Assessing the default probabilities of economic sectors in Korea

Thesis by

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ABSTRACT

This research analyzes the effects of external shock (example financial crisis) on the default probabilities of seven economic sectors (namely Financial, Industrial, Consumer Goods, Consumer Services, Telecommunications, Basic Materials and Technology) in the Korean economy using the Merton-KMV Model.

INTRODUCTION

Default risk is the uncertainty surrounding a firm's ability to service its debts and obligations. Prior to default, there is no way to discriminate unambiguously between forms that will default and that will not. However, we can make probabilistic assessments to the likelihood of default. All sectors have different probability of default due to the nature of their business. For example, financial institutions and telecommunication sectors have larger liabilities where as software companies have smaller liabilities and asset value. This in turn changes the default probabilities.A healthy firm will have less probability of default compared to non-healthy companies. Defaults have important consequences for credit risk management as well as for regulation and systemic risk management.

One of the primary goals of financial regulation is to maintain economic stability, e.g., to avoid crises and sudden adverse changes in the financial system.History has shown that the banking crises generates significant costs to the realeconomy (Hoggarth et al., 2002),however it is usually less severe in countries where banking systems are highly regulated (Angkinand, 2009).The 2008 subprime crisis showed us the need and importance of a robust risk management culture (Ackermann, 2008). For investors and financialinstitutions, it is highly imperative to detect risk trends and makecomparisons across countries. This reduces the overall risk and minimizes the risk. Barrrell et al. (2006) has shown that not only is the welfare of the economy reduced due to the financial instability, there is also a reduction in the consumption andincrease in uncertainty. Thus, taking into account the inherentrisk of the economic sectors, as well as the possibility of contagion effects, stringent policy actions from government authorities is crucial to reduce damages to the economy and increase economic stability. But in order to do that we should be able to predict the crisis and crises and assess the degree of risk of theinstitution/country concerned. Predicting the risk can provideimportant information to regulators and policymakers to make informed decisions.

Background

The financial crisis in 2008 led to the takeover of Bear Stearns by JP Morgan. Bear Stearns was struck by a deep liquidity crisis.The American investment bankLehman Brothers filed for Chapter 114 bankruptcy.This was the starting point of a crisis which turned out to beone of the largest in the history. Financialinstitutions all over the world were damaged due to a slowdown in the international tradecaused by questioning of their solvency and creditability as well as decreased confidenceamong investors. The financial crisis also affected the countries all over the world.

Several banks made the mistake of not holding enough capital in reserve in case of creditdowngrades. Basel II agreements imply that the capital requirements of the banks riseexponentially due to credit downgrades. The idea of Basel II is therefore to match the capitalrequirements with the firms’ ratings while Basel I has an overall requirement of a capitalreserve of 8% regardless the company.

To predict the credit risk and theprobability of default among companies, several models have been developed. They are Actuarial Models, Credit Migration Models and Contingent ClaimsModels (Arora et al.,2005).Today, the most common models are the Credit Migrationmodels (Credit Metrics) and the Structural models (KMV).

Purpose

To maintain a healthy economy it is important to predict the credit risk and the probability of default among the companies. However, external shocks can increase the default probability of the companies and it is important to understand whether external shocks can push an otherwise healthy company into default. The financial crisis saw two big banks (Bear Stearns[1]& Lehman Brothers[2]) and many small companies to declare bankruptcy. The crisis in the banking sector created a crisis in the economy which in turn made it difficult for the companies in non-financial sector to survive. To maintain a healthy economy it is imperative that firms have a low default probability.

Even though the financial crisis originated in US due to mortgage backed securities, its implications have been felt worldwide. The bankruptcy declared by Bear Stearns and Lehman Brothers demonstrated that if not enough checks are in place, there is no such thing as "Too Big to Fail". The ripple effect created by the financial crisis in America affected the

[1]http://www.economist.com/node/13226308
[2]http://www.investopedia.com/articles/economics/09/lehman-brothers-collapse.asp

economies in Europe and Asia too. Countries like Greece, Cyprus and Spain are on the brink of collapse.

The Korean economy was affected too by the financial crisis. However, to analyze the total effect on the economy, we have to analyze whether the firms were healthy enough to withstand the crisis and their balance sheets were strong enough to honor their commitments to their debt holders. So, in this thesis we empirically investigate the industry specific default rates.

Problem Discussion

This research will study the different sectors in the Korean economy and analyze whether the default probability in those sectors increases in the event of an external shock. The default probability will indicate the weaker sectors in the economy and will enable the government to make informed policy decisions to enhance the strength of those sectors by placing various policy measures in place.

LITERATURE REVIEW

The existing literature that describes default process in credit risk can be divided into two primary types of models: *structural models* and *reduced form models*.Reduced form models assume a firm's default time is inaccessible or unpredictable and driven by a default intensity that is a function of state variables. The parameters governing the default hazard rate are inferred from market data and financial ratios provide a significant indication of the likelihood of financial distress, such as Altman's Z-score (Altman 2002). In this regard, the defaults and recovery rates are exogenously modeled in reduced form models while default is generated within the structure model. Thus, the structural approach has the advantage of better communication among loan obligators, credit analysts and credit portfolio managers in terms of understandable economic variables. Also, the treatment of recovery rate in reduced form models is exogenously specified whereas in the structure models recovery rates are determined by the value of the firm's assets and liabilities at default.

Structured models, also known as contingent claims framework or option pricing approach, determine the time of default through evolution of firm's economic and financial conditions. Thus, defaults are endogenously generated and pricing the credit risk is directly linked with the value of the firm relative to a credit-event-triggering threshold or barrier. The structural approach was initiated by Merton (1974) who considers the valuation of risky debt with the seminal work of Black and Scholes (1973). In his model, the firm's value is simply a

European call option and thus implies the default can only happen at the maturity. Extending Merton's model to a first passage model, Black and Cox (1976) specify default as the first time the firm's asset value falls to a trigger value and allows the default to occur at any time. With this framework, Longstaff and Schewartz (1995) introduce that interest rate follows a mean reverting stochastic proves and that there are deviations from strict absolute priority into a two factor model. Leland and Toft (1996) further assume that the debt has finite life and incorporate the optimal capital structure relative to the impact of taxes and bankruptcy cost in corporate debt value analysis. Their barrier option model defines endogenously the bankruptcy threshold. Ericsson and Reneby (1988) demonstrate the finite maturity coupon securities with bankruptcy cost, corporate taxes and deviations from the absolute priority rule. Collin-Dufresne and Goldstein (2001) extend the Longstaff and Schewartz (1995) model by introducing a stationary leverage ratio of a firm.

