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CVaR measurement and operational risk management in commercial banks according to the peak value method of extreme value theory

Fengge Yao *, Hongmei Wen, Jiaqi Luan

Financial College, Harbin University of Commerce, Harbin 50028, China

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ABSTRACT

Management of operational risk is of prime importance in risk management for commercial banks, and many theoretical and practical studies of operational risk management have been carried out. Conditional value-at-risk (CVaR) models based on the peak value method of extreme value theory are used here to measure operational risk. Loss data for commercial banks are used in an empirical analysis. Tests are carried out using a CVaR model to calculate VaR and CVaR at 95% and 99% confidence levels to assess expected and unexpected losses for operational risks.

1. Introduction and literature review

The importance of operational risk attracted international attention at the end of the 20th century. The 1995 Barlin Bank Bankruptcy and other huge losses due to operational risk shocked management and academia [1]. According to a survey of members of the British Bank Association, 67% ranked operational risk as equally or even more significant compared to credit risks. Research by the World Bank has shown that one of the most frequent causes of bankruptcy in the global banking industry is operational risk. In fact, operational risk is now one of the most threatening factors faced by financial institutions [2]. With the development of the banking industry, the scale of banks is ballooning, complexity and trade volumes are increasing, new models (such as internet banks, electronic trading) are emerging, trade instruments and financial technologies are becoming increasingly complicated, clearing and settlement systems are expanding, information technology is commonly applied, outsourcing is escalating, and new risks are inevitable. These realities increase the operational risks faced by financial institutions, so more detailed studies of operational risk management on theoretical and empirical levels are required. In addition to qualitative management of operational risks, more risk estimation models are applied in research. Measurement methods such as factor analysis, loss distribution, value at risk (VaR) models, revenue models, and volatility models are maturing [3].

Chinese commercial banks have been slow in considering operational risks. However, reports in the mass media on cases involving huge losses arising from operational risk have highlighted the importance of operational risk management for financial regulatory bodies and the banking industry in China. In March 2005, the China Banking Regulatory Commission (CBRC) published clearly defined operational risks and proposed 13 relevant suggestions [4]. In May 2007, the CBRC defined operational risks for Chinese banks, listed factors in risk management systems, and provided detailed requirements for management of operational risk [5]. Although in the coming years commercial banks in China will still operate under the Basel Agreement of 1988, in the short term, they do not need to worry about allocating capital for operational risk [6]. The CBRC has clearly pointed out that under the shifting competition pattern of the international financial industry, the Chinese banking industry will have to research the management of operational risk as soon as possible. In 2007, the CBRC pointed

* Corresponding author.
E-mail addresses: yfg1971@yahoo.com.cn (F. Yao), wen-hm@163.com (H. Wen).

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out that "large commercial banks with affiliates in other countries and areas and with international business accounting for a large part of their revenue should operate under the Basel New Capital Accord". In December 2009, the CBRC published validation guidelines for measurement of commercial bank capital, which clarified the testing range, included advanced methods and supporting systems for capital econometrics, and covered an internal rating system for credit risks and internal models of market risks [7]. Although the large banks in China are still in the early stages of operational risk management, with scanty data for operational risk losses (ORLs) and quantitative techniques, some of them have stated that the standard method will be replaced by the advanced method for measurement of operational risks in 3–5 years after application of the Basel New Capital Accord. Thus, management of operational risks will move to a higher criterion in China. As the risks facing commercial banks become complicated and volatile, Chinese commercial banks will have to further research relevant theories, regulations and practical applications to construct efficient operational risk management models to measure and control operational risks.

