PRICE DISCOVERY OF CREDIT RISK WITH SPECIAL REFRENCE OF SELECTED STOCK, BOND MARKETS

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Introduction

The price discovery process which is also referred as the price discovery mechanism represents the phenomenon of estimating the price of certain asset in the market in the course of the interactions of the involved buyers and asset's sellers. Price discovery phenomenon comprises buyers and sellers approaching at certain transaction price for a particular item for certain defined time interval. In certain dynamic marketplace, the price discovery comes into existence incessantly whereas items are purchased and sold. The price would sometimes come down the extent and sometimes it gets increased from its mean value consequently the noise caused because of the uncertainties, and momentary variations in supply caused due to the act of purchase and sell; trading.

A closed market possesses no price discovery the most recent trade value is all which is recognized or known. In general it is normal in few marketplaces where in fact the real last traded price is not used but some kinds of average or weighted mean is taken into consideration. It happens for preventing manipulation in price by exhibiting certain execution of outliers on or at market close. In parallel, one limitations of this approach is that market close prices are not always obtainable at the instant of market close, in fact even after the executive market close is unleashed; it is feasible for "corrections" to be issued later still.

Price discovery states for the phenomenon that exhibit how exactly new information on an causal asset is built-in into a security price in a market when numerous closely associated securities are traded in numerous markets (Hasbrouck 1995). Conversely, credit risk is performed for its pricing in a number of financial markets when the obligor performs issue of numerous financial securities.

Whenever multiple markets do not respond to new information concurrently, one market predominates other and whenever these kinds of lead-lag relation comes into existence, the dominating market is referred as to facilitate price discovery. There is scrupulous factors influence price discovery for financial market for credit risk. Four predominant factors are liquidity, cost of transaction, credit ratings and maturities. Employing the equity as per defined time span, bond and CDS market data, it can be found that the various market segments such as stock market, bond market, credit derivative market and bond market these all are co-integrated for certain long term credit risk price discovery. For some small span of time, both stock market as well as credit derivatives market dominates the bond market for accomplishing credit risk price discovery. Then while, the credits risk price discovery affiliation amid stock market and credit derivatives market is uncertain in both circumstances of short term as well as long run.

One study done by Gonzalo and Granger (1996) for price discovery contribution analysis for common factor component and Hasbrouck information share (1995) advocates that stock market facilitates more than 80% of price discovery input for credit risk among three markets and the contribution from credit derivatives market's credit risk price discovery is comparatively much less as compared to the stock market, whilst the bond market facilitates the minimum. Credit ratings merely influences the credit risk price discovery amongst equity, credit derivatives and bond market for its long run operation, but no momentous effects of ratings in short term. In case of long run, the higher ratings segments facilitate comparatively additional credit risk price discovery as compared to the investment grade rating segments. Very few substantiation is retrieved for the effects of maturities on the credit risk price discovery phenomenon amid equity, bond and credit derivatives market, and the liquidity factor plays a significant role in the financial market's credit risk price discovery, which is consistent with the liquidity and trading cost explanations of other previous price discovery.

REVIEW OF LITERATURE

Overview of Price Discovery

Price discovery proposed to the procedure throughout which financial markets congregate on the equilibrium price of a fundamental benefit. It is the procedure of discovery an asset's complete information or fundamental value. Theoretically, when two markets for the same underlying asset are faced with the new information arriving simultaneously, these markets should react simultaneously and uniformly. When both markets do not react contemporaneously, one market leads the other. With such a lead-lag relationship, the leading market is said to provide price discovery.

The importance of price discovery lies in that, first, it is a necessary feature of efficient and transparent markets. The efficient market hypothesis requires no arbitrage opportunities and market prices that quickly reflect any new information affecting fundamental values. Second, if one market is leading other markets in setting an equilibrium price, then the securities in the other markets are mispriced, at least temporarily. Security prices will eventually converge to equilibrium price set by the leading market. Finally, price discovery study should provide empirical evidence for theoretical modeling of market and credit risk. Efficient market conditions suggest that all financial markets price the same underlying asset equally and simultaneously. However, trading cost, liquidity, market microstructure, and market imperfections, such as differing tax rates, information asymmetries, and prepayments could distort pure arbitrage relationships.