The quantitative modeling of credit risk has become anextensive and important topic today, because of theinnovation of the credit derivatives and different varieties of debt products. Many academicsand practitioners have shown great interest in models that forecast the credit risk of the firm. However, the most important one is the model developed by Merton (Merton 1974). Merton's model was further developed by the firm called KMV Corporation, a firmspecialized in credit risk analysis. The KMV Corporation was later taken-over by Moody's. The model is now called Moody's- KMV Model. KMVdeployed the framework of Merton, in which the equity value of the firm is a call option onthe underlying value of the firm's asset with a strike price equal to the face value of the firm's debt.The KMV model uses the value of the equity, thevolatility of equity and several other observable parameters to obtain the value of the firm's asset andvolatility. After obtaining these two inferred quantities,it applies the assumption that “the value of thefirm follows a geometric Brownian motion” tospecify the default probability of the firm.

In order to determine theaccuracy and effect of the KMV model several studies have been performed. Many of the studiescan be found on Moody’s website[3].Several other studies include the improvement of the KMV Model. Crosbie and Bohn(2003) summarized the KMV Model. They made some modifications to the assumptions in order to make it more relevant. They used the model tocalculate the market value and volatility of the firm’s asset from equity and this in turn improvedthe accuracy in the calculation of the Distance-to-Default.Kealhofer and Kurbat(2000) replicated Moody's research results to argue that Moody's model captured moreinformation and reacted more quickly compared to other traditional rating agencies.Bharath and Shumway (2004)examined the accuracy and the contribution of the KMV-Merton defaultforecasting model by constructing its naive alternative probability.

[3]http://www.moodys.com/Pages/GuideToDefaultResearch.aspx

The Merton KMV model is not only used by academics as a reliable measure but the Basel Committee on Banking Supervision (1999)[4] considers exploiting the Merton KMV model a viable practicecurrently employed by numerous banks. Thus this model enjoys confidence in both the risk management of thebanking sector and the accuracy of academic research.

Contingent Claims Analysis (Gray et.al 2006) is a generalization of the option pricing theory of Black-Scholes and Merton. It is based on the following three principles:(i)thevalues of liabilities are derived from the assets,(ii) liabilities have different priorities (senior and junior claim), and (iii) assets follow a stochastic process. The liabilities consist of senior claims, junior claims and subordinated claims (such as subordinate debts). As total assets decline, the value of risky debt declines and credit spreads on risky debt rise.

[4] http://www.Basel.org/bcbs/irbriskweight.pdf

THEORETICAL FRAMEWORK – THE KMV MODEL

In this paper we will use the Merton credit risk model in order to determine thedefault probability of seven sectors in the Korean market. Default risk is defined as the uncertainty surrounding afirm's ability to amortize the debts and fulfill its obligations. (Crosbie & Bohn, 2003)

Option Nature of the Equity

TheMerton-KMV model is based upon Merton's assumption that a firm's equity is a European call option on the underlying assets. The bondholders of a company have the first right on the assets of the company where as the shareholders have the residual right, i.e. at the debt maturation, the bondholders will receive their debts in full and the equity holders will get the remaining amount. In the event of the non-payment of the debt, the bondholders will take control of the remaining assets of the firm and the equity holders will receive nothing.

Therefore, the value of the equity is equivalent to a call option on the underlying value of the form with the strike price which is equal to the face value of the debt at maturity of debt obligation.If the market value of assets exceeds nominal debt, the calloption is at the money. At the maturity time, if the value of the firm's asset is greater than the debt, we exercisethe option to gain the pay off, otherwise, we have nothing.

Merton-KMV Model

The Merton-KMV model is based upon Merton's assumption that a firm's equity is a European call option on the underlying assets. When defining the equity of a company as a European call option on the asset of thecompany, the parameters used are the time to maturity, T, and the strike price, X, which is equal to the liabilities of the firm. The following are the assumptions made by Merton;

- There are no transactions cost or taxes, in other words, the market is constituted to be a perfect market.
- There are also a significantly large number of investors. There is no limitation and the investors can buy and sell anything without restrictions on special transactions like short selling etc.
- The interest rate is constant and known.
- Assets are traded continuously over time.
- The company is assumed to be founded by a single class of equity and a single class of debt (Miller-Modigliani). The complex debt structure (like preferred shares etc.) is not taken into consideration.
- There is only one homogeneous class of bonds issued by the firm, maturing within the period. The firm is obligated to pay back the bond to the bondholder at T.
- The firm's assets follow a geometric Brownian motion and are tradable :

$$dV_A = \mu V_A dt + \sigma_A V_A dz \quad \text{----------------- (1)}$$

where; V_A is the firm's asset value

dV_A is the change of the asset value

μ is the are the firm's asset value drift rate

σ_A isthe asset value volatility

dz is a Wiener process.

From previous equation we know that in the Merton model the compensation to the shareholders at time T is defined as:

$$V_E = \max(V_A - X, 0) \quad \text{--------------------------------- (2)}$$

where; V_E is the market value of equity

V_A is the market value of asset

X is the exercise price (which are the liabilities of the firm)

The previous equation implies that a firm's equity value is defined by a call option. The bondholder's own the firm, have put X into the firm and receive the benefits of the firm.

However, once the value of the firm exceeds the exercise price X, then the equity holders will exercise their right to buy the firm, as it will now have positive value. The reasoning behind the argument is that the equity holders own the firm, owe X amount to the bondholder. Therefore, if the value of the firm exceeds the value of debt then the equity holders retain the firm. If the value of debt is greater than the value of the firm then the bondholders have the right on the asset of the firm. They can sell the firm and take the proceeds.

The result ofthe Merton model is presented in equation below

$$V_E = V_A N(d1) - e^{-rT} X N(d2) \quad \text{----------------------------- (3)}$$

Where N(*) is the cumulative standard normal distribution function and *r* is the risk free interest rate.

$$d1 = \frac{\ln \frac{V_A}{X} + \left(r + \frac{\sigma_A{}^2}{2} \right) T}{\sigma_A \sqrt{T}} \quad \text{---------------------------------- (4)}$$

$$d2 = d1 - \sigma_A \sqrt{T} \quad \text{--(5)}$$

As we have seen in the above equation the value of the firm's equity is a function of the total value of the firm. Further, the volatility of the firms asset value, σ_A, is related to the volatility of the firm's equity σ_E as shown in equation below.

$$\sigma_E = \left(\frac{V_A}{V_E}\right)\left(\frac{dV_E}{dV_A}\right)\sigma_A \quad \text{-------------------------------- (6)}$$

