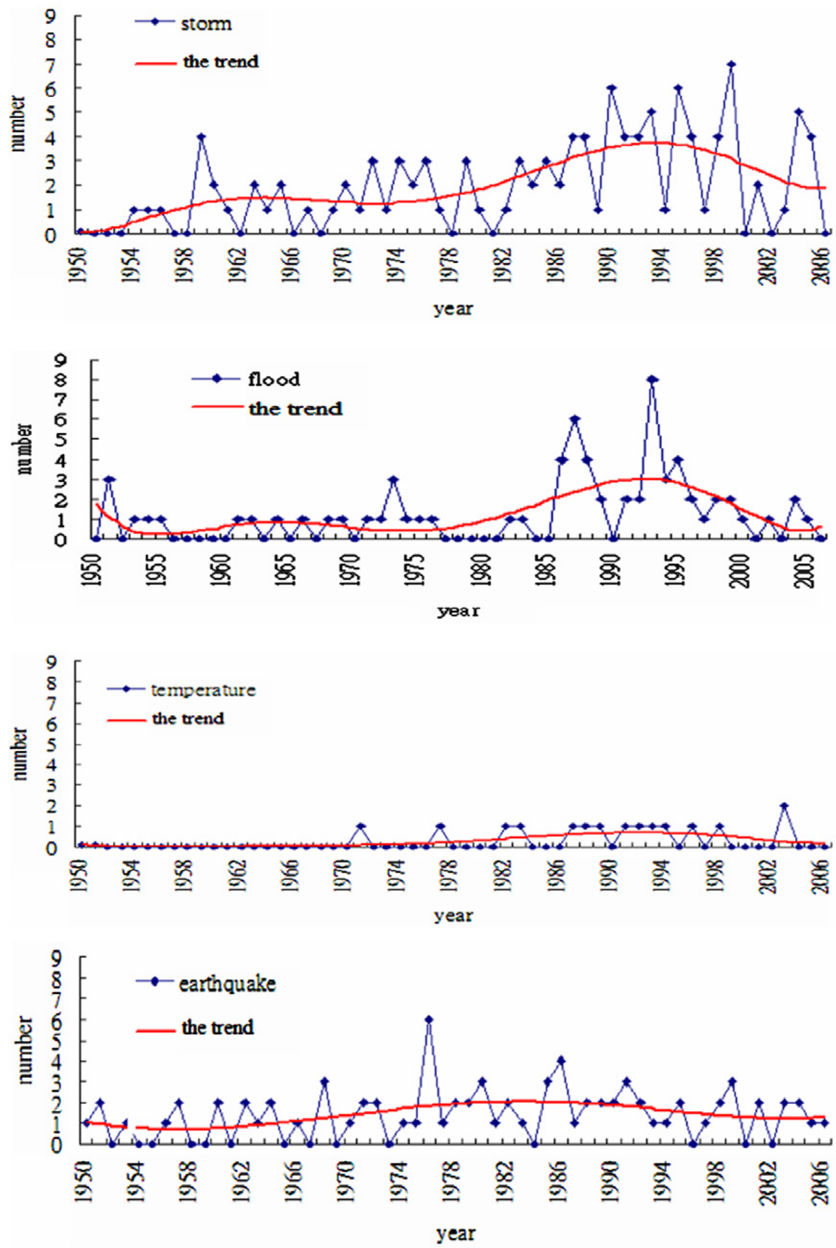

Fig. 1. Great natural disasters from 1950 to 2006.
Source: Geo Risks Research, Munich Reinsurance Company, 2007.

Table 1
The ten most costly catastrophes in the United States.

Event	Date	Insured loss ($billions)	2007 Dollars ($billions)
Hurricane Katrina	25/08/05	41.1	43.6
Hurricane Andrew	23/08/92	15.5	22.9
Terrorist attacks in US	11/09/01	18.8	22.0
Northridge earthquake	17/01/94	12.5	17.5
Hurricane Wilma	02/09/04	10.3	10.9
Hurricane Charley	19/10/05	7.5	8.2
Hurricane Ivan	20/09/05	7.1	7.8
Hurricane Hugo	11/08/04	4.2	7.0
Hurricane Rita	27/09/91	5.6	6.0
Hurricane Hugo	15/09/89	4.6	5.0

Source: Insurance Services Office, Inc. (ISO), Insurance Information Institute.

mean-reverting hazard rate process with contagion is developed to derive the default probability of counterparty risk. A combined model of default probability and recovery rates is thus obtained to describe expected default losses or residual value. Since the literature seldom simultaneously take mean reversion and credit contagion into the risk management and pricing model, this article uses the model to re-estimate catastrophe insurance contracts.

The contributions of this paper are as follows. First, given the greater severity and frequency of CATs, this paper uses a more general doubly compound Poisson process instead of a traditional