The empirical investigation in the part of price discovery is to some extent limited to the study of cash as well as futures markets. Garbade with Silber deliberated commodity prospect. Stoll & Whaley observed US stock directory futures. Poskitt has considered New Zealand interest rate futures. Upper & Werner (2002) observed German Bund markets as well as Mizarach&Neely has been proposed for US government bond markets. Flemming&Ostdiek (1996) initiated the trading cost hypothesis to give details price invention, which recommended that the market with the low on the whole trading costs will respond initial to new information. Booth, Lee, &Tse (1996) also recommended that superior transaction costs might reduce market information effectiveness. The common agreement in the cost discovery literature is that futures markets lean to guide cash markets owing primarily to comparatively lower transaction costs into futures markets.

The liquidity enlightenment of price invention was studied by Yan and Zivot (2004) in the FX markets. They originate that considerable price discovery transpire throughout the USD markets due to the superior liquidity of this market. The comparative liquidity as well as lower transaction costs of the USD markets is contributing to the competent incorporation of diverse economic information.

Price discovery is also interrelated to market microstructure. Auction markets, inter-dealer markets, open-outcry markets, computer trading systems and deficiency of price limits might result in conditions conductive to larger information competence as well as price discovery. Grunbichler et al. (1994) demonstrated that the employ of an electronic operate platform in the futures market amplified price discovery potential. Berkman&Steenbeek (1998) demonstrated that the deficiency of daily price limits resulted in greater information competence and a superior information share. Tse and Zabotina (2001) originate that markets with open outcry have higher market excellence than electronic market throughout volatile phase. Hasbrouck (2003) completed that, for the S&P500 as well as Nasdaq-100 index, price detection was conquered by electronically-traded futures agreement. Market imperfections can deform price detection. Information imperfections as well as asymmetric indication qualities can decrease price modification velocity. Taxation prepayment preference and dissimilar maturities guide to deformation of arbitrage correlation between closely-linked markets. Harris, McInish, and Wood (2002) originate in US commercial bond market little issue and implied selection frequently hamper corporate bond pricing. Lastly, Upper as well as Werner (2002) scrutinize financial markets' price detection during normal as well as volatile market circumstances. They establish the contribution to of price discovery of the spot market decreased considerably as well as spot trading merely go after the futures market throughout additional stressful periods. Price discovery was connected with sooner trading and wider spreads through more volatile periods.

Review of Price Discovery of Credit Risk

Prior credit risk investigation has highlighted entirely on testing credit risk models in personality financial markets, such as examining structural models in evenhandedness markets or concentrated form models in bond markets. Credit risk price invention investigates should calculated credit risk information from every credit-linked financial market consist of the bond, equity, moreover the rising credit derivatives markets.

Numerous credit risk price detection studies have listening carefully completely on information from immediately a particular or at the majority2 financial markets. For instance, Longstaff, Mithal, as well as Neiss (2004) considered a example of US bonds as well as originate that the information inside equity markets guide bond markets. Blanco, et al. (2004) established price discovery relations between the credit defaults swap market as well as a section of commercial credit markets by investigative the credit default swaps (CDS) spread as well as bond corporate treasury give way. It has been establish that the credit default swaps (CDS) market dominated the price discovery procedure while the connection market is not important. Blanco, Brennan, along with Marsh (2005) examined a set of European and US credits through applying credit default swaps (CDS) prices with credit spreads inside bond cash market along with establish that the credit default swaps (CDS) market is the main impetus for price invention. Crouch & Marsh (2005) examined arbitrage correlation among the credit default swaps (CDS) spreads as well as asset swap prices. Applying data for 9 huge auto manufacturers with different credit ratings, they established that credit default swaps (CDS) prices led benefit swap prices for the preponderance of this corporation. Campbell & Hendry (2006) intentional elevated incidence data in the price discovery procedure in equally Canadian & US 10-year government bond markets. They instituted that price discovery arises relatively additional frequently in futures markets than inside cash markets.