But according to the Black Scholes model (please refer to the appendix)

$$N(d1) = \frac{dV_E}{dV_A} \quad \text{--------------------------------- (7)}$$

The volatility function can therefore be written as

$$\sigma_E = \left(\frac{V_A}{V_E}\right)N(d1)\sigma_A \quad \text{-------------------------------------- (8)}$$

By simultaneously solving equation (3) and (8) we derive the values he firm's asset value, V_A and the firm's asset volatility, σ_A .Thus, the firm's asset quantities, the current value and the volatility are derived from the market value of the firm's equity and the equity's instantaneous volatility, alongwith knowing the outstanding and maturity of debt. The debt's maturity is chosen as the value of the liabilities is set to equal the face value of the debt.The firm is default when thevalue of firm's asset falling below the default point (DD), which is the face value of the debt.To calculate the default probability, the new parameter is introduced, called the distance todefault, which is the distance between the expected value of the firm's assets and the default point and then divides this divergence by an estimate of the volatility of the firm ina time horizon. And then, the distance to default is substituted into a cumulative densityfunction to calculate the probability that the value of the firm will be less than the face valueof debt at the maturity of the debt.

Distance to Default

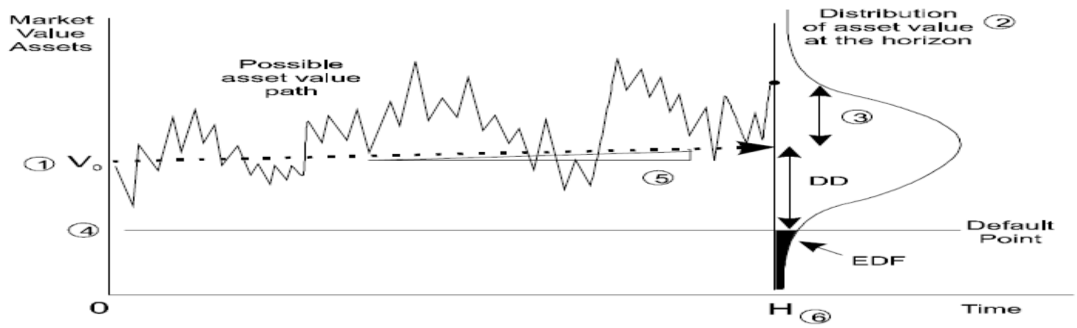
The distance-to-default (DD) is defined as:

$$DD = \frac{\ln \frac{V_A}{X_t} + \left(\mu - \frac{{\sigma_A}^2}{2} \right) t}{\sigma_A \sqrt{t}} \quad \text{---(9)}$$

where; μ is the drift rate and is assumed to be equal to r (risk free rate).

There are six variables which determine the distance-to-default (DD) and are illustrated in the Figure 1 below (Crosbie & Bohn, 2003). The figure shows that a firm defaults when the value of the firm's assets (1) is belowthe default point (4) and thereby ends up in the shaded region, EDF (Expected Default Frequency). Hence, the defaultprobability of a firm is the probability that this event will occur.

Figure 1: Illustration of Probability of Default



The following are the values/parameters which are included in the figure above:

1. Current asset value, V_t

2. Distribution of the asset value at time T

3. Volatility of the future asset value at time T

4. Level of default point, X

5. Expected rate of growth in the asset value over the horizon

6. Length of the horizon, T

The measure of distance-to-default can be interpreted as the amount of standard deviationsthe asset value is from default. Crosbie & Bohn (2003) argue that the firm will default when the value ofthe assets is below the default point.

Distance to capital

The distance-to-default measure does not include the complexities related to financial firms andtherefore isn't reliable for the financial organizations.The distance-to-capital is derived from distance-to-default.

The distance-to-default (DD) is defined as:

$$DC = \frac{\ln \frac{V_A}{\lambda X_t} + \left(\mu - \frac{\sigma_A{}^2}{2} \right) t}{\sigma_A \sqrt{t}} \qquad \text{-----(10)}$$

$$DD : \lambda = 1$$

$$DC = \lambda = \frac{1}{(1 - PCAR_i)}$$

Where $PCAR_i$is the capital requirement, which according to Basel I is set to eight percent. For non financial firms, λ is equal to one.

Probability of Default

Probability of default is the probability that the asset value will be below than the defaultpoint, which is shown in the following derivation. (Crosbie & Bohn, 2003)

$$P_t = \Pr\left[V_A{}^t \leq X_t \,|\, V_A{}^0 = V_A \right] = \Pr\left[\ln V_A{}^t \leq \ln X_t \,|\, V_A{}^0 = V_A \right] \qquad \text{------ (11)}$$

where; $p_t$is the probability of default at time horizon t

is the market value of the firm's asset at time t

$X_t$is the exercise price at time t

The value of the firm's asset at time t is shown in equation below, given that the value at time0 is the value of the firm's asset, since the change in the value of the firm's asset is describedby the geometric Brownian motion in equation (1):

$$\ln V_A^{\,t} = \ln V_A + \left(\mu - \frac{\sigma_A^{\,2}}{2} \right) t + \sigma_A \sqrt{t} \varepsilon \qquad \text{------------------- (12)}$$

where; μis the expected return on firm's asset and εis the random component of the firm's return

Crosbie and Bohn (2003) receive the equation below (13) by combining equation (11) and(12)

$$P_t = \Pr\left[\ln V_A + \left(\mu - \frac{\sigma_A^{\,2}}{2} \right) t + \sigma_A \sqrt{t} \varepsilon \le X_t \right] = \Pr\left[-\frac{\ln \dfrac{V_A}{X_t} + \left(\mu - \dfrac{\sigma_A^{\,2}}{2} \right) t}{\sigma_A \sqrt{t}} \ge \varepsilon \right] \text{-- (13)}$$

Due to Black and Scholes assumptions about εbeing normal distributed with an expectedreturn equal to zero and a variance equal to one, Crosbie and Bohn (2003) define theprobability of default as in equation (14) below:

$$PD_t = N\left[-\frac{\ln\frac{V_A}{X_t} + \left(\mu - \frac{\sigma_A{}^2}{2}\right)t}{\sigma_A\sqrt{t}} \right] = N(-DD) \quad \text{-------------} \ (14)$$

DATA

The data is for seven sectors in the Korean market. They are Consumer Goods, Consumer Services, Industrials, Basic Materials, Telecommunications, Technology and Financial sector. The default probability and distance to default was calculated for each sector at the aggregate level. The market value of the unknown assets(V_A), and the volatility of assets(σ_A) the sectors were calculated using equity (V_E) and volatility of equity (σ_E) by using matlab. The calculations are based on the daily Market Value of equity, the stock price index (to derive volatility of equity), risk-free interest rate and indebtedness at the sectoral level. The data is from year 3007 to 2012.

