
Preface

The modeling and management of credit risk is the main topic within banks and other lending institutions. *Credit risk* refers to the risk of losses due to some credit event as, for example, the default of a counterparty. Thus, credit risk is associated with the possibility that an event may lead to some negative effects which would not generally be expected and which are unwanted. The main difficulties, when modeling credit risk, arise from the fact that default events are quite rare and that they occur unexpectedly. When, however, default events take place, they often lead to significant losses, the size of which is not known before default. Although default events occur very seldom, credit risk is, by definition, inherent in any payment obligation. Banks and other lending institutions usually suffer severe losses when in a short period of time the quality of the loan portfolio deteriorates significantly. Therefore, modern society relies on the smooth functioning of the banking and insurance systems and has a collective interest in the stability of such systems. There exist, however, several examples of large *derivative losses* like Orange County (1.7 billion US\$), Metallgesellschaft (1.3 billion US\$) or Barings (1 billion US\$), which took place between 1993 and 1996. These examples have increased the demand for regulation aiming at financial stability and prove that risk management is indeed a very important issue.

A particular form of credit risk is referred to as *concentration risk*. Concentration risks in credit portfolios arise from an unequal distribution of loans to single borrowers (*name concentration*) or industrial or regional sectors (*sector* or *country concentration*). In addition, certain dependencies between different borrowers can increase the credit risk in a portfolio since the default of one borrower can cause the default of a dependent second borrower. This effect is called *default contagion* and is linked to both name and sector concentration.

Historical experience shows that concentration of risk in asset portfolios has been one of the major causes of bank distress. In the 1980s banks in Texas and Oklahoma suffered severe losses in both corporate and commercial

real estate lending due to significant concentrations of lending in the energy industry. Moreover, the regional dependence on oil caused strong correlation between the health of the energy industry and local demand for commercial real estate. In the last years, the failures of large borrowers like Enron, Worldcom and Parmalat were the source of sizeable losses in a number of banks. Furthermore, the relevance of concentration risk is demonstrated by the recent developments in conjunction with the *subprime mortgage crisis*, which started in the United States in late 2006 and turned into a global financial crisis during 2007 and 2008. Subprime refers to loans granted to borrowers of low credit-worthiness. In the United States many borrowers speculated on rising housing prices and assumed mortgages with the intention to profitably refinance them later on. However, housing prices started to drop in 2006 and 2007 so that refinancing became increasingly difficult and, finally, lead to several defaults. Many mortgage lenders had used securitization methods as, for example, mortgage-backed securities (MBSs) or collateralized debt obligations (CDOs). Thereby the credit risk associated with subprime lending had been distributed broadly to corporate, individual and institutional investors holding these MBSs and CDOs. High mortgage payment defaults then lead to significant losses for financial institutions, accumulating to US\$170 billion in March 2008. The crisis had spread worldwide. In Germany, for example, the IKB Deutsche Industriebank suffered dramatic losses from the subprime market downturn, leading to a bail out in August 2007. This also points out the importance of an effective measurement and management of concentration risk. Within the subprime or mortgage sector, loans are highly correlated and defaults spread quickly by contagion effects.

In addition to these examples, the amount of specific rules, which are imposed by the supervisory authorities to control concentration of risks, shows the importance of diversification of loan portfolios with respect to regions, countries and industries. These examples, rules and the ongoing research demonstrate that it is essential for the evaluation and management of a bank's credit risk to identify and measure concentration of risks within a portfolio.

It is the aim of these lecture notes to reflect the recent developments in research on concentration risk and default contagion both from an academic and from a supervisory perspective. After a short introduction to credit risk in general, we study in Part I several important model-based approaches which allow banks to compute a probability distribution of credit losses at portfolio level. Being the precursor of the asset-value models, the famous *Merton model* is discussed in some detail. Based on this approach we present some of the most prominent industry models to capture portfolio credit risk, namely *CreditMetrics* of J.P. Morgan [77] and *PortfolioManager* of KMV [84]. Moreover, as a representative of the class of *reduced-form* or *mixture models*, we discuss the *CreditRisk⁺* model of Credit Suisse [30]. Besides these industry models, we also study the *Internal Ratings Based* (IRB) approach, on which

Basel II is based. These models then provide a basis for measuring concentration risks, which will be the main task of Part II. Here, we also give a short overview of simple ad-hoc measures for the quantification of concentration risk in credit portfolios. For a decent measurement of concentration risk, however, model-based approaches are preferable. Thus, most of Part II deals with different methods for the measurement of name and sector concentration in credit portfolios. Part III focusses on the topic of default contagion which is linked to both name and sector concentration risk. Here we can distinguish mainly three classes of approaches; the *copula models*, methods from *interacting particle systems* and *equilibrium models*. We give an overview over the different approaches for the treatment of default contagion and discuss the similarities between these methodologies. The book is intended to reflect the current state of research in the area of concentration risk and default contagion. While discussing potential drawbacks of some of the approaches, we also give an outlook in which direction research in this area can lead in future.

These lecture notes were developed when I gave a PhD course on financial economics at the University of Bonn. They are intended for mathematicians as well as for economists having a profound background in probability theory. I have included an introduction to credit risk modeling in Part I to keep this book as self-contained as possible. In Parts II and III, I focus on the main ideas behind the presented approaches. Therefore, I try to avoid some of the technicalities while maintaining mathematical precision. For detailed proofs of some of the statements I refer to the original papers presented.

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