In conclusion, price discovery investigation for credit risk information crosswise every credit-linked economical markets, stock market, bond market (cash & futures), as well as credit derivatives market is absent unfamiliar. This described revision concentrate on this gap in the literature survey by examining the price discovery of credit risk (utilizing dissimilar credit risk measurements) crosswise every 3 markets: bond, equity, as well as credit derivates.

STATEMENT OF THE PROBLEM

The present study tries to understand and assessing the relationship between stock and bond market based on the concept of price discovery of credit risk.

– **Objectives of the study**:

1. To identify price discovery process and price discovery of credit risk.
2. To identify whether the stock market or the bond market is leading the other market in pricing an obligor's credit risk? In other words, which market provides price discovery for credit risk?

– **Hypothesis:**

To test whether the stock market or the bond market is the leading indicator of credit risk.

- *Hypothesis1: In financial sector the stock market dominates the bond market in credit risk price discovery for certain investment grade obligor;*
- *Hypothesis0: In credit risk price discovery the stock market dominates the bond market for a non-investment grade obligor;*

Research Methodology

1. Approaches of Credit Risk price Discovery

In certain work accomplished by Schreiber and Schwartz (1986) the paradigm of price discovery was stated as "explore for the price of stability". Similarly, Baillie (2002) represented price discovery in terms of "collection and the interpretation of data or news or events" and Lehmann (2002) stated it like "the process of incorporation of the data information contained with the financier trading into market prices." Such kind of understandings advocate that the price discovery is nothing else but a specific adaptive or dynamic phenomenon for exploring equilibrium that can be characterized by the speedy amendment of market prices from its previous equilibrium state to the new formed equilibrium stage with the influx of new data or market information. In general the process of credit risk price discovery represents a mechanism which lays down the foundation for pricing certain assets and confiscates certain new credit risk information.

Credit risk price discovery dynamics are characterized by:

1.1 Long term price discovery

How to identify the common efficient price and its innovation in long run?

If several securities on the same underlying asset are traded in several closely related markets, we should expect the price of a security would not deviate from its equilibrium price because of the arbitrage forces keeping the price close to the long–run equilibrium price. Empirically, the common efficient price and its innovations could be tested by examining cointegration of transaction price time series. This study follows Johansen cointegration test procedure to examine financial market's long-term equilibrium price of credit risk.

1.2 Short-term price discovery

How to identify the influences of the transitory price deviation from equilibrium on asset values in short-run?

The short-term price discovery dynamics is represented by the transitory price deviation from equilibrium price. The short-run transitory price deviations and the incorporation of new information into market price can be tested by examining the lead-lag relationships of different markets. This study will use Granger causality test, vector regression model (VAR), vector error correction model (VECM) and impulse response function (IRF) to investigate the short term lead-lag relationship of credit risk price discovery in financial markets.

1.3 Price discovery contribution

How to identify different market's contribution to credit risk pricing? Namely, how to measure each financial market's contribution to price discovery? The prices in the informationally-linked markets have a common factor innovation that links the stochastic processes in the cointegrated markets. The impact of new information on prices could be captured by the proportions of this common factor attributable to each market. The contributions could be captured by contributions of innovation in each market to the total variance. In this study, I will follow Hasbrouck (1995) information share (IS) methodology and Gonzalo and Granger (1995) common factor components (CFC) methodology to econometrically measure each financial market's contribution to credit risk price discovery.

2. Lead-lag relationship among stock market, bond market and credit derivative market

Short-term credit risk price discovery involves testing the lead-lag relationship among these markets. The Granger causality test and impulse response analysis are two econometrical techniques to examine the lead-lag relationship among time series. Both Granger causality test and impulse response analysis could be conducted in Vector Autoregressive Model and Vector Error Correction Model (VECM) depending on the stationarity and cointegration trend among testing time series.