The market value of the equity

The daily market value of the equity is directly extracted from DataStream at the beginning of the each year in which we start to forecast. The sectoral data includes the equities which constitutes the respective indices and have been on the stock market for the last five years or more. The financial sector has thirteen equities, the industrial has twenty-five equities, consumer Goods has fifteen equities, consumer services consists of six equities in the index, telecommunications and technology has three equities each and basic materials have eleven equities in the index.

Risk-free interest rate& Time

The interest rate of one year risk-free rate is used. The data is downloaded from DataStream.In general, the companies have a complex liability structure and it is difficult to determine the details of the maturity structure. However, we can determine the current liabilities and the long term liabilities. So, we assume the firm's liabilities willbe matured in the time of one year.

Liability of the firm

The value of the firm's liability which we have used in the calculation is roughly equal to the short-termone plus half of the long-term one. The data of the short-term and long-term are from the balance sheet of the firm.Professional credit rating agencies like Moody's use different liabilities like junior and senior secured bonds, subordinated bonds, zero coupon bonds. Since it is difficult to get the detailed data on the various liabilities, we use the short-term debts and half of long-term debts.

EMPIRICAL METHODOLOGY

Equity Volatility

The volatility of the equity is calculated by the historical equity return data. Since in theassumption that the stock price follows the geometric Brownian motion, we would assumethat i is the log return at the ith day, Si and Si-1 are the closing price of the stock at theith and i- 1th day respectively. Then we have

$$\mu_i = \ln \frac{V_A}{V_{A-1}} \quad \text{---- (15)}$$

By using the following equation by Hull, we can calculate the volatility of equity

$$\sigma_E = \frac{\sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\mu_i^{\,2} - \frac{1}{n(n-1)}\left(\sum_{i=1}^{n}\mu_i\right)^2}}{\sqrt{\frac{1}{n}}} \quad \text{----- (16)}$$

Where n is the number of trading days which is approximately equal to 252.

The value and volatility of the firm's asset

Asset Risk is measured by the asset volatility, the standard deviation of the annual percentage change in the asset value. Asset volatility is related to, but different from equity volatility. A companies 'leverage has the effect of magnifying its underlying asset volatility. As a result, industries with low asset volatility (example banking), tend to take on larger amounts of leverage while high asset volatility (example technology) tend to take on less. As a consequence of these compensatory differences in leverage, equity volatility is far less differentiated by industry and asset size than is asset volatility.

We usethe relationship between the market value of a firm's equity and the market value of its assetwhich is explained in equation (3) and the relationship between thevolatility of the firm's assets and the volatility of firm's equity, which is explained in equation (8). In order to solve theseequations we calculate the liabilities from the balance sheet of the respective companies. We take the short term debts and one half of the long term debts. The parameters asset value and the asset value volatility are optimized by using Excel andmatlab.

Calculating Distance to Default/Distance to Capital and Default Probability

Once we calculate the asset value and asset volatility we use equation (9) and equation(10) to calculate the distance-to default and distance to capital (for financial) respectively. Then we use equation (14) to calculate the default probability for all the economic sectors.

Limitations

Merton's Model is in some inferior to Moody's KMV model. Moody's KMV uses the VK-model founded by OldrichVasicek and Stephen Kealhofer (Arora t. al 2005). Thismodel is an extension of the Black-Scholes-Merton framework but is based on differentassumptions than the Merton-KMV model. Moody's KMV assumes that firm's capitalstructure consists of five different types of claims on the firm's cash flow; short-term liability,long-term liability, common equity, preference equity and convertible equity. Further, themodel assumes that the option is a perpetual down-out option with an unlimited time horizonand the possibility to be exercised at any time. Moody's doesn't assume any distribution butinstead uses a large database containing American bankrupted companies in order to find thelink between distance-to-default and probability of default. Through the database, thelikelihood of going bankrupt can be related to different levels of distance-to-default and it isthereby possible to find an Expected Default Frequency (EDF™).

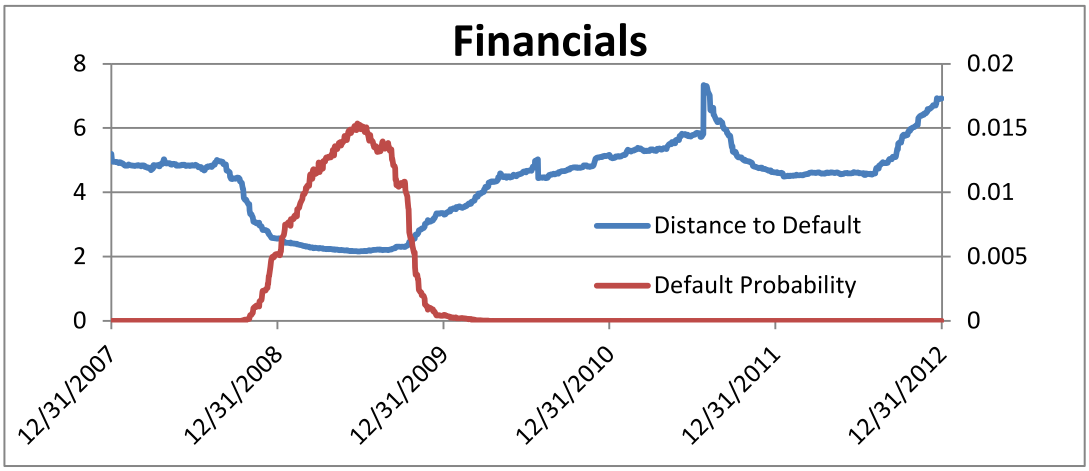
The data is readily available for large publicly traded and therefore the study only uses those companies which are listed on the stock market. However, there are many Small and Medium sized companies which also affect the economy but it is difficult to get data for those companies.

The most important implication in Merton approach is that Merton-KMV uses the normal distribution to define the probability default. In fact, using the normal distribution is very poor choice to define the probability default.In Merton approach, the default point is a constant, and equals to the debt.However, in Moody's approach, the default point is a variable; it somehow links to therepurchase or issue of debts. In particular, the firm often adjusts their liabilities as theynear default. Secondly, the default time is not necessary equal to the maturity time of thedebt obligation; it could be any time before or at the time horizon. Indeed, market datacan be updated daily because of changes in default point. Finally, the asset returns arewider tails than the normal distribution.

