

Review of Analytical methods of analysing credit risk

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Main Concepts:

- Credit risk – arises from the potential that a borrower or counterparty will fail to perform on an obligation; money will be owed but not repaid (Van Gestel & Baesens, 2009). Three types of credit risk: default risk, country risk and concentration risk.
- Default – means there has been delayed or missed payment of interest

Main concepts:

Two ways of measuring default risk:

- Rely on rating agencies (Moody's, S&P). For

exa

Moody's		S&P		Fitch		
Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	
Aaa	P-1	AAA	A-1+	AAA	F1+	Prime
Aa1		AA+		AA+		High grade
Aa2		AA		AA		
Aa3		AA-		AA-		
A1	P-2	A+	A-1	A+	F1	Upper medium grade
A2		A		A		
A3		A-		A-		
Baa1		BBB+		BBB+		
Baa2	P-3	BBB	A-3	BBB	F3	Lower medium grade
Baa3		BBB-		BBB-		
Ba1		BB+		B		
Ba2	BB	BB				
Ba3	BB-	BB-				
B1	B+	B+				
B2	B	B				
B3	B-	B-				
Caa1	Not prime	CCC+	C		CCC	C
Caa2		CCC		Extremely speculative		
Caa3		CCC-		Default imminent with little prospect for recovery		
Ca		CC				
C		C				
/		D		/		
/	DD					
/			D			

Main concepts:

- The other way is to apply credit risk models
- Bond- debt investment in which an investor loans money to an entity (corporate in my case of the research) which borrows the funds for a specific period of time at a fixed/changing interest rate.

Aims of the research:

- To give an overview and critical comparison of primary credit risk models based on theoretical and empirical approach
- To give an extension of one of the existing models
- To give an attempt of designing a new model for credit risk measurement

Objectives of the research :

- To evaluate the existing approaches of credit risk measurement through analytical analysis and by giving comparison of models based on observation of weak and strong sides of each approach
- To show how effective the models are in measurement and reduction of credit risk

- To develop an empirical model that describes the relationship between credit risk of a financial institution and its determinants
(STATA, MonteCarlo Simulation, MATLAB, EIKON, Linear Regression, DataStream are used)
- To apply credit risk models to UK banking sector and test the validity of each model using corporate bonds data

- to develop a new prototype of an analytical model of measuring credit risk by discovering new horizons in the area of credit risk and extending one of the existing models
- To show why statistical analysis is important in quantification of the potential losses to reduce credit risk based on an empirical evidence
- To consider future forecasts of developing

an effective credit risk management is a critical success for financial institutions in order to prevent potential bank capital losses and possible bankruptcy

Credit risk analysis through analytical modeling has attracted researchers for many years. However, due to the difficulty of validation of the models further additional research is still required

Motivation

I would like to make a potential contribution to the existing knowledge in credit risk analysis area, possibly by developing a new model by means of mathematical tools

My academic background: to combine mathematical and financial skills in one research

Literature review: theoretical approach

1. 1st approach

BIS method

a) Basel I (1988) – focuses on credit risk and risk-weighting of assets (RWA), banks require to hold 8% of RWA.

b) Basel II (2004) – consists of three pillars:

- Minimum Capital Requirement (MCR)

Capital ratio = total capital/(credit risk + market risk+ operational risk)

- Supervisory Review Process (SRP)
- Market Discipline (MD)

Also, Basel II consists of Standardized approach (STD) and the internal-ratings-based approach (IRB). IRB consists of Foundation IRB and Advanced IRB approach.

c) Basel III (2009, first version) – framework on capital adequacy, stress testing and market liquidity risk

2. 2nd approach

a) CreditPortfolioView – proposed by McKinsey

- a discrete multi-period model where default probabilities depend on the condition of macro-variables (Crouhy et al, 2000).

Probability of default = $f(\text{GDP, unemployment rate, ..., exchange rate})$.

