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Contagion effect on bond portfolio risk measures in a hybrid credit risk model

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ABSTRACT

This paper illustrates how modelling the contagion effect among assets of a given bond portfolio changes the risk perception associated to it. This empirical work is developed in a hybrid credit risk framework that incorporates recovery rate risk. Dependence structures among firms and between external shocks affecting firms together are considered. The presence of correlations among firm leverage ratios and the interrelation between default probabilities and recovery rates produces clusters of defaults with low recovery rates. This has a major impact on standard risk measures such as Value-at-Risk and conditional tail expectation. Consequently, an appropriate measurement of the contagion has a tremendous effect on the capital requirement of many financial institutions.

1. Introduction

Credit risk has two main components: the possibility of default and uncertainty regarding the recovered amount. Historically, the focus has been placed on default probabilities. Two major classes of models have been opposed. The structural models specify some dynamics for the firm asset value and default occurs whenever the latter hits some specified threshold derived from the firm's liabilities.

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Although appealing because it provides an intuitive understanding of the default trigger, this approach is not readily applicable. Firstly, the market values of the firm's assets and liabilities are not observable, which complicates the estimation procedure. Secondly, many models in this family assume that the asset value dynamics are modelled using a diffusion process. This implies that the default time is predictable, which does not match the observed credit spreads, which are in turn much wider than those arising from the modelling methodology. In response to these issues, a series of reduced-form models have been proposed including the seminal work of Jarrow and Turnbull (1992, 1995) and Duffie and Singleton (1999). It is assumed that an unobservable intensity process drives the default. Consequently, default arises as a surprise, and estimation/calibration techniques allow for a good replication of observed credit spreads and credit-sensitive derivatives. However, proponents of the structural approach argue that this methodology lacks financial intuition.

Recently, many hybrid credit risk models have been proposed to reconcile structural and reduced-form approaches. One major class of this literature is based on how the information available to investors is modelled. In opposition to the structural models, the assumption of complete information is relaxed and default loses its predictability. A non-exhaustive list of contributions includes Duffie and Lando (2001), Jarrow and Protter (2004), Çetin et al. (2004), Giesecke (2004) and Giesecke and Goldberg (2004). Another class of hybrid models constructs intensity processes that depend on structural variables allowing for economic/financial interpretation of default. Madan and Unal (2000), Chen et al. (2004), Bakshi et al. (2006), Boudreault et al. (in press), among others, belongs to this class of models.

When it comes to portfolios, it is important to take into account the dependence that may exist between credit events. Initially, attention was focused on default contagion. More specifically, a large number of publications have focused on how the default of one firm can affect other firms' likelihood of default. Originally, two methods have been favoured and can be applied regardless of whether the base model belongs to the class of structural models or reduced-form approaches. The first methodology involves introducing common factors in the processes responsible for default triggers. A non-exhaustive list of contributions includes Schönbucher (2000), Duffie and Gârleanu (2001), Andersen and Sidenius (2004), and professional models such as Moody's-KMV (by Moody's) and CreditMetrics (by RiskMetrics, formerly owned by J.P. Morgan). The second approach uses a copula to create a dependence between default times. Contributions in this area include Li (2000), Schönbucher and Schubert (2001) and Laurent and Gregory (2005). Some of the papers of the first category can be rewritten as a copula-based approach.

Contrary to the bottom-up approaches presented above, the top-down approaches, arising more recently, consist in modelling the portfolio losses, viewed as a whole instead of specifying a model for each obligor/firm entity. Usually, defaults are triggered by a self-excited cumulative intensity process, which implies that defaults occur in clusters. However, default events are not related to particular obligors/firms and, consequently, require additional assumptions in order to compute portfolio losses. Errais et al. (2010) and Dassios and Zhao (2011) figure among this category.

One key contribution of this paper is to measure how contagion affects not only default time, but also recovery rates. Therefore, the chosen methodology is a bottom-up approach based on the hybrid model of Boudreault et al. (in press) in which the default probability and the recovery rate are functions of the firm's leverage ratio. It induces an inversely proportional relationship between default probabilities and recovery rates that is present in empirical studies[2]: highly rated firms have low default probabilities and high recovery rates.

Below, we enhance Boudreault et al.'s (in press) single-firm framework to capture the contagion risk present in a multi-firm framework. A first layer of dependence is achieved by correlating the leverage ratios. The second dependence structure arises from the surprise elements present in the reduced-form framework. Adding interrelations among them may be interpreted as a common shock that affects many firms simultaneously.

Modelling contagion among credit-sensitive assets is only the first step toward a good risk-management strategy. The second step is to measure the contagion. Since defaults are rare events, direct

[2] Altman and Kishore (1996), Altman et al. (2004) and Altman (2006).