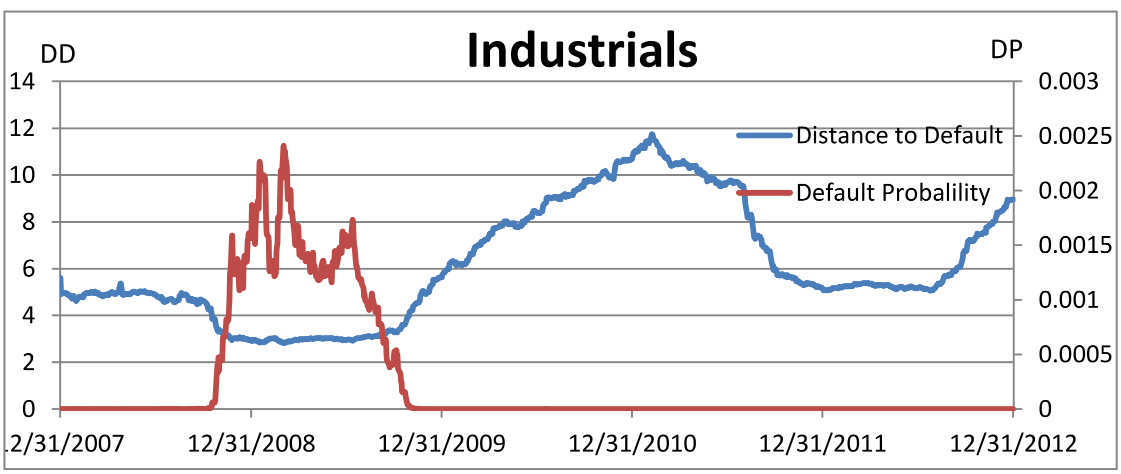
RESULTS& DISSUSSION

The Distance to default is on the left axis and default probability is on the right axis.

