SMIB — A PILOT PROGRAM SYSTEM FOR STOCHASTIC SIMULATION IN INSURANCE BUSINESS

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Abstract. In this paper, we describe the program **SMIB** (**S**tochastic **M**odeling of **I**nsurance **B**usiness). It is a pilot program system for stochastic modeling of insurance business with dynamical control of investment.

1. Introduction

The program **SMIB** was elaborated by Analytical Finance Group (D. Silvestrov, A. Malyarenko and M. Drozdenko) in the frame of the project "Stochastic Modeling of Insurance and Finance Processes and Systems" supported by the Knowledge Foundation. The program is based on multivariate dynamical model describing functioning of an insurance company. This model was developed by D. Silvestrov in co-operation with P. Näyskä and S. Sarvamaa (Sampo Insurance Group, Turku), M. Gyllenberg (University of Turku) and R. Östermark (Åbo Akademi University).

2. Parameters

The program **SMIB** works on IBM PC compatible computers under operating systems Microsoft Windows 95/98/2000/NT/ME/XP. It is written using Microsoft Visual C++ and Microsoft Foundation Classes library. The program has standard Microsoft-style graphical user interface.

Input information of the program includes quotas of capital invested in different types of assets, time-dependent switching thresholds for that quotas and safety loading coefficients, parameters of dynamical equations describing the functioning of an insurance company, etc.

Output information includes ruin probabilities, histogram of the distribution of capital at the given time horizon, expectation, variance and quantiles of that distribution, etc.

3. Description

The basic idea of the system is to involve Monte Carlo method for producing multiple time scenarios of the behaviour for the capital of an insurance company. The capital can be invested into different types of assets.

Each type of investment has its own profitability and risk. The insurance business and the investment process are simulated with the use of the multi-parameter non-linear dynamical model. Premiums, claims, and profits of different types of investments are described by equations of autoregressive type. Non-stationary in time threshold strategies are used to control investments and insurance business. Analytical methods do not work here, but Monte Carlo simulation does.

The program system **SMIB** is oriented on studies of

- ☞ capital distributions at different time horizons;
- ☞ extra-small ruin type probabilities;
- ☞ mechanisms of ruin events (cumulative effect of moderate claims or effect of a super-large catastrophic claim) depending on nonlinear investment and insurance strategies;
- ☞ parameters of investment and insurance processes;
- ☞ distributions of claims and return increments.

4. Examples

The user can change the availability of different types of investments, the quotas of capital among different types and some other characteristics using the Strategy panel of the program (Fig. 1).

Other panels describe different aspects of our dynamical model, including equations, values of parameters etc. The thresholds are shown on Fig. 2.

The user can produce this dialog window by pressing the **Quota** button (Fig. 1). The values of the thresholds can be changed by dragging the levels with the help of the mouse. Thus the threshold levels dependence of time can be as complicated as necessary. The lowest threshold (Fig. 2) is called the *level of bankruptcy*. If the capital becomes lower than this level, the company is ruined. It can not be changed by dragging, but can be set in the Strategy panel instead. The result shown in Fig. 3 corresponds to the example of quotas shown on Fig. 1.

Here the user can see the histogram of the distribution of capital at the end time point under the condition that the company was not ruined. The value of the ruin probability and the values of different characteristics of that distribution, including expectation, variance, and quantiles, are also available.

The resulting patch of ruin trajectories, which corresponds to the example described in Figures 1 – 2 and 10^6 simulated scenarios, is shown in Figure 4. These trajectories can be classified in different ways, for example, in groups, which contain ruin trajectories that have the maximal claim in given limits.

