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The value of Value-at-Risk: A theoretical approach to the pricing and performance of risk measurement systems

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ABSTRACT

Risk-based capital adequacy requirements are the main tool employed by government regulators to assure bank stability. This approach allows banks to choose from a number of alternative methods for calculating the required capital. Many systems for measuring risk differ significantly in cost, precision, and in the potential "capital savings". We develop a statistical model for evaluating risk measurement systems and optimizing the selection process. The model is based on queuing theory. The selection of the optimal system is a function of available capital, the volume and the character of bank activity. While the most precise system may lower a bank's minimal capital reserve requirements, it is not necessarily the optimal system once total costs are evaluated.

1. Introduction

Regulators in many countries use capital adequacy requirements to control the stability of banks by restricting their exposure to risk. The initial Basel 1988 Capital Accord was based on a fixed ratio of risk-weighted assets (typically 8%) that should be financed by equity or equity-equivalent instruments. This accord has been adopted in most countries (Annual Report of BIS) and is designed to address credit risk. The original Capital Accord has been revised a few times since then. The revised capital adequacy framework is based on a more flexible approach to risk management in banking. As stated in the annual report of BIS, "While there is a continued focus on internationally active banks, the underlying

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principles should be suitable for application to banks of varying levels of complexity and sophistication in all countries".

The Basel 1988 Accord reflects credit risk and is applied somewhat arbitrarily to the whole portfolio with allowances for risk-weighting the asset categories. The Basel 1998 Accord recognizes a part of the portfolio as a trading book. A different approach is used for measuring the risk of this part, which is comprised of publicly traded assets. Internal models based on either standard or VaR based evaluation are allowed. The Basel 2 approach takes this one step further by allowing internal models for measuring (non-traded) credit risk. In the last few years BIS conducted a series of studies (QIS) in order to gauge the impact of the new approach on minimal capital requirements (MRC). We focus in this paper on the advantages of sophisticated models of risk measurement and specifically on the capital savings reflected in reducing MRC.

Minimal capital requirements are contingent primarily on risk assessment, which includes both market and credit risk measurement. In many countries the first part – market risk assessment – is already implemented. This means that banks employ internal models to quantify their market risk. The current regulatory framework gives banks greater discretion by allowing them to choose between the standard incremental risk and better tailored VaR-based approaches to risk management (see Jackson, Maude, and Perraudin (1997)).

VaR for capital requirements is measured as the lower 1% quantile of the Profit & Loss distribution over a 10-business day horizon. Models employed to calculate VaR vary between institutions both in terms of their sophistication and the risk factors used. This measure became very popular during the last decade; particularly in view of the "capital savings" it affords financial institutions. In general, adoption of the VaR approach has enabled banks to meet capital adequacy requirements with capital reserves of less than the standard 8%. However, the measure itself has several problems, such as the lack of sub-additivity.[1] Moreover, the methods used for calculating VaR are based on different assumptions, and often produce results with low precision. Banks may pay dearly for over-simplification and risk incurring regulatory surcharges for inaccurate internal models. In spite of these shortcomings, there remains a general consensus that the correct approach to capital adequacy is based on probability distribution rather than an arbitrary rule of a thumb, such as the flat 8% of assets mandated in the original 1988 Basel Accord. The goal of this paper is not to compare the different approaches of risk measurement, but rather to price the added value to a bank from using an internal model for risk measurement. Our model quantifies the benefit of lowering the minimal capital requirements for a given level of risk against the cost of developing and employing a risk measurement system. There are many ways to implement VaR. They vary in cost and in their degree of precision. Similarly, the capital savings derived from employing VaR vary across institutions and the specific models employed. An optimal choice regarding risk measurement systems, therefore, is contingent on the capitalization of a bank, and the type of primary activity in which the bank engages. In this paper we propose a model for optimizing the selection of a risk measurement system.

The list of available software for measuring risk is long and constantly growing (see for example Kates (2000) for a comparison of 50 different systems). These programs calculate the required capital according to the standard model or according to the P & L distribution. The implementation of an effective risk management system should improve the bank's performance, i.e. allow for better risk diversification and more precise hedging.

From the standpoint of the bank, an optimal decision weighs the costs required in developing or purchasing such a system against performance benefits. A different approach based on the optimisation of the capital structure of a financial firm, is described in Shepheard-Walwyn and Litterman (1998). Many ready-to-use systems are currently available: CARMA, RiskWatch, RiskMetrics, Four Fifteen, Outlook, TARGA, Kamakura and Panorama, to mention a few. The prices of the software vary from a few thousand dollars a year for lower-end products to millions of dollars a year for the upper end. In addition to the initial investment, the costs of implementation, updates, databases, salaries and other expenses can contribute significantly to the total cost of ownership (see Spain (2000)).

[1] An alternative measure of risk which avoids this problem can be based on the expected loss among the lowest quantile, see Artzner, Delbaen, Eber, and Heath (1999), also Artzner (1999).