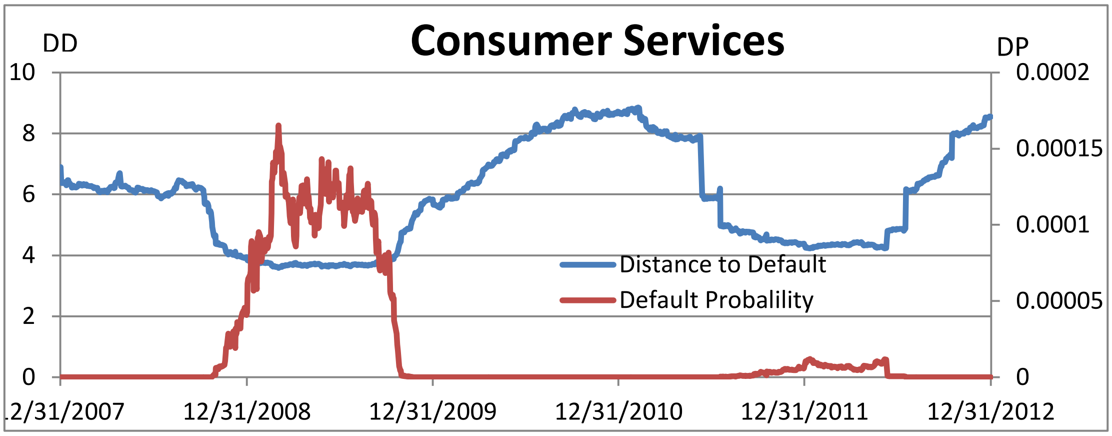
Financial Sector



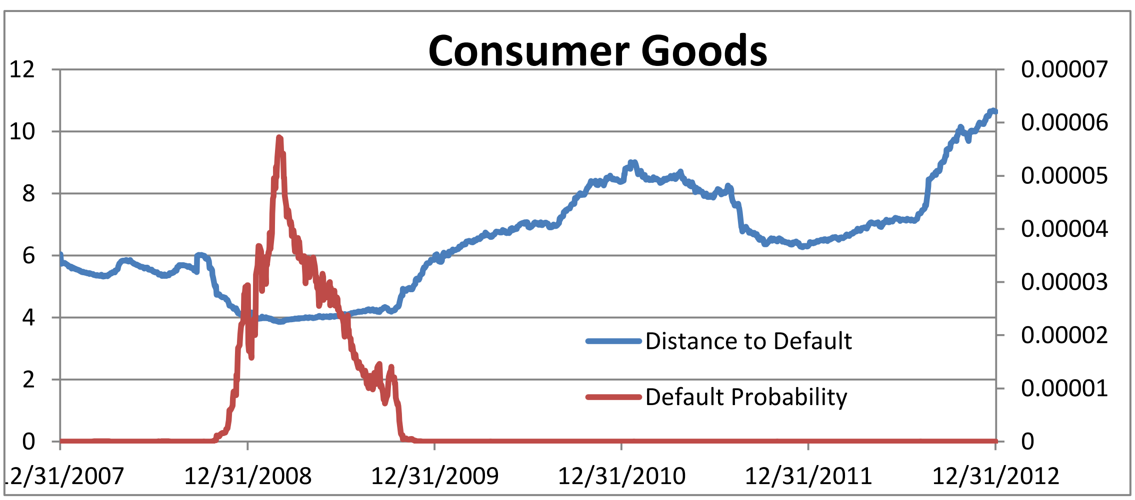
Industrials



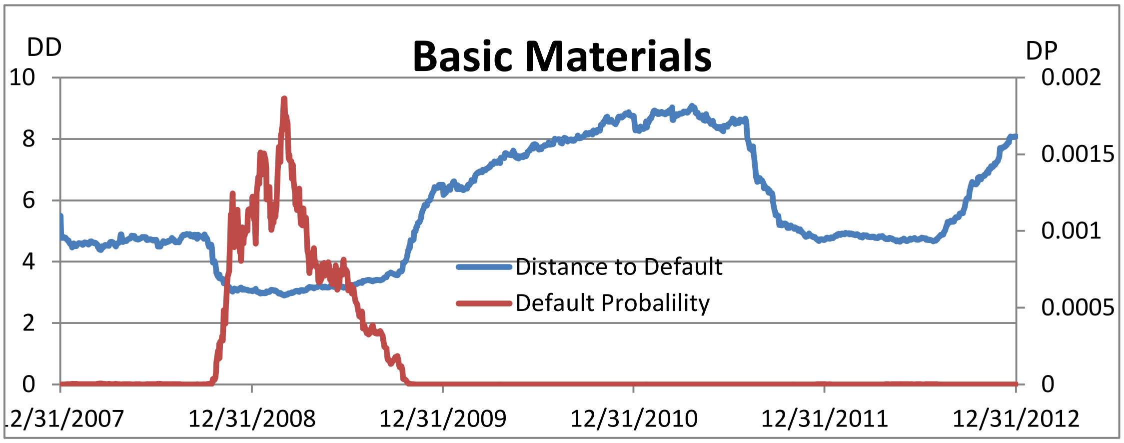
Consumer Services



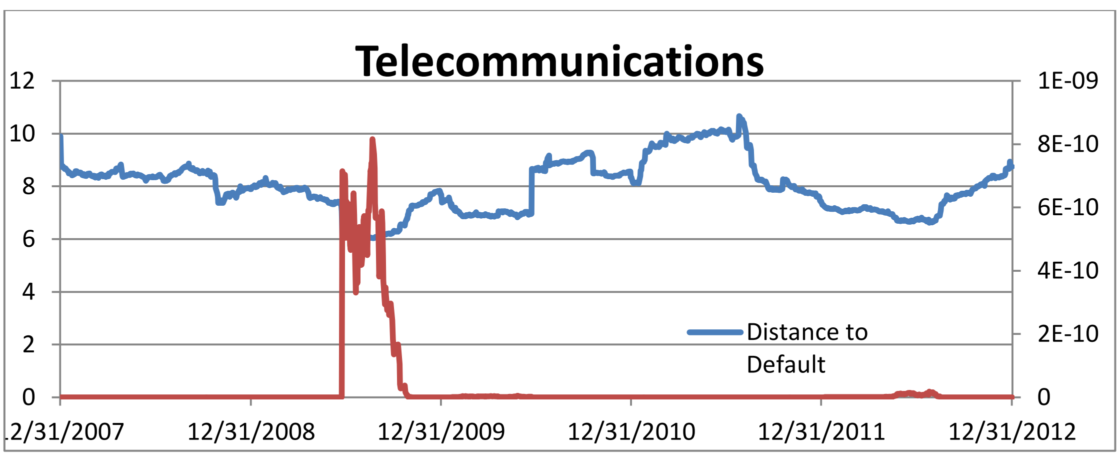
Consumer Goods



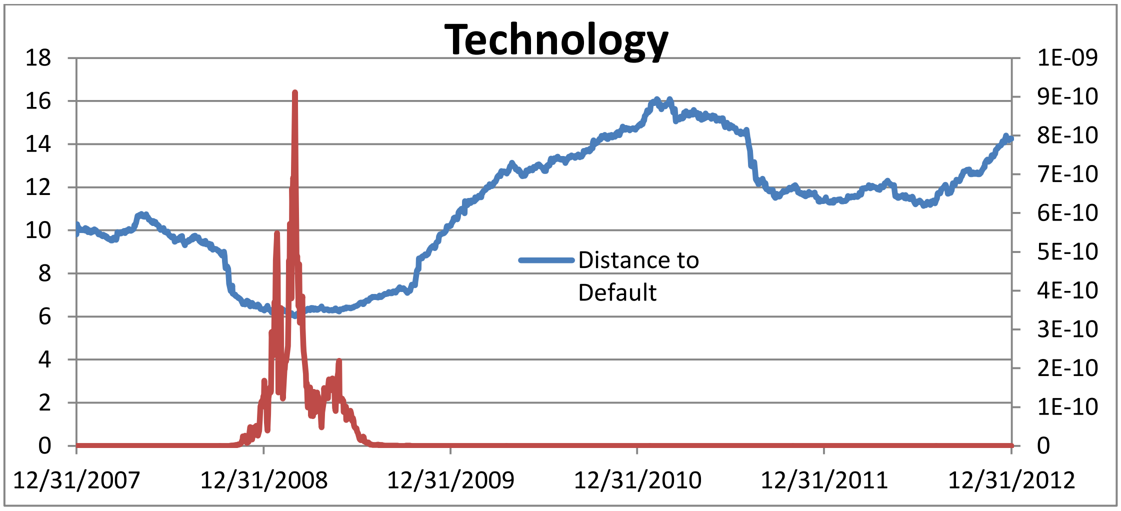
Basic Materials



Telecommunications



Technology



The above figures show that all the sector show an increase in default probability during the global financial crisis. It also shows that the distance to default and default probabilities are inversely related, i.e. when the distance to default decreases the default probability increases.

The financial sector which consists of banks, insurance companies and financial institutions had an increased probability of default during the financial crisis. The default probability increased during the last quarter of 2008 and was the same till the end of 2009. However, after that period the results show that the financial sector is sound.

For Consumer Services sector, the Distance to default in the year 2011 was similar to that of the year 2008-2009. The result also shows that there was a slight increase in the default probability in 2011, but now the sector has recovered.

Consumer Goods, Telecommunications and technology sector have very low probability of default. However, their default probability was very low even during the financial crisis. Telecommunications didn’t have much fluctuation in its distance to default, but the other sectors how that the distance to default decreased during 2008-2009 and during 2011-2012.

KOREAN GOVERNMENT POLICIES

Government's Response to Financial Crisis

The Korean government's response to the financial crisis played a crucial role in mitigating the crisis from escalating further in to a recession for the Korean economy.

Reduction of the base rate:

The Bank of Korea (BoK) lowered its base rate on six occasions between October 2008 and February 2009, by 3.25 percentage points altogether from 5.25% to 2.00%, the lowest level since the policy rate target began to be announced in May 1999.

Expansion of liquidity supply

The BoK supplied liquidity totaling KRW 18.5 trillion (equivalent to around 28.5% of reserve money as of end-2008) by means of open market operations to ensure the seamless circulation of funds in the money and bond markets. This included bank debentures and certain government agency bonds as the securities eligible for use in open market operation. Initially only treasury bonds, government-guaranteed bonds and monetary stabilization bonds could ne included.

Support for the expansion of banks' credit supply capacity

To facilitate the supply of credit through banks, the BoKraised the aggregate credit ceiling, paying banks' interest on their required reserve deposits, and helping banks to build up their capital. Various measures were taken to create incentives for banks to lend to SMEs. The BoK increased the aggregate credit ceiling by more than 50%. In order to help banks expand their credit supply by raising their BIS capital adequacy ratios, the BoK paid them one-off interest of KRW 0.5 trillion on their required reserve deposits.

Actions taken to stabilize the foreign exchange market

The BoK undertook timely and effective actions to contain foreign exchange market unrest at an early stage and avoid it escalating into a foreign exchange crisis. The following were the steps taken by BoK:

- USD 30 billion swap arrangement with the US Federal Reserve.
- 180 billion yuan/KRW 38 trillion swap arrangementwith the People's Bank of China.
- Expanded the ceiling of an existing currency arrangement with the Bank of Japan from USD 3 billion equivalent to USD 20 billion equivalents.
- Provided a total of USD 26.6 billion in foreign currency liquidity to banks experiencing difficulties in raising overseas funding.