As operational risk requirements became more rigorous, some international banks proposed risk measurement models. However, there is no unified econometric model in the banking industry. Major models for operational risks were researched and developed by banks individually. Because of differences in internal historical data for each bank, judgments on the possibilities and losses for operational risks are diverse. A bank chooses methods according to its own conditions. The first supporters of quantitative measurement of operational risks were Cremonino and Giorgino [8] and Wilson [9]. They believed that operational risks can be calculated by VaR as credit risks. By constructing a database of internal and external ORLs and estimating the loss distribution at a confidence level of 95%, a company can obtain the VaR of operational risks and carry out pressure tests. Cruz et al. formally defined operational risk VaR (OpVaR) and used a series of statistical techniques to estimate losses due to operational risks [10]. Since then the VaR model has been the core model for operational risks. However, there are some defects in the VaR model. It does not consider the risk in the distribution tails, where losses may exceed the VaR. Furthermore, it does not satisfy time additivity. Artzner et al. used the expected shortfall to estimate losses exceeding the expected VaR as a coincidence indicator for risk measurement [11]. Rockafeller and Uryasev defined conditional value risk as the mean loss over VaR to overcome the failure to reflect loss at the distribution tail [12]. In addition, it provides a risk optimization method. The authors discussed equation definitions, traits and calculations. They presented a sample CVaR approach and partial portfolio optimization when asset profits fulfill a normal distribution and studied a CVaR model when losses fulfill a general distribution. Nikolas et al. used CVaR to analyze asset deployment in an empirical study and compared the mean absolute deviation (MAD) [13]. This method increases the application scope of CVaR from market risk to measurement of diverse risks, and laid the foundation for use of CVaR for operation risk [13].

The loss distribution method is believed to be the most complicated, rigorous and risk-sensitive econometric method. It has a high technology content and an autonomous model and is widely used by large international banks for econometric analyses. However, financial disasters due to operational risks with low probability are so scanty that it is difficult to construct suitable models, since distributions estimated by the usual statistical methods do not reliably reflect the tail distribution for ORLs. Therefore, McNeil [14] and Medova and Kyriacon [15] used the extreme value method to deal with operational risks. Gençay and Selçuk found that loss data were confined to a fat tail distribution, whereas the traditional distribution failed to consider the extreme situation and thus underestimated operational risks [16]. The extreme value theory (EVT) peaks over threshold (POT) model uses samples exceeding a certain threshold to construct a formula. This is an effective method in practice as it utilizes limited extreme observations [17]. Di Clemente and Romano explained how to introduce operational risk models and analysis methods into a risk management system and used an operational risk EVT model [18]. Mignola and Ugoccioni applied EVT in an empirical analysis of operational risks and proposed that measurement of operational risk relied on the shape, scale, and position characteristics of loss distributions [19]. Embrechts (2004, 2006) combined VaR with EVT to measure operational risks in practice [20]. However, EVT is not a general application. Discrepancies such as upward slope issues can arise for small samples. In addition, there are some problems when simply using VaR and EVT together when the operational risk exceeds a critical level [21]. Since 2004, researchers have tried to improve EVT to obtain more precise extreme values and to calculate the capital required to cover operational risks. Moscadelli derived a distribution function for operational losses above a certain critical level, and calculated the expected loss above the expected threshold using an extra function and adjusted coefficients for the sample mean as a reference for capital operational risk [22]. Credit Suisse used a credit risk model for quantitative analysis of operational risks [23].

Chinese academics have also researched operational risks for commercial banks using quantitative models in empirical analyses, and some have discussed the application of VaR and EVT in such research. Chen et al. discussed use of a pressure test and EVT in an extremely volatile context and their application in risk management [24]. Gao used an extreme value method to analyze the tail of the ORL distribution [25]. Considering the fat tail of the ORL distribution and its coherence with loss issues, Yang used a single-variable EVT to construct a measurement model of a single loss issue and a multi-variable extreme value connective function to reflect correlation between the tail and loss issues to avoid underestimation of operational risk and overestimation of capital requirements [26]. Zhang and Zhang sampled the operational risk exposure issues of a Chinese state-owned commercial bank from 1988 to 2002 and used a POT model to assess VaR and ES values to calculate the economic capital required in one year to protect against operational risk exposure [27]. Gao and Li used EVT to calculate the extreme value of operational loss for Chinese commercial banks [28]. They applied an improved small-sample unbiased estimation Hill method (HKKP) to estimate the tail parameter for operational loss, and a minimum estimated accumulated possibility distribution, an experienced accumulated possibility distribution and mean square errors to obtain a relatively precise threshold value, and then estimated ORL points for a given confidence level. In addition, they used a