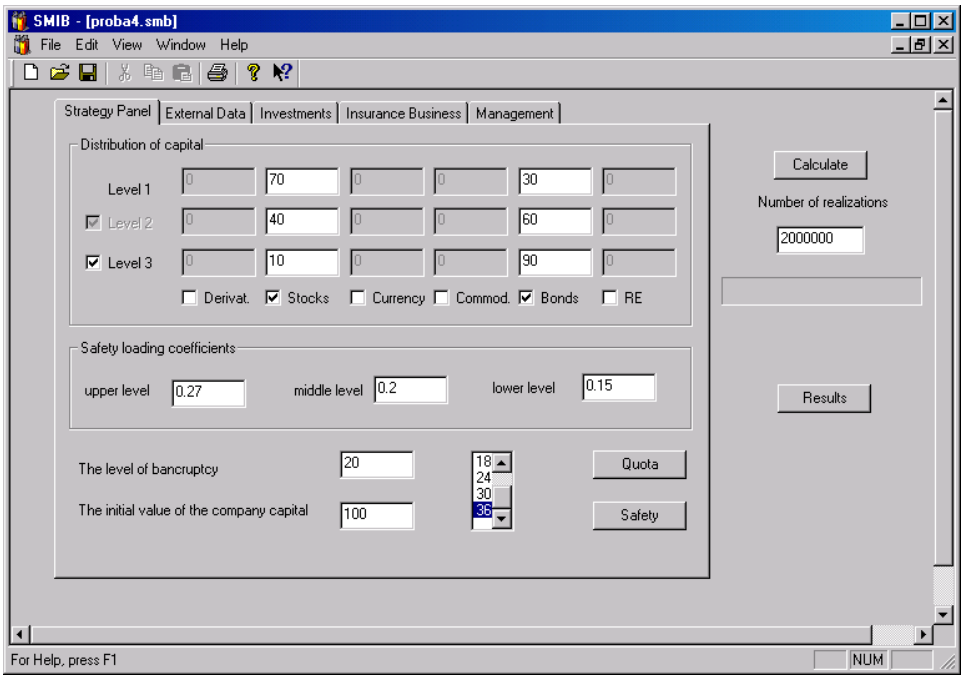

FIGURE 1. The Strategy Panel of the program SMIB.

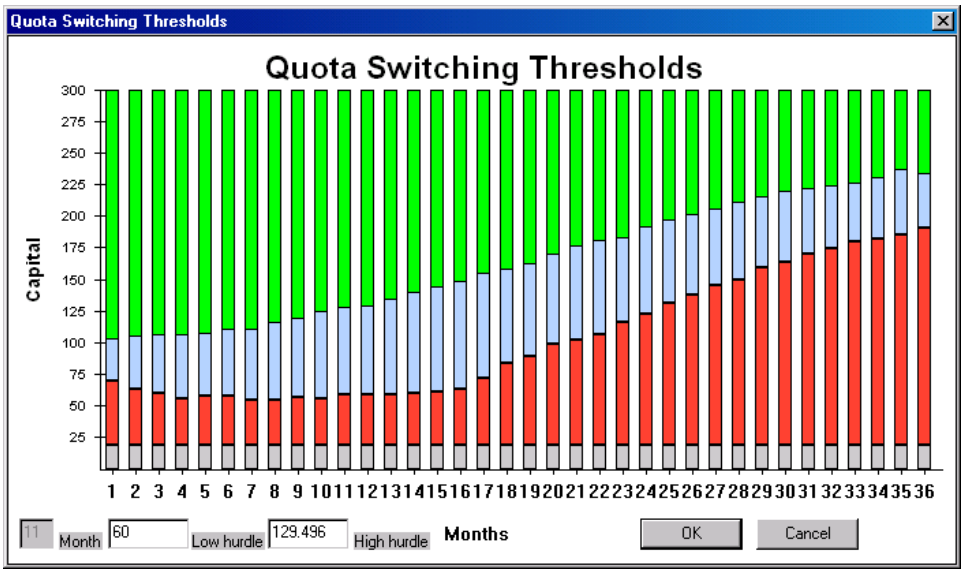

FIGURE 2. Quota Switching Thresholds.