- Introduced the Foreign Currency Loans Secured by Export Bills Purchased scheme in order to provide incentives for banks to be active in handling trade financing for SMEs.

Assessment of Bank of Korea's Policy Response

The steps taken by the BoK following the collapse of Lehman Brothers in September 2008are considered to have played a very important role in stabilizing the financial and foreignexchange markets and are accelerating the recovery of business activity.

In terms of timeliness, the BoK contributed to bringing a prompt halt to the spread of financialinstability by putting in place the majority of its countermeasures immediately after the onsetof the crisis. In particular, considering that the fiscal expansion policies could only fully comeinto effect from the beginning of 2009, the monetary policy response in the immediateaftermath of the crisis is thought to have played a vital role in lessening the impact on theeconomy. The foreign currency liquidity supply schemes worked as a firewall, preventing theworsening overseas funding conditions from evolving into a currency crisis, and contributedto Korea maintaining its international credibility. For example, international credit ratingagencies, such as Standard & Poor, unanimously endorsed the BoK's and thegovernment's [5] foreign currency liquidity supply measures as swift and

[5]The government (Foreign Exchange Stabilization Fund) also announced its own foreign currency liquiditysupply measures amounting to USD 10 billion through swap trading, USD 14 billion through competitiveauction loans, and USD 11 billion through support for trade finance, totaling USD 35

adequateimmediately after their announcement (17–21 October 2008) and maintained their currentsovereign ratings for Korea.

The BoKprincipally made use of conventional policy instruments, such as the reduction of interestrates and the expansion of liquidity by means of loans and open market operations, instead of using unconventional measures.

Efforts were also directed as far as possible in employing these conventional policyinstruments in order to prevent them from becoming deeply entrenched. The expansion ofliquidity, which was supplied principally through the purchase of long-term RPs (up to a91-day maturity),has been withdrawn seamlessly at the maturity. Similarly, the extension ofthe securities eligible for use in open market operations was subject to a sunset clause.

The entry into currency swap agreements with the central banks of several major countrieswas extremely useful, not just in terms of resolving the foreigncurrency liquidity shortage problem but also in restoring investor confidence at home andabroad. The establishment of the currency swap arrangements themselves actually had apositive announcement effect in stabilizing the financial market, as price variables haveshown rapid recoveries, not just in Korea but also in countries experiencing similar financialunrest[6].

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billion altogether. Anadditional USD 27.4 billion was supplied through the Export-Import Bank of Korea

[6]**http://www.bis.org/publ/bppdf/bispap54o.pdf**

CONCLUSION

Final Discussion

Probabilities of default are valuable pieces of information for supervisors and policy makers when assessing the health of the financial system. They are usually calculated withstock market data and used to identify and predict upcoming crises as early aspossible, as an attempt to minimize its negative effects. Furthermore, as a rule,authorities and regulators must primarily remain watchful not to the actualvalue of the probability, but to movements in the probabilities of failure, as todetect upward trends and avoid failure (Clare, 1995).

This research shows that the default probability increases in the event of external shock, like the global financial crisis of 2008. The research shows that extreme shocks could drive otherwise solvent firms into default over a short-time horizon. As the above graphs show, the probability of default increased in all the economic sectors across the board. However, the Korean economic sectors recovered quickly and once the extreme crisissituation was over the sectors were back to their pre-crisis stage. The research also shows that the distance to default and default probabilities are inversely proportional.

The monetary policy should take account of the expansion of credit and movements inasset prices in order to avoid a repetition of the financial crisis. In setting the policy rate,aside from the focus on prices and growth, greater attention should be given to creditconditions and movements of asset price variables such as real estate and share prices.

The Bank of Korea was among the first of the emerging market central banks to respond by reducing its policy rate by a cumulative 325 basis points between October 2008 and February 2009. It also took effective steps to increase the liquidity available to the Korean financial system, for example, by expanding the set of counterparties for repurchase transactions and broadening the pool of assets eligible as collateral. To help the banking system remainsstable and able to continue lending to creditworthy borrowers, the Bank of Korea also helped set up a bank recapitalization fund. As it can be seen from the results, all these measures helped the Korean companies in weathering the global financial crisis and brought the economy to normal.

Future Research& Policy Considerations

We can apply the concept of Merton model and apply to determine the relations between different sectors. This result can be combined with the IMF's Balance Sheet Approach to analyze a country's default risk on the basis of sectoral balance sheet. The sectors can be further divided into sub-sectors to determine which sectors are conditions.

Korean Government's Future Policy Considerations:

The simple interest rate policy and the unconventional measures taken as part of theresponse to the crisis need to be unwound step by step. If the stance of financial easing isunwound too rapidly, there is a concern that it could hamper the recovery of activity, and if itis not possible to shift to a pre-emptive policy stance, there is a high risk of asset bubblesand inflation. Pursuing exit strategies incrementally with appropriate timing while keeping aneye on the extent of the improvement in, and sustainability of, global financial and economiccircumstances would therefore be the preferable course of action. It is also vital to strengthencommunication efforts such as adequate advanced signaling to economic agents in order tominimize adverse impacts.

International cooperation should be strengthened in order to counter the risk of thespread of advanced country economic unrest to emerging market countries and the risk of asudden stop. For the Korean economy, foreign exchange market stability has improved greatlycompared to the situation prevailing in 1997 during the foreign currency crisis, helped by thestability-oriented focus of macroeconomic policies and the building up of foreign exchangereserves. However, additional efforts are still required in view of the capital exodus and theforeign exchange market unrest experienced following the collapse of Lehman Brothers.

In particular, considering today's financial environment in which capital movement betweencountries has greatly expanded because of the globalization of finance and economicactivity, it is important to strengthen international policy cooperation with regard to theregulation of capital movements to overcome the problem of “original sin” of emergingmarket countries.

Discussions concerning the regulation ofhedge funds and the international regulation of both multinationalfinancial institutions and the supervisory system should be expanded to reduce the volatility in thefinancial market.

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APPENDIX

THE BANK FOR INTERNATIONAL SETTLEMENTS

The Bank for International Settlements[7] was established in May, 1930 and is the world's oldest international financial organization. It acts as a bank for Central Banks and helps them to ensure monetary and financial stability and to foster international cooperation. It acts as a prime counterparty for Central Banks in their financial operations, promotes discussion and facilitating collaboration among Central banks, serves as an agent or trustee in connection with international financial operations, conducts research on policy issues confronting central banks and financial supervisory authority and supports dialogues with other authorities that are responsible for promoting financial stability[8].

