Finance Research Letters 000 (2015) 1–10

Contents lists available at ScienceDirect

Finance Research Letters

journal homepage: www.elsevier.com/locate/frl

Efficient estimation of unconditional capital by Monte Carlo simulation☆

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ARTICLE INFO

Article history:
Received 3 July 2015
Accepted 16 October 2015
Available online xxx

JEL Classification:
C58
G17
G21
G32

Keywords:
Capital estimation
Charge-off
Credit risk
Monte Carlo simulation
Unconditional capital

ABSTRACT

We address the problem of determining the unconditional capital required by a credit portfolio using Monte Carlo simulation. By elaborating on a tractable analytical framework, we propose a new efficient simulation algorithm that overweights recession periods, which are the most important periods for determining the final capital figure, thereby improving its efficiency for a given number of simulations. We discuss the optimality and practical advantages of this algorithm. We also conduct an empirical analysis based on American charge-off data, which shows that the proposed algorithm achieves remarkable improvements in efficiency, without introducing any bias and at a negligible implementation cost.

1. Introduction

In this note, we consider a practical problem related to the determination of the capital required by the credit portfolio of a bank, i.e., its estimation by Monte Carlo simulation. Monte Carlo capital estimation is a simple, effective, and widely used method for estimating the capital requirements of credit portfolios,

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http://dx.doi.org/10.1016/j.frl.2015.10.010
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BCBS (2009). It is more versatile than the standard analytical approximations, such as those discussed by Glasserman (2004b), but it usually incurs a significant computational cost. An efficient simulation algorithm reduces the variability of the estimator for a given number of simulations without introducing any bias or increasing the computational cost compared with the standard Monte Carlo simulation.

Improving the efficiency of Monte Carlo simulation methods for capital estimation has been a major concern for banks and it has attracted significant attention, as discussed in the overview of Glasserman (2004a). Due to the wide range of loss distributions that banks use in their capital models, the problem has been approached mainly from a common framework, Glasserman and Li (2005) and Glasserman et al. (2008), although some studies have aimed to tackle less general formulations, particularly in terms of the underlying correlation structure, Bassamboo et al. (2008) and Chan and Kroese (2010). In this note, we also consider a more specific capital estimation problem by restricting the scope to the case of the unconditional loss variable, thereby taking advantage of its specific features. To the best of our knowledge, this is the first study to focus exclusively on this specific loss variable.

The unconditional loss random variable does not represent a specific economic scenario, but instead it captures a long-term risk profile. In this note, the unconditional loss variable is assumed to be formed as an equally weighted mixture of conditional loss variables, which represent different economic scenarios, i.e., recessions and expansions, as described in Bangia et al. (2002), Pederzoli and Torricelli (2005), Bruche and González-Aguado (2010), and Rodriguez and Trucharte (2007).

We propose a new simulation algorithm based on the idea of drawing more values from the conditional loss variables related to recession periods, which are the most important periods involved in the determination of the final capital figure. Thus, the values in the tail of the unconditional loss variable are generated more often, thereby improving the efficiency of the estimation. We derive the optimal simulation weights and discuss the practical advantages of the algorithm.

We also present the results of an empirical analysis based on American charge-offs data for six different portfolios. The results showed that (i) the optimal simulation weights follow a cyclical pattern and they are only significantly greater than zero during the recession periods, especially during the Great Recession, thereby making them useful for signaling and ranking crisis; and (ii) the proposed simulation algorithm achieves a large average reduction close to 77% in the standard deviation of the classic capital estimator.

The remainder of this paper is organized as follows. In Section 2, we present the analytical framework that forms the basis of this study. In Section 3, we introduce and discuss the proposed efficient Monte Carlo simulation algorithm. In Section 4, we present the empirical results. Finally, we give our conclusions in Section 5. Appendix A contains the proof of the result obtained in Section 3.

2. Analytical framework

We employ a standard formulation for the credit loss model, see Frey and McNeil (2002), Gordy (2003) and Carey (2002). Our starting point is a continuous credit loss random variable L, $L \geq 0$. L represents the loss generated by a credit portfolio during a given time horizon. For the sake of simplicity, we focus only on the stand-alone case, i.e., we do not consider the aggregated loss random variable for all the credit portfolios of the bank, although our analysis can easily be extended in this manner.

L is given by the following expression:

$$L = eH, \tag{1}$$

where e is the current total volume of credit exposure for the portfolio and H is a charge-off rate random variable. H represents the percentage of the portfolio exposure that defaults and it is not recovered during the time horizon. Therefore, H comprises both the probability of default and the loss given default. H has support in (01) because it models a charge-off rate, whereas L has support in $(0e)$ because it models a charge-off loss.

We are interested in the unconditional distribution of credit losses, which represents a long-term scenario instead of a specific economic environment. Therefore, H represents an unconditional charge-off rate random variable. Following Bangia et al. (2002), Pederzoli and Torricelli (2005), Bruche and González-Aguado (2010), and Rodriguez and Trucharte (2007), we obtain the unconditional loss variable by aggregating different conditional loss variables. Thus, H is defined as an equally weighted mixture (or simply a mixture) of conditional charge-off rate variables. In Bangia et al. (2002), these conditional variables rep-