

# Melbourne Centre for Financial Studies Academic Research Grant

## The Relation between Asset Volatility, Credit Quality and Recover

Dr Harald Scheule, Senior Lecturer Finance, The University of Melbourne

### 1. Abstract

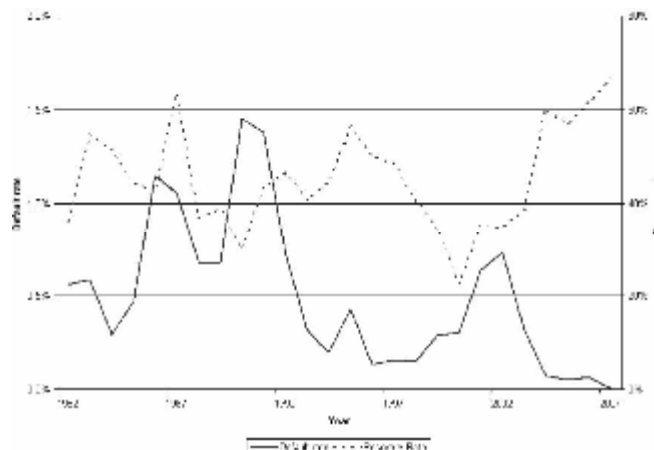
Most industry credit portfolio risk models are based on various isolated modules for default probabilities and recoveries in the event of default. However, empirical evidence suggests a negative relation between both. The proposed project will develop a single framework which derives credit risk parameters simultaneously in a simple asset value model. It explicitly accounts for i) dependencies between the parameters and ii) the fact that recoveries can only be observed after a default event. An empirical analysis will link bond recoveries with credit ratings and subordination levels and will provide evidence for the relationship between asset volatility, credit quality and recovery rate. Implications on the economic and regulatory capital of financial institutions will be shown.

The proposed project will assist to solve the industry difficulties in the measurement and management of credit risks. The recent turmoil in relation to US sub-prime mortgage loans has shown that the assumption of independence between the likelihood and severity dimension of credit risk leads to a tremendous underestimation of credit portfolio risk.

Australian financial institutions are heavily exposed to financial risk in relation to mortgage loans. The project will provide financial institutions and regulators with the statistical concept and empirical models to forecast future credit losses. It may lead to an improvement of current models applied for calculating specific and general provisions, regulatory capital as well as validation of these models. As a result, the accuracy and therefore capability to cover future losses of Australian financial institutions may improve. This will contribute to the stability to the financial system and maintain the functions which financial institutions provide in Australia

### 2. Background and aims of project

The current US-sub-prime mortgage crisis highlights that during economic downturns, default and recovery rates of multiple borrowers generally deteriorate jointly. The following chart shows that default and recovery rates for US bond issues are negatively correlated and that economic downturns occurred in 1991 (First Gulf War) and 2001/02 (World Trade Centre terrorist attack and downturn in the Internet Economy):



Unfortunately, contemporary credit risk models are based on isolated modules for default probabilities and recoveries in the event of default. As a result, future credit portfolio losses may be severely underestimated and as a response to this shortcoming, the proposed project will develop a single framework which derives credit risk parameters simultaneously in an asset value model. It explicitly accounts for i) dependencies between the parameters and ii) the fact that recoveries can only be observed after the occurrence of a default event. An empirical analysis will link bond recoveries with credit ratings and subordination levels and will provide evidence for the relationship between asset volatility, credit quality and recovery rate. Implications on the economic and regulatory capital of financial institutions will be shown.

The project will extend work by Pykhtin (2003) by empirically parameterizing a sample selection model. It includes observable idiosyncratic as well as unobservable systematic information. More specifically, the following contributions will be made:

