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Quantitative models for operational risk: Extremes, dependence and aggregation

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Abstract

Due to the new regulatory guidelines known as Basel II for banking and Solvency 2 for insurance, the financial industry is looking for qualitative approaches to and quantitative models for operational risk. Whereas a full quantitative approach may never be achieved, in this paper we present some techniques from probability and statistics which no doubt will prove useful in any quantitative modelling environment. The techniques discussed are advanced peaks over threshold modelling, the construction of dependent loss processes and the establishment of bounds for risk measures under partial information, and can be applied to other areas of quantitative risk management.[1]

JEL classification: C.14; G.10; G.21

Keywords: Copula; Dependence; Fréchet class problems; Generalized Pareto distribution; Mass transportation; Operational risk; Peaks over threshold; Point process; Risk aggregation; Statistics of extremes

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1. Introduction

Managing risk lies at the heart of the financial services industry. Regulatory frameworks, such as Basel II for banking and Solvency 2 for insurance, mandate a focus on operational risk. In the Basel framework, operational risk is defined as the risk of loss resulting from inadequate or failed internal processes, people and systems or from external events. This definition includes legal risk, but excludes strategic and reputational risk. A fast growing literature exists on the various aspects of operational risk modelling; see for instance Cruz (2002, 2004) and King (2001) for some textbook treatments. For a discussion very much in line with our paper, see Chapter 10 in McNeil et al. (2005).

In this paper we discuss some of the more recent stochastic methodology which may be useful towards the quantitative analysis of *certain types* of operational loss data. We stress the "certain types" in the previous sentence. Indeed, not all operational risk data lend themselves easily to a full quantitative analysis. For example, legal risk defies a precise quantitative analysis much more than, say, damage to physical assets. The analytic methods discussed cover a broad range of issues which may eventually enter in the development of an advanced measurement approach, AMA in the language of Basel II. Moreover, in the case of market and credit risk, we have witnessed a flurry of scientific activity around the various regulatory guidelines. Examples include the work on an axiomatic approach to risk measures and the development of advanced rating models for credit risk. This feedback from practice to theory can also be expected in the area of operational risk. Our paper shows some potential areas of future research. Under the AMA approach, banks will have to integrate internal data with relevant external loss data, account for stress scenarios, and include in the modelling process factors which reflect the business environment and the internal control system; see EBK (2005). Moreover, the resulting risk capital must correspond to a 99.9%-quantile (VaR) of the aggregated loss data over the period of a year. Concerning correlation, no specific rules are given (for instance within EBK, 2005) beyond the statement that explicit and implicit correlation assumptions between operational loss events as well as loss random variables used have to be plausible and need to be well founded.

In Section 2, we first present some more advanced techniques from the realm of extreme value theory (EVT). EVT is considered as a useful set of tools for analyzing rare events; several of the operational risk classes exhibit properties which in natural way call for an EVT analysis. To the ongoing discussion on the use of EVT, we add some techniques which could address non-stationarity in (some of) the underlying data.

In Section 3 we turn to the issue of dependence modelling. In a first instance, we assume no dependence information is given and, using the operational risk data introduced in Section 2, work out the so-called worst-VaR case for the aggregate data.

In Section 4, we then turn to the problem of modelling the interdependence between various operational risk processes. Here, several approaches are possible. We concentrate on one approach showing how copula-based techniques can be used to model dependent loss processes which are of the compound Poisson type. As already stated above, there is so far no agreement on how to model correlation. The methodology we offer is sufficiently general and contains many of the approaches already found in the literature on operational risk as special cases. This section puts some of these developments in a more structured context and indicates how future research on this important topic may develop further.