2.1 Vector Autoregressive Model (VAR)

Weak stationarity is the sufficient and necessary condition for the use of VAR models. If the credit risk measures in stock market, bond market and credit derivative market all show weak stationarity, the lead-lag relationship among each variable could be tested in following VAR system

$$\begin{bmatrix}\Delta S_t\\ \Delta B_t\\ \Delta D_t\end{bmatrix}=\begin{bmatrix}C_1\\ C_2\\ C_3\end{bmatrix}+\begin{bmatrix}\sum_{j=1}^{p}\varphi_{1,j}\,\Delta S_{t-j}\\ \sum_{j=1}^{p}\varphi_{2,j}\,\Delta S_{t-j}\\ \sum_{j=1}^{p}\varphi_{3,j}\,\Delta S_{t-j}\end{bmatrix}+\begin{bmatrix}\sum_{j=1}^{p}\varphi_{1,j}\,\Delta B_{t-j}\\ \sum_{j=1}^{p}\varphi_{2,j}\,\Delta B_{t-j}\\ \sum_{j=1}^{p}\varphi_{3,j}\,\Delta B_{t-j}\end{bmatrix}+\begin{bmatrix}\sum_{j=1}^{p}\varphi_{1,j}\,\Delta D_{t-j}\\ \sum_{j=1}^{p}\varphi_{2,j}\,\Delta D_{t-j}\\ \sum_{j=1}^{p}\varphi_{3,j}\,\Delta D_{t-j}\end{bmatrix}+\begin{bmatrix}\varepsilon_{1,t}\\ \varepsilon_{2,t}\\ \varepsilon_{3,t}\end{bmatrix}$$

Where S is credit risk measures in stock market, B is credit risk measures in bond market and D is credit risk measures in credit derivatives market. After the VAR model estimation, lead-lag relationship could be tested using Granger causality test or impulse response analysis.

Granger (1969) causality tests the empirical relationship among time series without imposing limitations on the long-run consistency of price dynamics. The bivariate autoregressive specification of Granger causality with intercept between stock market credit risk and bond market credit risk could be written as

$$\Delta S_t = c_1 + \sum_{j=1}^{q} a_{1,j}\, \Delta S_{t-j} + \sum_{j=1}^{q} \beta_{1,j}\, \Delta B_{t-j} + V_{1,t}$$

$$\Delta B_t = c_2 + \sum_{j=1}^{q} a_{2,j}\, \Delta S_{t-j} + \sum_{j=1}^{q} \beta_{1,j}\, \Delta B_{t-j} + V_{2,t}$$

The joint rejection of $H_0: \beta_{1,t-1} = \beta_{1,t-j} = \cdots = \beta_{1,t-q} = 0$ implies that ΔB strictly Granger causes ΔS. Similar statistical significance of $a_{2,t-j}$ across all lagged endogenous variables indicates a similar feedback effect of ΔS on ΔB. When ΔB strictly Granger causes ΔS, we also say that the change of bond market credit risk leads the change of stock market changes.

Another way to test the lead-lag relationship is analyzing the impulse response of each time series on the shocks. The moving average representation could be written as

$$\begin{bmatrix} S_t \\ B_t \\ D_t \end{bmatrix} = \begin{bmatrix} \bar{S} \\ \bar{B} \\ \bar{D} \end{bmatrix} + \sum_{i=0}^{\infty} \begin{bmatrix} \phi_{11}(i) & \phi_{12}(i) & \phi 3(i) \\ \phi_{21}(i) & \phi_{22}(i) & \phi_{23}(i) \\ \phi_{31}(i) & \phi_{32}(i) & \phi_{33}(i) \end{bmatrix} \begin{bmatrix} \varepsilon_{St-i} \\ \varepsilon_{Bt-i} \\ \varepsilon_{Dt-i} \end{bmatrix}$$

Or

$$X_t = \mu + \sum_{i=0}^{\infty} \phi_i \varepsilon_{t-i}$$

The coefficients $\phi_{jk}(i)$ are called impulse response function. After VAR parameters estimation, the impulse response function could be plotted to identify the response of each time series to the shocks. This study will use both Granger causality test and impulse response function to test the short-term credit risk price discovery among the three markets.

