A SHORT NOTE ABOUT FORECASTING NATCAT RESERVES USING THE CIR² MODEL

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In this note we highlight some features of the CIR² model we have developed, which is a generalised two-factor square root model (i.e. a model where, under certain conditions, both losses and volatility are positive and where volatility increases with the level of loss). In the framework we present, calculation of the mean and variance of loss are correlated processes; this is a new theoretical approach, and difficult to implement insofar as there are no closed-form solutions. This methodology is designed primarily for use by insurers and reinsurers that need to avoid high variation in their reserves; however, it could be extended to apply to any business that is exposed to extreme events and aims to preserve a stable cash flow to shareholders. In fact, though generalised linear models are common instruments in the pricing of non-life insurance contracts, they are inadequate for extreme claims. As such, the suggested model could be helpful for pricing in this instance.

Traditional techniques used to model the cost of natural catastrophes for insurance purposes apply probabilistic approaches, usually based on: geographically situated assets (e.g. density of population, houses, activities, infrastructure, etc.); damage functions that translate the impact into economic losses; hazards such as floods and earthquakes; and adaptation measures (e.g. seawalls, improved building codes, etc.). >

This approach may result in accurate estimates, but the granularity and volume of data it requires presents practical problems – in particular the difficulty of obtaining information spanning an extended time series.

Our alternative approach, which borrows from econometric analysis, uses a model that can analyse a single time series to not only predict losses themselves, but also their volatility. Considering volatility as a factor is of key importance, because NatCat activity is widely variable and occurs in non-Gaussian distributions; these characteristics also mean many sophisticated models give flawed results while simpler models – such as autoregressive or moving average (MA) – are more successful.

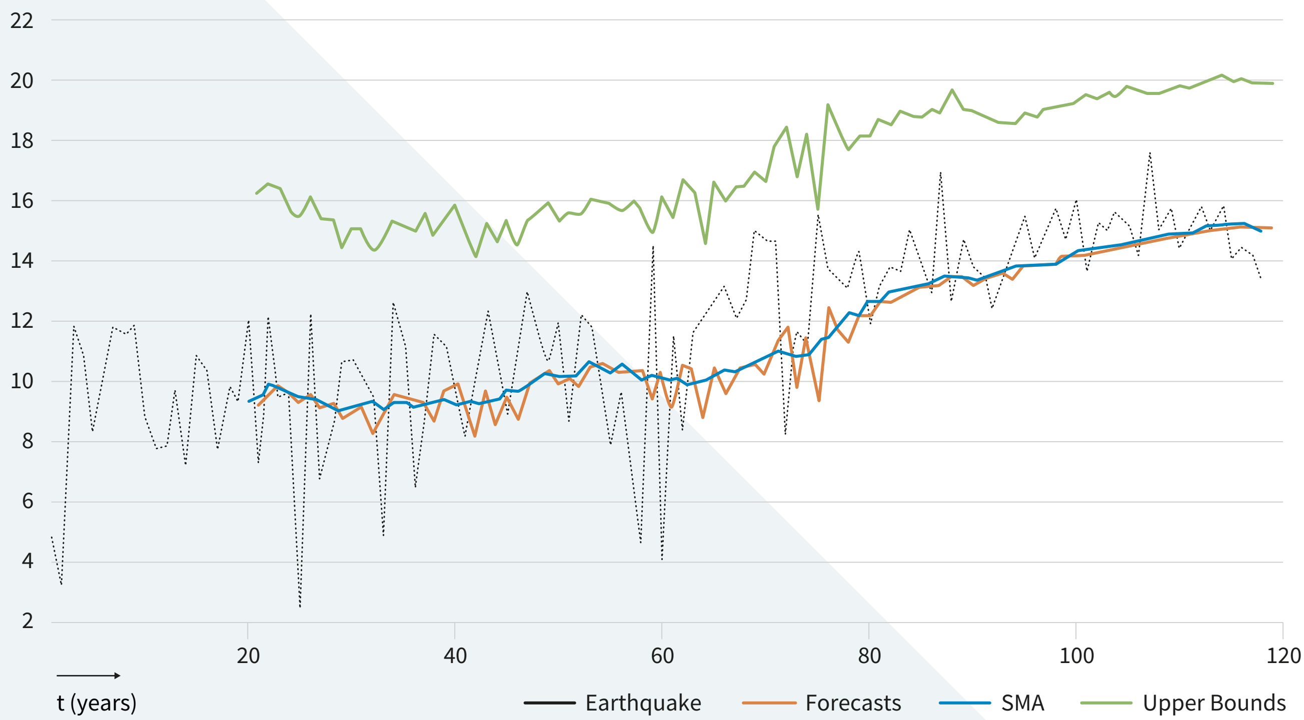
Furthermore, to protect the company against exceptional '*bad*' years, the model needs to be able to provide a reliable estimate of the maximum loss, and classic Value-at-Risk (VaR) approaches are not adequate for this. From the numerous models suitable for such an estimation, we have chosen a General Pareto Distribution (GPD) to calculate an upper limit for the maximum expected loss. The resulting estimate represents '*our*' value at risk and is referred to as VaRGPD.

To conclude, we demonstrate the accuracy of our results and the validity of the model by means of backtesting, using Kupiec (POF), Christoffersen (CC) and TUFF/TBFI tests.

The CIR^2 parameters are first calibrated over a '*training*'period, after which expected loss, volatility and maximal loss are regularly forecasted over a given horizon. Estimates are available with horizons of 1, 5, 10 and 15 years. *Figure 1* shows an example, with the log losses of the natural disaster (dotted black line) displayed over a time series of 120 years with a 1-year horizon. For calibration here, we used a rolling >

FIGURE 1: EARTHQUAKE FORECASTS

The dotted black line shows the log losses of the natural disaster Xt; the blue line is its (ex-post) SMA; the orange line represents the corresponding forecasts xF; finally, the green line refers to the upper bound VaRGPD. Out-of-sample forecasts.



20-year window to estimate the first triplet of values representing loss, volatility and maximal loss for the next year. Iterating this procedure through the full time series (120 years long) produced forecasts for the remaining 100 years. NatCat loss behaviour is rather erratic and difficult to anticipate, but insurers need to make estimates of the expected cost for a selected horizon. Shown in blue on the graph, the simple moving average (SMA) is calculated based on actual occurrences. The red line represents our forecast values, along with the upper boundary in green. For this last value we used the VaR obtained using the GPD method mentioned above. The graph shows that the CIR² forecast line is not only fairly close to the ex-post SMA but also, with a single exception over the whole period, is always above the peaks of actual losses realised.

As well as the data represented in figure 1, we also applied the CIR² model to 5-year, 10-year and 15-year horizons and analysed the resulting forecasts against actual results (*see figure 2*).

For the 1-year horizon, all forecasts were out-of-sample. As expected, the longer the horizon, the higher the error. However it should be noted that although for drought the error is almost 50% higher when comparing a 5-year horizon with a 15-year horizon, for earthquakes or extreme temperature the increase is much smaller.

One limitation of the proposed approach is that, while for some hazards (e.g. earthquake, storm and flood) long-term forecasts are limited within a certain range, for others (e.g. flood and extreme temperature) predictions suffer larger margins of error.

DISCLAIMER

As the intent of this note is to provide a very high-level summary, additional information can be found at the following link: **Forecasting reserving of NatCat with the CIR 2 model.** <

FIGURE 2