- a multi-factor model, simulates joint conditional distribution of default and migration probabilities for various rating groups in different industries (Crouhy et al, 2000)

- b) CreditMetrics** – proposed by JPMorgan
- estimation of credit rating migration likelihoods, probability of moving from one credit quality to another including default
 - uses Binomial distribution: calculation of the change in asset value for each borrower and testing for default (Koyluoglu and Hickman, 1998)
 - use of Monte-Carlo simulation – to calculate credit VAR
 - originates from Merton model (1974)
 - Credit risk estimation through volatility of value estimation

c) **CreditRisk⁺** -released by Credit Suisse Group

- no assumption of the cause of the default
- default rates are continuous random variables
- default distribution $\Gamma[\alpha_k, \beta_k]$ follows Poisson Distribution with probability density function:

$$P(x \leq X \leq x+dx) = f(x)dx = [e^{(-X/\beta)} x^{(\alpha-1)} dx] / \beta^{(\alpha)} \Gamma(\alpha)$$

- calculation of volatility σ_k of default rate

3. 3rd approach

a) Structural models

(i) Merton model,

$$V_E = V_A N(d_1) - e^{-r(T-t)} D N(d_2),$$

(ii) Black-Cox set-up

$$P[T \leq T | T > t] = N(h_1) + \exp \{2(r - \sigma^2/2) * \\ * \ln(K/V_t) / \sigma^2\} N(h_2), \text{ where}$$

$$h_1 = [\ln(K/e^{r(T-t)} V_t) + \sigma^2 2(T-t)] / [\sigma T-t] \text{ and}$$

$$h_2 = h_1 - \sigma T-t.$$

(iii) KMV approach

$$V_E = f(V_A, \sigma_A, K, c, r), \quad \sigma_E = g(V_A, \sigma_A, K, c, r),$$

(iv) Time-changed Brownian motion (TCBM)

– modeling of a firm's asset value process and the firm's time of default (Hurd, 2009).

$$L_t = X_{G_t}, t \geq 0.$$

Here TCBM is generated by X and G .

b) Reduced-form models

(i) Hull-White model – assumes short rates have a normal distribution and that they are subject to mean reversion

one-factor case:

$$dr_t = (\theta(t) - ar_t - \eta(t)v(t,u))dt + \eta(t)dW_t$$

two-factor case:

$$dr(t) = (\theta(t) + u(t) - ar(t))dt + \sigma(t)dW_1(t)$$

$$du(t) = -b \cdot u(t)dt + \sigma_2(t)dW_2(t) \text{ where } dW_1(t)dW_2(t) = \rho dt.$$

(ii) Jarrow-Turnbull model – calculates Bond Default Rate and pricing of Credit Default Swap

$$Df_0(t,u) = \alpha_0(t,u)dt + \sigma(t,u)dW_1(t)$$

Gap in the research:



Gap :

1. Software to measure and test credit risk improves on constant basis so research becomes deeper and develops as well
2. Validation of analytical models is difficult as they rely on a timeframe of one or more years. As a result, longer period and high confidence level which created difficulty in assessing the

accuracy of models. So the search for effective new credit risk models is on-going

3. The previous research didn't provide any evidence on testing CreditPortfolioView, CreditRisk+, KMV and CreditMetrics models on UK bond market in order to give a comparison and check the validity of the approaches.

Research questions:

1. To give an overview and critical comparison of existing primary industry models for credit risk analysis (CreditPortfolioView, KMV, CreditRisk+, CreditMetrics):
 - a) to evaluate each model based on the research carried out before?
 - b) what models are more effective in credit risk analysis and to what extent?

- c) Check the validity of each model,
how these models reduce the risk?
- 2. how could some of the models be
extended in order to reduce potential
losses for financial institutions?
 - a) my own contribution to the
development and expansion of one of
the models
 - b) construction of a new prototype
analytical model using the data from
UK
banking sector

3. How important is to measure credit risk using mathematical approach and why is it necessary to implement new models to analyse credit risk in application to corporate bonds? What are future forecasts of doing so?

Proposed data collection:

- Collection of secondary data, primarily in theoretical part of literature review
- Collection of primary data, can be seen in empirical part of literature review

Proposed data collection cont.:

- Data collection can mainly supply **quantitative data** in my research, especially when testing credit risk models on UK corporate bonds' data. Here the approach is formal and structured, techniques used are mainly tests and calculations, responses are numerical and outcomes can be quantified and objective (based on data received)

Proposed data collection-data sources:

DATASTREAM (THOMSON REUTERS) & Bloomberg for bond indices & credit default data, **EIKON** for pricing data, historical actuals and forward looking estimates)

Credit rating agencies' data: S & P annual reports, Moody's Corporate default database, Moody's Investors services (on bond rating)