Basel Committee on Banking Supervision

The Basel committee [9] consists of central banks from the largestindustrialized countries (Argentina, Australia, Belgium, Brazil, Canada, China, France, Germany, Hong Kong SAR, India, Indonesia,Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, Russia, Saudi Arabia, Singapore, South Africa,Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States) worldwide and was established in 1974. It provides a forum for regular

[7] http://www.Basel.org/about/index.htm
[8] https://www.Basel.org/about/functions.htm
[9] http://www.Basel.org/bcbs/about.htm

cooperation on banking supervisory, enhances understanding of key supervisory issues and works to improve the quality of banking supervision worldwide.

Further, the committee worksfor stability in the economy and one task of the committee is to maintain the internationalstandards on capital adequacy, known as Basel I (1998) and Basel II (2008). The Baselcommittee is a part of BIS, but BIS is not a participant in the decisions that are taken within the committee (Dwyer 2006). Sixty central banks are members of BIS[10].

Basel Capital Accord (Basel I)

Credit risk management and measuring the probability of default of a company or an economic sector is a complicatedprocess. There is anuncertainty underlying the probability of default and an economic recession willincrease the chain reaction of default amongst various sectors. In order to reduce the default correlations the Basel framework includes the standard for capital requirement which states that the financial institutions must hold at least eight percent of its assets as a reserve against unexpected loss.

[10] Algeria, Argentina, Australia, Austria, Belgium, Bosnia and Herzegovina, Brazil, Bulgaria, Canada, Chile, China, Colombia, Croatia, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong SAR, Hungary, Iceland, India, Indonesia, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Macedonia (FYR), Malaysia, Mexico, the Netherlands, New Zealand, Norway, Peru, the Philippines, Poland, Portugal, Romania, Russia, Saudi Arabia, Serbia, Singapore, Slovakia, Slovenia, South Africa, Spain, Sweden, Switzerland, Thailand, Turkey, the United Arab Emirates, the United Kingdom and the United States, plus the European Central Bank

Basel Capital Accord (Basel II)

The Basel capital accord[11] (Basel II) was initially published in June 2004 and was intended to create an international standard for banking regulators to control how much capital banks need to put aside to guard against the types of financial and operational risks banks (and the whole economy) face. It was implemented in 2008-2009 after the banking crisis caused mostly by credit default swaps, mortgage backed security markets and similar derivatives. While Basel I focuses on a single risk measure and stated that all loans should be treated equally, Basel II is more focused on risksensitivity. Basel II takes the financial institutions' internal methodologies, supervisory reviewand market discipline into account. It is further more flexible and risk sensitive. The structureof Basel II is constituted by three pillars; minimum requirement, supervisory review processesand market discipline. The first pillar, minimum requirement, regards the bank's capital ratio[12] which has to be atleast 8% according to Basel I. Second, supervisory review processes, i.e. the requirement thatthe supervisory have to secure that each financial institution, has an internal process in orderto acknowledge the risk associated with a certain loan. They should also make sure that anamount of capital appropriate for the risk of the loan is being held. The third pillar is aboutincreasing the market discipline by improving the disclosures of banks. The aim is to helpmarket participants in order to understand financial institutions' risk exposure and theircapital.

[11] http://www.bis.org/publ/bcbsca.htm

[12] Capital adequacy ratios (CARs) are a measure of the amount of a bank's core capital expressed as a percentage of its risk-weighted asset. (Hull)

BLACK SCHOLES MODEL

The Black and Scholes[13] Option Pricing Model calculate a method to measure how the discount rate of a warrant varies with time and stock price.

The model is divided into two parts. The first part, SN(d1), derives the expected benefit from acquiring a stock outright. This is found by multiplying stock price [S] by the change in the call premium with respect to a change in the underlying stock price [N(d1)]. The second part of the model, Ke(-rt)N(d2), gives the present value of paying the exercise price on the expiration day. The fair market value of the call option is then calculated by taking the difference between these two parts.

[13] http://bradley.bradley.edu/~arr/bsm/pg04.html

The Model:

$$C = SN(d_1) - Ke^{(-rt)}N(d_2)$$

C = Theoretical call premium

S = Current Stock price

t = time until option expiration

K = option striking price

r = risk - free interest rate

N = Cumulative standard normal distribution

e = exponential term (2.7183)

$$d_1 = \frac{\ln(S / K) + \left(r + {s^2}/{2}\right)t}{s\sqrt{t}}$$

$$d_2 = d_1 - s\sqrt{t}$$

s = standard deviation of stock returns

ln = natural logarithm

Assumptions of the Black and Scholes Model:

1) The stock pays no dividends during the option's life

Most companies pay dividends to their share holders, so this might seem a serious limitation to the model considering the observation that higher dividend yields elicit lower call premiums. The model can be adjusted by subtracting the discounted value of a future dividend from the stock price.

2) European exercise terms are used

European exercise terms dictate that the option can only be exercised on the expiration date. American exercise term allow the option to be exercised at any time during the life of the option, making American options more valuable due to their greater flexibility. Towards the end of the life of a call, the remaining time value is very small, but the intrinsic value is the same.

3) Markets are efficient

This assumption suggests that people cannot consistently predict the direction of the market or an individual stock.

4) No commissions are charged

Usually market participants do have to pay a commission to buy or sell options. However, here it is assumed that no commissions are charged.

5) Interest rates remain constant and known

The Black and Scholes model uses the risk-free rate to represent this constant and known rate. The discount rate on U.S. Government Treasury Bills with 30 days left until maturity is usually used to represent it.

6) Returns are lognormally distributed

This assumption suggests, returns on the underlying stock are normally distributed, which is reasonable for most assets that offer options.

The Black and Scholes Model:

Delta:

$$\text{Delta} = N(d_1)$$

Delta is a measure of the sensitivity the calculated option value has to small changes in the share price.

Gamma:

$$\text{Gamma} = \frac{d^2C}{dS^2} = \frac{e^{(-d^2/2)}}{S\sigma\sqrt{2\pi T}}$$

Gamma is a measure of the calculated delta's sensitivity to small changes in share price.

Theta:

$$\text{Theta} = \frac{dC}{dt} = \frac{\dfrac{S\sigma}{e^{(d^2/2)}}}{2\sqrt{2\pi T}} - \frac{rE}{e^{rT}} * N(d - \sigma\sqrt{T})$$

Theta measures the calculated option value's sensitivity to small changes in time till maturity.

Vega:

$$\text{Vega} = \frac{S\sqrt{T}}{\frac{e^{(d^2/2)}}{\sqrt{2\,\pi}}}$$

Vega measures the calculated option value's sensitivity to small changes in volatility.

Rho:

$$\text{Rho} = \frac{TE}{e^{rt}}\, N(d - \sigma\sqrt{T})$$