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MEASURING THE OPERATIONAL COMPONENT OF CATASTROPHIC RISK: MODELLING AND CONTEXT ANALYSIS

Abstract

Recent debacles in the financial industry are a reminder that although risk management tools have greatly developed over the past 15 years, industry vulnerability has not declined proportionately. It is therefore necessary to develop models and approaches towards risk modelling that allow to pool together the experience of as many institutions as possible in order to increase the precision of such models. In our study we investigate how risk could be inferred from publicly available stock market data. Such data could be analysed in two dimensions. To explore the cross-sectional dimension we build on Allen and Bali (2007), refining their estimation procedure. We also explore the time-series dimension by investigating how markets price data loss episodes – a class of operational events that is especially interesting given the difficulties encountered in measuring their impact using standard approaches.

1 Introduction

In order to survive extreme losses banks are required to maintain enough capital that should allow them to survive adverse years with probability of at least 99.9%. Capital requirement is set based on institution’s exposure to credit, market and operational risk.
In this research we focus on methods to estimate economic and regulatory capital for operational risk. Achieving the high level of precision required by Basel II necessitates the efficient combination of various data sources for risk analysis – internally collected loss data, expert evaluations (scenario analysis), loss experience of peer banks (external loss data). Directive 2006/48/EC\(^1\) explicitly mandates the use of external data to estimate the probability and impact of rare, yet severe, loss events:

“The credit institution's operational risk measurement system shall use relevant external data, especially when there is reason to believe that the credit institution is exposed to infrequent, yet potentially severe, losses. A credit institution must have a systematic process for determining the situations for which external data must be used and the methodologies used to incorporate the data in its measurement system.” (Directive 2006/48/EC, Annex X, Part 3, Sec. 1.2.3)

There are two inter-related types of information an analyst aims to extract from external data: the frequency of large losses, and the severity of large losses. The purpose of this research is to critically assess how different sources of external loss experience can be used to in the estimation of frequency and severity of large losses to the satisfaction of the requirements of directive 2006/48/EC.

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\(^1\) The implementation of Basel II in European Communities (EC) member countries is laid down in community directives 2006/48/EC on taking up and pursuit of the business of credit institutions, and 2006/49/EC on the capital adequacy of investment firms and credit institutions.
Available external losses commonly used by financial institutions are data pools created by banks in order to build a shared operational loss database (e.g. ORX consortium), or publicly available loss reports gathered by external parties (e.g. Moody’s OpVantage). There is also a variety of models that infer risk from stock market data; many of these are based on event studies. Another interesting variant of the latter approach has recently been pursued by Allen and Bali (2007) that employs extremes of stock returns to estimate loss exposure. We demonstrate that both event studies and cross-sectional analysis could provide valuable insights into the severity of rare, extreme losses.

2 Context

Basel II provided a positive list of what is considered operational risk: “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” (Para.644). This definition is now the de facto standard definition of operational risk.

Compared to comprehensive definitions, the Basel II definition excludes strategic and reputational risks. This omission was arguably due not to some fundamental reason but to the lack of a concept how to assess those risks and how to translate that assessment into a capital requirement. However, the still ongoing financial turmoil clearly supports the use of a more comprehensive definition for internal economic and regulatory capital measurement.

An interesting direction of research is risk inference based stock market data. Such research has often focused on stock market responses to various events. In operational risk context it
tends to discover overreaction of stock prices to announcements of certain types of losses – usually ones that might imply failed processes or deliberate misrepresentation of financial performance. A plausible explanation of is that the overreaction is due to asymmetric information between issuers and investors; the latter could not know if a loss announcement is due to an one-off event or due to flawed processes that could result in uncovering further losses. Hence the stock’s risk premium increases, which in turn results in overreaction. Therefore, the overreaction could be interpreted as a reputational loss.

The impact of information security-related events has been investigated by a number of authors (e.g. Garg et al., 2003; Campbell et al., 2003; Cavusoglu et al., 2004; Acquisti et al., 2006; Gatzlaff and McCullough, 2008) who find that there is statistically significant negative stock response to information security (IS) breaches. Breach severity is found to depend on type of the lost data, sector of the company, type of breach, and Tobin’s Q.