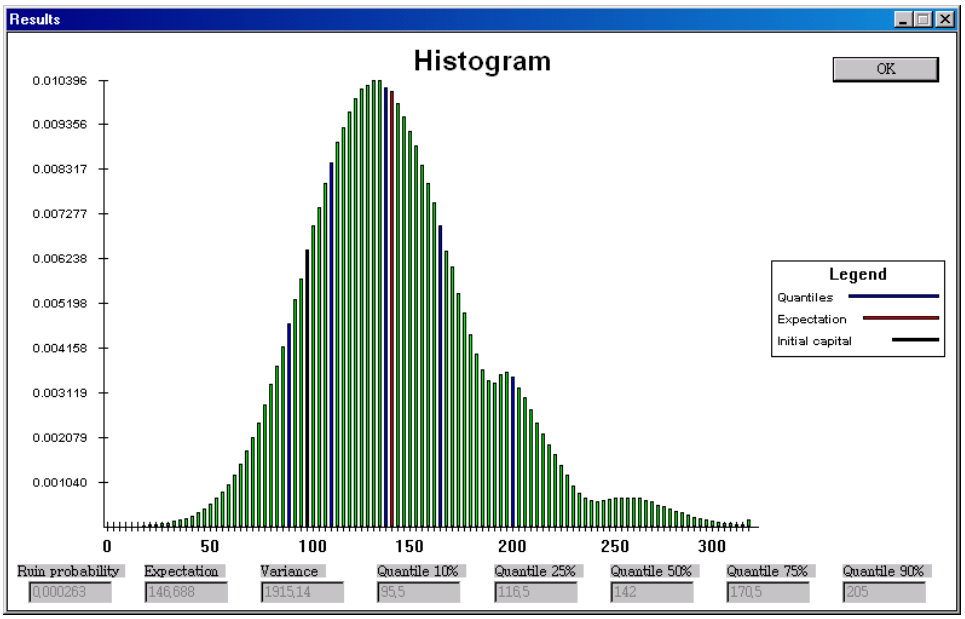

FIGURE 3. The distribution of capital in the end of simulation period (initial capital is equal to 100).

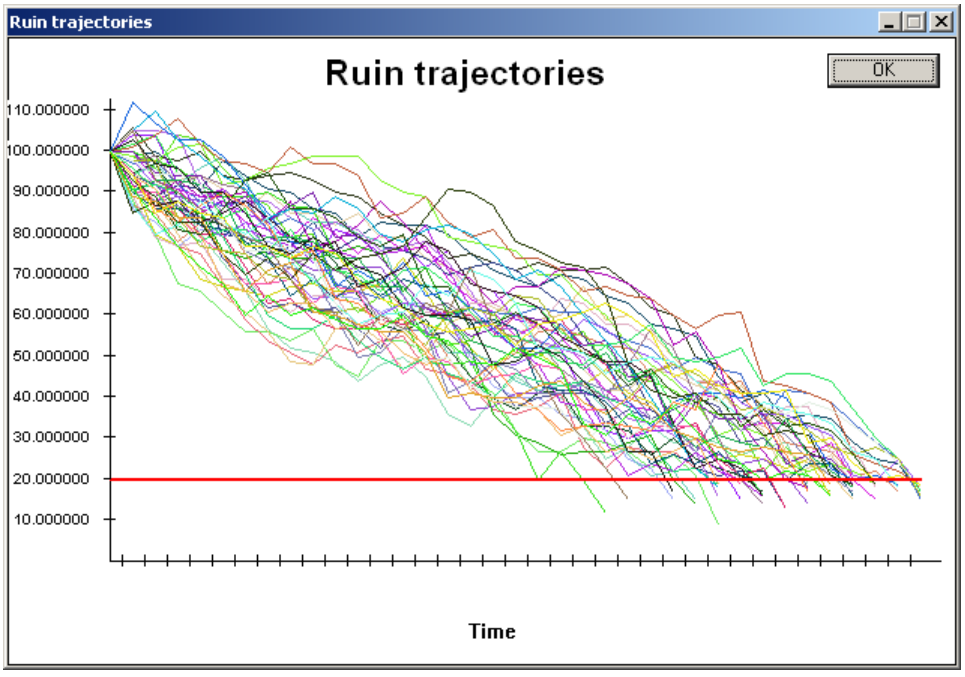

FIGURE 4. The overall picture of the patch of ruin trajectories.

5. Applications

SMIB is a pilot program system. It can be used in research studies of functioning of insurance companies directed to finding of optimal dynamic strategies of investments. Experimental studies realised so far show very interesting and non-trivial results. In particular computer experiments show that non-linear character of non-stationary threshold investment strategies sharply impacts the resulting distribution of capital. It can be highly non-symmetric, multi-modal and display non-trivial tail effects. It is not out of picture to note that SMIB can also be used in studies of dynamical strategies of re-location of capitals in investment funds.

In context of practical implementation of the program SMIB can be considered as a prototype of advanced program tool that can be used by experts in insurance companies and investment funds and other financial institutions. It is already used in the course on actuarial mathematics within the Master programme "Analytical Finance" introduced at the Mälardalen University in 2001.

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