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Bayesian inference for generalized linear mixed models of portfolio credit risk

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Abstract

The aims of this paper are threefold. First, we highlight the usefulness of generalized linear mixed models (GLMMs) in the modelling of portfolio credit default risk. The GLMM-setting allows for a flexible specification of the systematic portfolio risk in terms of observed *fixed effects* and unobserved *random effects*, in order to explain the phenomena of default dependence and time-inhomogeneity in historical default data. Second, we show that computational Bayesian techniques such as the *Gibbs sampler* can be successfully applied to fit models with serially correlated random effects, which are special instances of *state space models*. Third, we provide an empirical study using Standard and Poor's data on U.S. firms. A model incorporating rating category and sector effects, and a macroeconomic proxy variable for state-of-the-economy suggests the presence of a residual, cyclical, latent component in the systematic risk.

JEL classification: G31; G11; C15
Keywords: Credit risk; Generalized linear mixed model; State space model; Bayesian inference

1. Introduction

It is well accepted that credit default events show dependence. A first observation supporting this view is that default intensities seem to vary over time according to economic cycles. This can be seen in Fig. 1, which is based on six-monthly default data from Standard and Poor's (S&P) for

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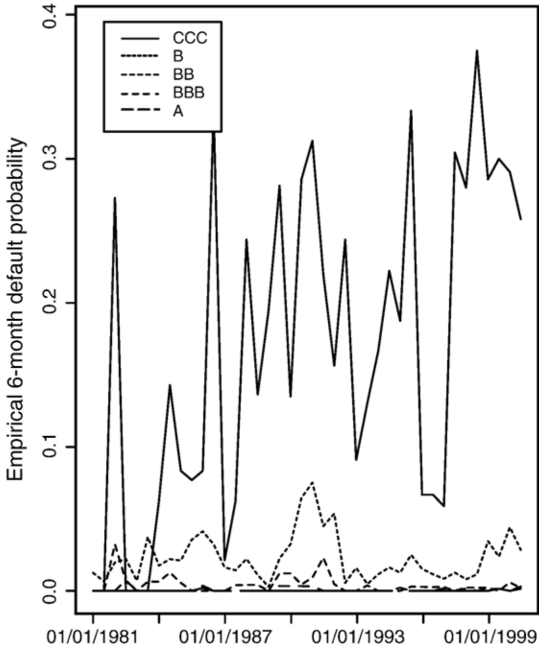

Fig. 1. Empirical bi-annual default rates according to Standard and Poor's for 20 years (U.S. obligors only). Note the cyclic behaviour of the B- and BB-default rates. (The CCC-class is very noisy due to its relatively small size.)

the years 1981–2000. Periods with many defaults are in general preceded and followed by other periods with many defaults, and this is particularly evident for B- and BB-rated companies. A second source of dependence is direct business liaisons between obligors, so-called contagion, meaning that a company may itself face increased risk if one of its major customers defaults; see for instance Egloff et al. (2004). Capturing the dependence is of immediate interest to financial institutions lending money or holding credit-risky investments, since a disproportionally large number of defaults over a fixed time horizon may have severe consequences.

On the one hand, we require statistical models of default that address the issue of *cross-sectional dependence* in default rates within a time period due to common economic conditions (the so-called *systematic risk*). On the other hand, we aim to capture *serial dependence* caused by the cyclical behaviour of economic factors. The starting point for most portfolio credit risk models is that, conditionally on the systematic risk, defaults occur independently. A key concern of ours will therefore be the systematic risk.

Several empirical studies, such as Nickell et al. (2000) and Bangia et al. (2002), have verified time variation in default rates, and confirmed that this time variation may to some extent be explained by observed macroeconomic variables. Unfortunately, observed variables as proxies for the systematic risk are seldom completely satisfactory. The first important issue is the identification of appropriate proxies. Moreover, there may also be a lag between the cycle of a proxy variable and that of the default activity, and this lag may vary stochastically over time. Mastering the lags is of critical importance for regulatory purposes, so that banks do not, for instance, lower their capital levels in an apparent upswing of the economy.

The above shortcomings can be remedied by allowing for unobserved (latent) systematic risk components that capture the residual systematic risk once any observed parts have been