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Analyzing the impact of credit migration in a portfolio setting

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ABSTRACT

Credit migration is an essential component of credit portfolio modeling. In this paper, we outline a framework for gauging the effects of credit migration on portfolio risk measurements. For a typical loan portfolio, we find credit migration can explain as much as 51% of volatility and 35% of economic capital. We compare through-the-cycle migration effects, implied by agency rating transitions, with point-in-time migration, implied by EDF™ (Expected Default Frequency) transitions, and find that migration of point-in-time credit quality accounts for a greater fraction of total portfolio risk when compared with through-the-cycle dynamics. In a stylized analytic setting, we show that, when controlling for PD term structure effects, higher likelihood of moving away from the current credit state does not necessarily imply greater risk. Finally, we review methods for generating high-frequency transition matrices, needed for analyzing instruments with cash flows or contingencies whose frequencies are asynchronous to an available transition matrix. We further demonstrate that the naïve application of such methods can result in material deviations to portfolio analytics.

1. Introduction

Recent turmoil in the capital markets has led to a sharp rise in the number of negative rating actions taken by the leading rating agencies, signaling a deterioration in the credit quality of firms affected by adverse economic conditions. These credit quality dynamics highlight the importance of credit migration modeling as an integral part of modern credit risk solutions. Credit migration models play a vital role in pricing credit-risky instruments, as well as in assessing the risk of credit portfolios. Many credit instruments exhibit cash flows contingent on the credit quality of the reference entity, either implicitly, e.g., a prepayment option on a loan, which may be exercised in the event of improved credit quality of the borrower, or explicitly, e.g., a loan with grid pricing, which ties the contractual loan spread to the credit quality of the borrower. Pricing such credit-contingent cash flows requires a credit migration model. Further, to estimate the risk associated with a credit instrument or a portfolio, a credit migration model is needed to build a distribution of values at the analysis horizon.

Most practical credit risk models typically employ a discretized representation of credit qualities and utilize a finite-state Markov model, which posits that the probability of migrating to another credit state in the future does not depend on the past.[1] In a discrete-time framework, parameterizing a credit migration model amounts to estimating a Markov transition matrix, populated with migration probabilities over a specified time period. In a continuous-time framework, a generator matrix can be estimated, allowing for forecasts over any time horizon.

Parameterization of a Markovian credit migration model with an appropriate transition matrix is an important step in the specification of a credit risk model. Within the context of a credit portfolio management (CPM) framework, common considerations affecting the choice of a transition matrix include:

- *Asset class/industry/domicile*: A number of studies document the fact that rating transitions vary according to the industry or regional classification of the obligor, see, for example, Nickell et al. (2000) or Kadam and Lenk (2008). Depending on the granularity of the model, portfolio managers may choose to employ a custom transition matrix that is industry- or region-specific or estimated for a particular asset class.
- *Through-the-cycle vs. point-in-time*: Since agency ratings are considered through-the-cycle measures of credit quality (Cantor and Mann, 2003; Altman and Rijken, 2004), portfolio

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[1] Recently, in light of empirical evidence suggesting a non-Markovian behavior of credit rating migration, some researchers have considered alternative models; see, e.g., Frydman and Schuermann (2008).

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managers whom want to gain a long-term view of portfolio risk often employ a rating transition matrix as the driver of credit migration. Further, as Livingston et al. (2008) and Hill et al. (2010) document, different agencies' credit ratings may imply different migration patterns, suggesting that managers take into consideration the particular agency data used. Alternatively, we can use point-in-time measures of credit quality, such as Moody's Analytics EDF credit measure, to estimate a model that provides a more dynamic view of credit migration.

Since credit migration is a fundamental component of a CPM model, it is important to understand to what extent different migration matrices impact measures of portfolio risk. In particular, if portfolio risk is sensitive to the choice of a specific migration model, we must take care to ensure that portfolio statistics are driven by economically meaningful data, rather than by numerical artifacts or estimation noise.

While the literature on credit migration is plentiful, relatively little work addresses the parameterization of a credit migration model or the impact of credit migration on portfolio risk. Bangia et al. (2002) estimate transition matrices during economic expansion and contraction periods. They show that the loss distribution and economic capital of a synthetic bond portfolio vary significantly in different economic environments. Trück and Rachev (2005a) draw similar conclusions, finding that migration matrices estimated at different points of the business cycle produce significantly different VaR measures for a test portfolio. Further, they find a more dramatic impact on the confidence sets of estimated default probabilities. The experimental results documented in these papers suggest that the migration matrix choice can have a significant impact on the risk analysis of the portfolio.