There are a number of studies that have investigated stock market response to operational losses and various events that are included under the title of or intertwined with operational risk. Perry and de Fontnouvelle (2005) examine the stock market response to operational losses and find that there is statistically significant response to loss announcements. Where the stock market response exceeds the actual loss amount, the difference is interpreted as constituting reputational loss. They find that reputational loss depends on the type of loss and shareholder rights. Response to external events generally is not found to trigger reputational loss, while for events involving insider fraud reputational effect is equal or greater than the accounting loss.
Cummins et al. (2006) also find statistically significant response to operational loss announcements. Response to losses is found to be larger for insurance companies compared to banks. Response is found to exceed the amount of loss, implying that operational losses convey information on future earnings. Cruz (2002) proposes a model of inferring reputational value at risk from stock price changes and apply it to loss incidents in Daiwa, Nomura and NatWest. He finds a ratio between market response and underlying loss of 1.8, 12.5 and 73.3 respectively.

In the cross-sectional view, Allen and Bali (2007) quantify catastrophic risk by assuming that stock returns in a given month come from a common distribution. They then measure the tail risk by fitting those returns to a parametric distribution and by using extreme value theory. Operational risk is defined as idiosyncratic risk and is quantified by analysing abnormal returns from a multifactor model.

We contribute to these studies by exploring stock market reaction to data loss incidents in financial institutions. We classify data loss incidents to Basel II event types and we find a strong, statistically significant response to external fraud incidents. Unlike other insider fraud incidents, in data loss context the impact of internal fraud is found to be insignificant. Incidents falling in the domain of execution, delivery and process management are not found to be statistically significant although the negative mean response at various horizons tips that such response might be present but difficult to validate statistically in smaller samples.

We also refine the procedure in Allen and Bali (2007) for evaluation of catastrophic and operational value at risk, and estimate the modified specification using information on European
financial institutions spanning major turmoil episodes (Asian and Russian financial crises, dot com bubble, 9/11, sub-prime lending losses); the reader is referred to Serguieva et al. (2008) for details.

3 Methodology

3.1 Event study

Event studies are an established approach to analysis of the implication of various events. We use a single factor model (the market model) to estimate the expected returns on each stock. The specification relates the daily returns on a particular stock to a stock market index:

\[ r_{it} = \alpha_i + \beta_i r_{mt} + \epsilon_{it}, \text{var}(\epsilon_{it}) = \sigma_i \]

where \( r_{it} \) is the daily log-return on stock \( i \), \( r_{mt} \) is the daily log-return on the market index. The coefficients alpha and beta are estimated using ordinary least squares (OLS) regression. The estimation period starts one year before the event and ends 22 calendar days before the event. Abnormal returns \( AR_{it} \) are calculated as the difference between the actual and predicted stock returns, using the estimates for alpha and beta obtained from the estimation period:

\[ AR_{it} = r_{it} - \hat{r}_{it} = r_{it} - \hat{\alpha}_i - \hat{\beta}_i r_{mt} \]

If the data loss incident has no market impact, \( AR_{it} \) should be expected to be mean zero random variable, with normal or close to normal probability distribution. This hypothesis is tested using a parametric Z-test and the non-parametric binomial sign test.
3.2 Cross sectional analysis

Tail risk is estimated using results from extreme value theory (EVT), a branch of statistics that studies the probability distribution of rare, extreme events. In our study, we employ the peaks over threshold (POT) approach in order to estimate the high quantiles of monthly catastrophic and operational losses.

Suppose that $F(X)$ is the distribution of a random variable $X$, and let us denote the conditional distribution of the excesses $(X - u)$ over a threshold $u$ as $F_u(y) = P(X - u \geq y | X > u)$. The major proposition in the POT approach is that when $u \to \infty$ then $F_u(y) \to G(y)$, where $G(y)$ is a member of the (two-parameter) Generalised Pareto Distribution (GPD) family:

$$G_{\xi,\sigma}(y) = \begin{cases} 1 - \left(1 + \frac{\xi y}{\sigma}\right)^{-1/\xi}, & \text{if } \xi \neq 0; \\ 1 - \exp\left(-y/\sigma\right), & \text{if } \xi = 0. \end{cases}$$

Here $y = X - u$ is the excess over the threshold $u$, $\sigma > 0$. Among the parameters of the GPD, $\xi$ is of particular interest since it controls the thickness of the tail. Distributions with $\xi > 0$ correspond to medium- ($\xi \leq 0.5$) and heavy tailed ($\xi > 0.5$) distributions.

4 Data

Our dataset comprises all shares or depository receipts of financial companies traded on the stock exchanges in the UK, Germany and France. In order to ensure homogeneity of the sample in terms of risk profile, we focus on issuers classified as Banks, Life insurance, or Non-
life insurance in our sample. Share prices and sector classification are collected from the Thompson’s Datastream database.

Event study is based on data from Open Security Foundation’s DatalossDB. Stock prices and financial information is obtained from Thompson One Banker and Yahoo Finance.

References


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