- All input parameters of common credit portfolio risk models such as probabilities of default, expected losses given default or asset correlations will be modelled within one consistent framework. Examples for well known credit portfolio models are CreditRisk+ (Credit Suisse Financial Products 1997) and CreditMetrics (Gupton et al. 1997). Newer applications in relation to collateralized debt obligations are VECTOR from Fitch rating agency (see Fitch Ratings 2006), CDOROM from Moody's rating agency (see Moody's 2006) and CDO Evaluator from Standard and Poor's rating agency (see Standard & Poor's 2005). The specification of a dependence structure between different random variables will be solved endogenously. Previously, correlations were measured by external models for default events (compare e.g., Lucas 1995, Dietsch & Petey 2004, Hamerle et al. 2006, Frey & McNeil 2002, 2003, Roesch & Scheule 2004, Roesch 2005, McNeil & Wendin 2007) and between the default events and related recoveries (compare e.g., Frye 2000, Pykhtin 2003, Tasche 2004, Duellmann & Trapp 2005, Roesch & Scheule 2005). In other words, the proposed approach no longer requires the specification of correlations between the various random variables.
- The proposed approach overcomes the shortcoming of existing approaches that models which estimate the parameters in separate modules are subject to a miss-specification - generally an underestimation of credit portfolio risk, which results from the omission of elements of the association structure (compare Altman et al. 2006). The most prominent example for such a miss-specification are the recent proposals by the Basel Committee on Banking Supervision (2006) which are also known as Basel II.
- In a first-in-kind model, credit portfolio risk will be solely explained by observed historic recovery rates. In contrast to market values for debt or equity, recovery rates are generally observable for past borrower defaults. This approach will be particularly useful for retail loans. The majority of commercial banks' loan portfolios consist of mortgage loans for which rich recovery histories are available.
- The mathematical model set-up builds upon Pykhtin (2003) and additional perspectives of the model will be offered. Firstly, the model will be derived within an economic firm value model and therefore the parameters, e.g., the asset volatility of the model, will be interpreted within the context of this framework. An explicit relation between default probability, expected recovery and asset return volatility will be derived. Secondly, a parameter estimation algorithm will be developed. Due to the simplicity of the model, the estimation will involve a limited number of parameters and is therefore subject to a low degree of model risk. Thirdly, the parameterization of the model will be extended to include observable risk drivers. Thus, determinants of default probabilities and recoveries may be explicitly identified.

### **3. Description of Approach**

Following early work by Merton (1974), the default process can be modelled by the firm value, where a default occurs if the value of a firm falls below the value of debt.

In this setting it can be shown that the probability of default is equal to:

$$\Phi(-\text{Distance to Default})$$

where  $\Phi$  is the cumulative density function of the standard normal distribution and the Distance to Default is a function of the firm value, volatility of the firm value, value of debt, interest rate and time.

Similarly, it can be shown that the recovery rate given default is equal to the minimum of the ratio of the firm value to the debt value and one.

This framework can be transferred to a classical Tobit model (compare Tobin, 1958) which links the realisation of a firm's asset value process, i.e., available observed recovery rates (RR) to explanatory information. In this setting, the natural logarithm of the recovery rate is

$$\ln(RR_{it}) = \min(Y_{it}, 0)$$

with

$$Y_{it} = a + bx_{it-1} + gz_{it}$$

Note that  $y_{it} < 0$  implies the default of a borrower.

In other words, given historic recoveries (and related default events), the implied asset value process may be linked to

- i) observable idiosyncratic and systematic information ( $x$ ) and
- ii) random idiosyncratic and systematic variables ( $z$ ). Examples for observable information are proxies for liquidity, profitability or leverage of borrowers as well as proxies for the growth and development of the economy. In contrast to these observations, random variables reflect the degree to which information explaining credit portfolio losses is not available. The random idiosyncratic and systematic variables ( $z$ ) are assumed to be independent and identically standard normally distributed.

The estimated parameters can then be used to derive parameters for the credit quality of borrowers such as the probability of default, recovery rate, asset volatility, and correlation as well as the quality of credit portfolios such as Expected Loss and Value-at-Risk. Closed formulas for these measures will be provided.

The project comprises four consecutive steps which will be scheduled throughout a one-year period:

- **Step 1 (six months): Model development and simulation study**  
The random-effect Tobit model requires the Maximum Likelihood estimation of the parameters. This operation can be solved numerically using adaptive Gauss-Hermite-quadrature (compare Pinheiro & Bates 1995, Rabe-Hesketh et al. 2002). As a result, the models will be developed within a simulation study which ascertains the consistency and asymptotic normal distribution of the parameter estimates. Closed formulas for the probabilities of default, recovery rates, asset volatilities, asset correlations, Expected Losses and Value-at-Risk will be derived.
- **Step 2 (one month): Data preparation**  
The proposed project intends to merge credit ratings purchased from Standard and Poor's rating agency (see budget section) and bond price data. The historic recovery rate may be defined as the ratio between the bond price after 30 days of the occurrence of a default and the par value of the bond. Historic bond prices are available through the database Bloomberg to which the Department of Finance of the University of Melbourne subscribes. The dynamic behaviour of recovery implied asset return volatilities, correlations and their determinants will be analysed.
- **Step 3 (four months): Estimation of random-effect Tobit models**  
The empirical models will be estimated and values for the probabilities of default, recovery rates, asset volatilities, asset correlations, Expected Losses and Value-at-Risk derived.

- **Step 4 (one month): Analysis of implications on economic and regulatory capital**  
Models with different degrees of information will lead to different economic and regulatory capital. This link will be investigated in detail.

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