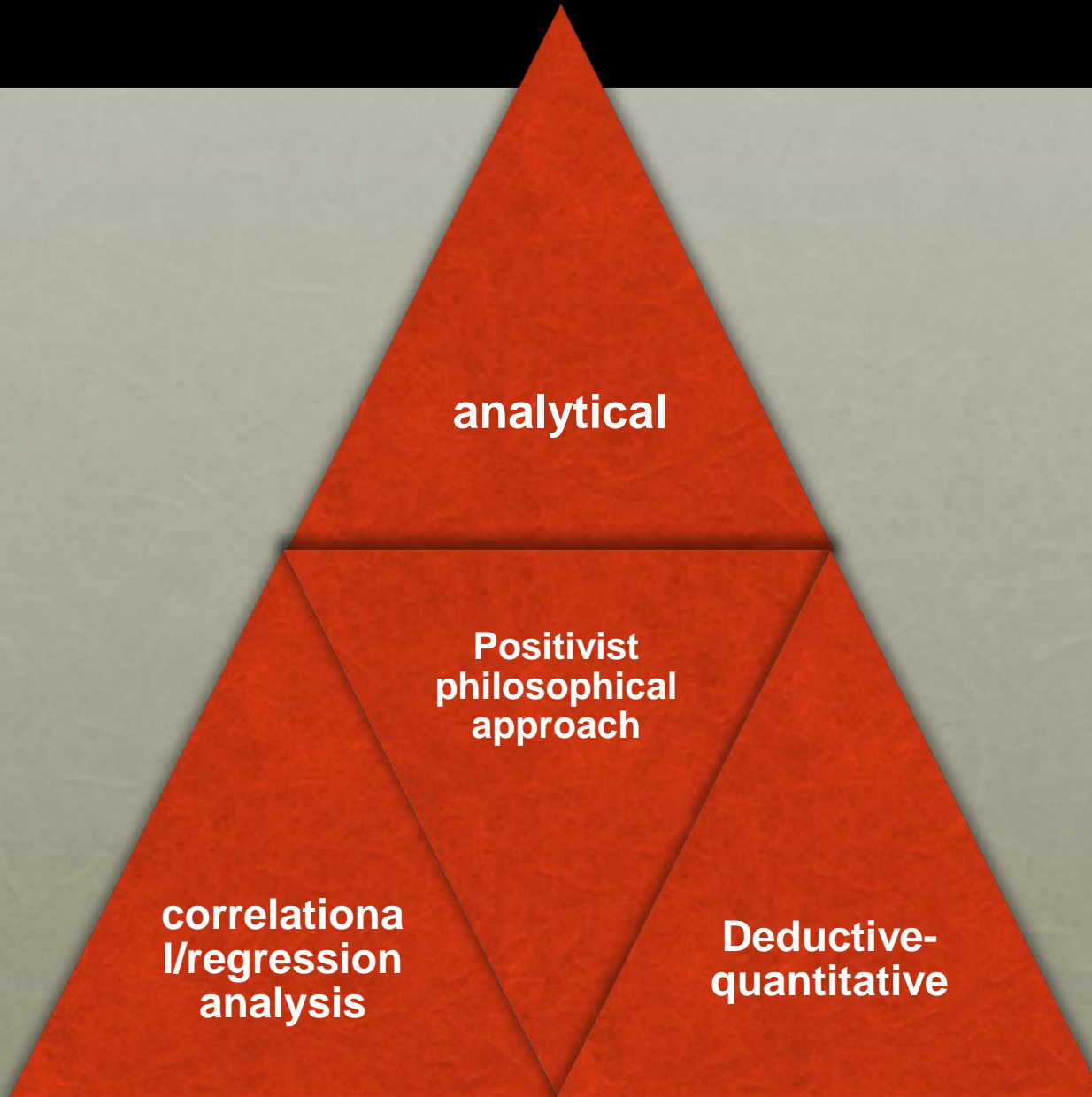
Meryll Lynch database – Meryll Lynch Corporate High Yield Index, Meryll Lynch Corporate Master Index

Annual reports for financial institutions, FTSE

Software used:

- STATA data analysis and statistical software
- Palisade @ RISK software for Monte-Carlo simulation
- MATLAB
- STATgraphics

Proposed methodology:



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