Realizing the need for a quantitative measure of difference between credit migration matrices, several authors propose distance measures that aim to capture economically significant differences. Jafry and Schuermann (2004) develop a metric for comparing migration matrices based on singular values (closely related to the induced matrix 2-norm) and use it to compare different methods of estimating migration probabilities. They demonstrate that under their proposed metric, statistically significant differences between transition matrices result in material differences in the economic capital of a fictitious bond portfolio. In related work, Trück and Rachev (2005b) suggest a class of so-called directed difference indices as a measure of distance between transition matrices. They demonstrate that their proposed measures exhibit high correlation with differences in credit VaR, indicating that these measures capture economically significant differences in migration dynamics.

This paper complements existing work in three main areas. First, we construct a class of low-dimensional migration matrices parameterized by a varying diagonal element, and show that when the default probability term structure remains unchanged, increasing the probability mass assigned to the diagonal results in non-monotonic behavior of the volatility of the value distribution at the analysis horizon. This example supports observations made in Jafry and Schuermann (2004) and Trück and Rachev (2005b), that the diagonal dominance of a matrix, often a used as a visual indicator for the inherent "riskiness" of a migration matrix, is not a sufficient characteristic of migration risk. This example also highlights the interplay between default risk and migration risk implied by a transition matrix. Second, we propose a framework for measuring the portion of portfolio risk attributable to credit migration, which facilitates comparison of the impact of different transition matrices on portfolio risk. In contrast to the distance measures outlined in Jafry and Schuermann (2004) or Trück and Rachev (2005b), our framework yields a portfolio-referent distance measure. Further, our framework allows for decoupling of default risk and migration risk. We employ this framework to study the differences between two migration models, one based on agency ratings, and the other based on the EDF credit measure. We find that credit migration explains a significant portion of the risk attributed to a test portfolio, and that migration of point-in-time credit quality, measured by EDF transition rates, accounts for a greater fraction of total portfolio risk when compared with through-the-cycle dynamics reflected by agency rating migrations. The third contribution lies in studying the performance of numerical algorithms for generation of high-frequency transition matrices from an annual matrix. We demonstrate that in some cases, application of such methods results in distortions to the implied annual transition probabilities and, consequently, to the calculated risk measures as well.

The remainder of this paper is organized as follows: Section 2 offers an overview of credit migration in the context of credit portfolio analysis. Section 3 describes a stylized analytic example that illustrates the behavior of an instrument's volatility in value as a function of migration probabilities. Section 4 details a framework to measure migration impact on portfolio risk, which can be applied to compare the migration effects of two different migration models. We use this framework to contrast EDF-based migration with rating-based migration. Section 5 discusses the problem of generating high-frequency transition matrices from an annual transition matrix. We describe two numerical algorithms for this purpose and demonstrate their performance when applied to a rating transition matrix and an EDF credit measure transition matrix. Section 6 offers concluding remarks.

2. An overview of credit migration and portfolio risk

In this section, we review the foundations of a discrete-time, finite-state, homogenous Markov model of credit migration, and relate it to the estimation of a value distribution of a vanilla credit instrument. We present two commonly used transition matrices and highlight the challenges in comparing different views of migration in analyzing portfolio risk. The discussion lays a foundation for the analysis in subsequent sections, where we propose two approaches to studying the impact of credit migration on portfolio risk.

To begin, assume that the universe of credit qualities is represented by a set of K states, where the first state corresponds to the highest credit quality, and the Kth state corresponds to the default state. In a homogeneous Markov chain model, credit migration dynamics are fully specified through a transition matrix containing probabilities of moving from one credit state to another. Let T denote this migration matrix of dimensions $K \times K$, so that $T_{i,j}$ is the probability of moving from state i to state j in one period. Assume the Kth state, corresponding to default of the obligor, is absorbing; once an obligor is in default, it remains in default. Thus, the Kth row of the matrix contains zeros in all entries, except at the Kth entry, which equals one.

A credit migration model facilitates estimating a portfolio value distribution at the analysis horizon. For simplicity, we concentrate on a single vanilla instrument.[2] A discretized value distribution at horizon associates each credit state with a future value, as well as a probability of realizing it. We can calculate the latter directly from the migration matrix; by the Markovian property, if p_t is a vector containing probabilities of realizing each credit state at time t, then $p_{t+1} = T \cdot p_t$. We can calculate the former using risk-neutral valuation techniques; the value of the instrument at a horizon credit state is the expected value of future cash flows, calculated in the risk-neutral

[2] Credit migration plays an important role in the valuation of instruments with embedded options. However, the dynamics of option values warrant special consideration, outside the scope of this paper.