2.2 Vector Error Correction Model (VECM)

In general way the paradigm called Vector Error Correction Model (VECM) can be stated as a inhibited Vector Autoregressive Model. As soon as the variables of the vector are found these are at first cointegrated at initial or first order. In such a system the vector error correction model (VECM) can be effectively employed for exploring the dynamicity of co-movement amongst the varied time sequences at varied levels. VECM represents a linear appearance of the stochastic information process of generation. The individual attributes in the representation is taken into consideration endogenous, encompassing from two entities. Initially, it represents a linear function of the previously realized attributes in the paradigm while the later or in secondary it represents a capricious novelty constituent. VECM restricts the long-run behavior of endogenous variables to converge to their cointegration relationships (through price adjustments) while allowing a wide range of short run dynamics of past price movements as random disturbances on joint price dynamics within a linear system of simultaneous equations. The degree of cointegration is reflected in the specification of error correction term, which gradually corrects past deviations from long-run equilibrium through a series of partial short-run price adjustments.

A VECM (p) is written as

$$\begin{bmatrix}\Delta S_t\\ \Delta B_t\end{bmatrix} = \begin{bmatrix}\delta_{1t}\\ \delta_{2t}\end{bmatrix} + \prod \begin{bmatrix}S_{t-1}\\ B_{t-1}\end{bmatrix} + \sum_{i=1}^{p-1} \Phi_i \begin{bmatrix}\Delta S_{t-1}\\ \Delta B_{t-1}\end{bmatrix} + + \begin{bmatrix}\varepsilon_{1t}\\ \varepsilon_{2t}\end{bmatrix}$$

Where

$$\prod = \begin{bmatrix}\alpha_1\\ \alpha_2\end{bmatrix}[1, -\beta]$$

The model can also be written as

$$\begin{bmatrix}\Delta S_t\\ \Delta B_t\end{bmatrix} = \begin{bmatrix}\alpha_1\\ \alpha_2\end{bmatrix}(S_{t-1} - \lambda - \beta B_{t-1}) + \sum_{i=1}^{p-1} \Phi_i \begin{bmatrix}\Delta S_{t-1}\\ \Delta B_{t-1}\end{bmatrix} + + \begin{bmatrix}\varepsilon_{1t}\\ \varepsilon_{2t}\end{bmatrix}$$

The lagged difference between both level series denotes the "error correction term" (or "cointegration term") as an additional endogenous variable of possible long-term consistency (with complete cointegration$\lambda = 0\ and\ \beta = 1$). A significant negative $\alpha_1$means stock market react to the price changes in bond market which implies that bond market is leading market.

And a positive $\alpha_2$shows that a change in stock market results in price adjustment in bond market and indicates that stock market leads the bond market. If both adjustment coefficients are significant with the correct signs, the relative magnitude of the two coefficients will reveal the leading market. The same as in VAR model Granger causality test and impulse response analysis could be applied to test the lead-lag relationship among these markets after VECM estimation.

Hypothesis Discussion

From the illustration of Merton model in Figure 1 the asset value (or equity price) drives a company's distance to default. The higher equity price, the further away this company is from the default. Also, from the liquidity and transaction cost explanation of price discovery,

