Evaluation of Portfolio of Financial and Insurance Instruments: Simulation of Uncertainty

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Abstract The increasing number of natural catastrophes leads to severe losses for production, in infrastructure and individual property. Classical insurance mechanisms may not be sufficient in dealing with such losses because of dependencies among sources of losses, huge values of damages, problems with adverse selection and moral hazard. To cope with dramatic consequences of such extreme events integrated policy is required. In this paper we discuss the model of portfolio which consists of a few layers of insurance and financial instruments, like catastrophe fund, catastrophe bonds, governmental help, etc. We use approach based on neutral martingale method and simulations. We price the catastrophe bond applying Vasicek model used for zero-coupon bond under assumption of independence between catastrophe occurrence and behavior of financial market. We discuss the effects of uncertainties which arise from estimation of rare events with serious, catastrophic consequences like natural catastrophes.

1 Introduction

The insurance industry faces overwhelming risks caused by natural catastrophes, e.g. losses from Hurricane Andrew hit 30 billion $ in 1992, the losses from Hurricane Katrina in 2005 are estimated on 40 – 60 billion $ (see (Muermann 2008)). To cope with dramatic consequences of such extreme events integrated policy that combines mitigation measures with diversified ex-ante and ex-post

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financial instruments is required. Without proper policies the natural catastrophes will increase long-term consequences for societies and economy of many countries, especially poor ones (see e.g. (MacKellar et al. 1999)).

The classical insurance mechanisms are not prepared for such extreme losses caused by natural catastrophes. Even one, single catastrophe could cause problems with reserves for many insurers or even bankruptcy of these enterprises. For example, after Hurricane Andrew more than 60 insurance companies became insolvent (see (Muermann 2008)). The traditional insurance models (see (Borch 1974)) deal with independent, rather small risks like car accidents. In such case the law of large numbers and the central limit theorem justify the ruin probability calculus and simple strategy of selecting an insurance contract portfolio: the greater the number of risks, the better (see (Borch 1974; Ermoliev et al. 2001)). Catastrophic risks require new approaches to the formation of a portfolio of an insurance company. The sources of losses from natural catastrophes are strongly dependent in terms of time and localization, e.g. single hurricane could start fire in many houses. The law of large numbers cannot be applied for such risks, and the traditional strategy of portfolio construction can only increase the probability of bankruptcy of insurer (see (Ermoliev et al. 2001)).

Additionally, classical insurance mechanisms are often criticized because of serious problems with adverse selection and moral hazard – e.g., hope for governmental help or possession of insurance policy may change people's attitude and draw them to growing crops in high risk regions, building houses in threatened area, not preventing additional losses, etc. Moreover, the primary insurers rely on classical reinsurance markets which are affected by price cycles connected with occurrence of natural catastrophes, terrorist attacks, etc.

The single event, e.g. earthquake or hurricane, could result in damages of $50–$100 billion. Keeping in mind that daily fluctuations on worldwide financial markets reach tens of billion $, securitization of losses (e.g. in the form of so called catastrophe bonds – see e.g. (Ermolieva et al. 2007; Nowak and Romaniuk 2009; Romaniuk and Ermolieva 2005)) may be helpful for dealing with results of extreme natural catastrophes (see e.g. (Cummins et al. 2002; Freeman and Kunreuther 1997; Froot 2001; Harrington and Niehaus 2003)).

For example, in agricultural regions natural disasters may lead to severe losses of agricultural production and, thus, to decrease of farmers' income (see e.g. (MacKellar et al. 1999)). The effects of such catastrophes are commonly known and various production planning practices were developed. However, these traditional risk management mechanisms are not always sufficient for dealing with extreme events (see e.g. (Nowak et al. 2008; Skees et al. 2002)). Additionally, due to lower level of income for rural areas, management of risks is especially price-sensitive. The demand for financial instruments depends on willingness of farmers to sacrifice a portion of their often uncertain income. The supply of financial instruments depends on feasibility of financial or insurance instruments and the ability of the insurance industry to manage losses at these prices. Therefore we should take into account the "fairness" requirement for both insurers and insureds (see e.g. (Ermolieva et al. 2007)).