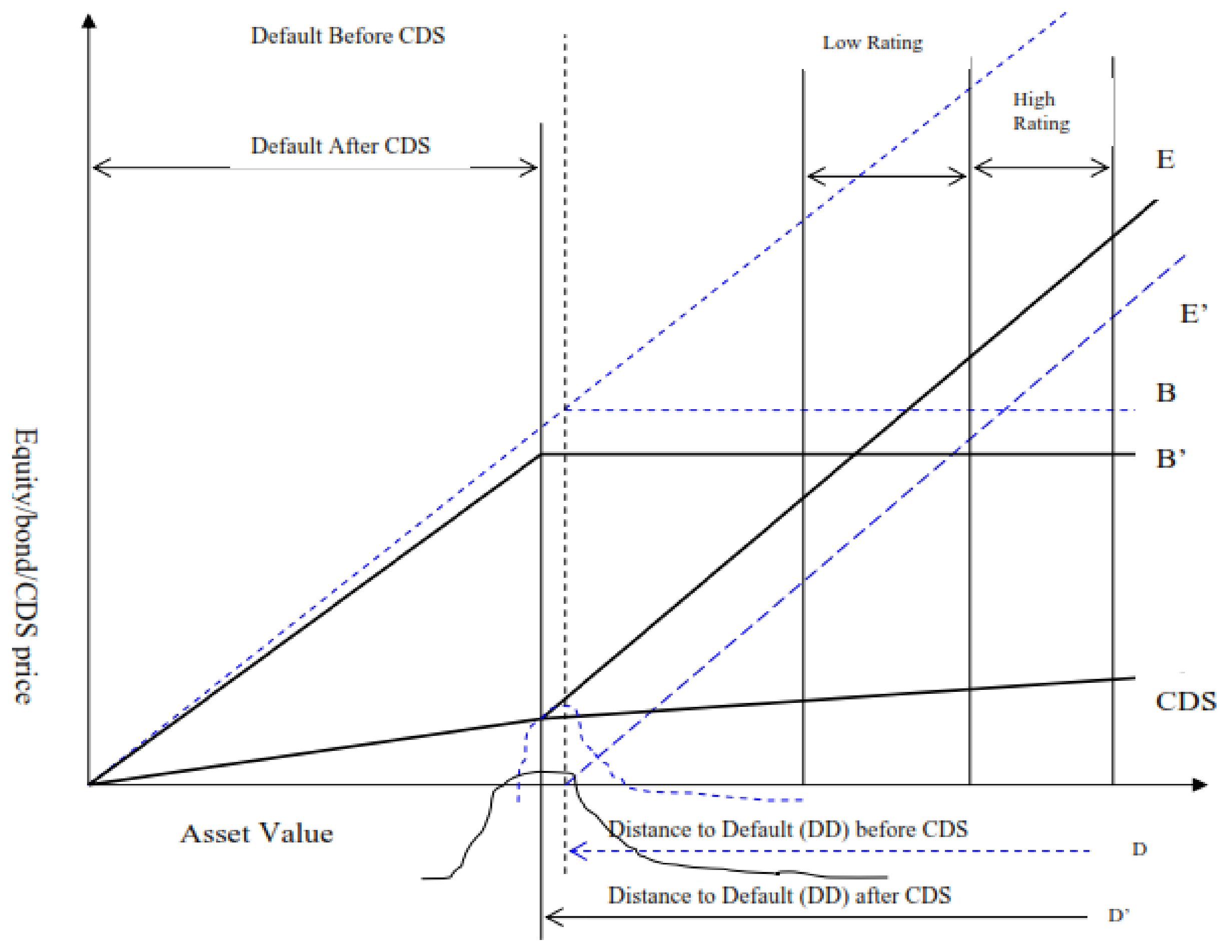

Figure 1 Credit risk relationship between equity, bond and CDS market

I expect stock market implied default probability will lead the bond market derived default probability because the stock market drives the default process and the stock market is a more liquid with lower transaction costs.

This leads to the research hypothesis:***Stock market leads the bond market in price discovery of an obligor's credit risk.***

I use distance to default (DD) as the measurement of stock market implied credit risk (Merton 1976), which is derived from the stock market transaction prices. The bond market implied credit risk is measured by several variables: option adjusted spread, i-spread, and z-spread (Duffie and Singleton, 1997), which is derived from bond prices. Due to the different market dynamics in investment grade and high-yield bond markets, two sub-hypothesis are as follows:

Hypothesis1: *Stock market leads the bond market in credit risk price discovery for an investment grade obligor;*

Hypothesis0: *Stock market leads the bond market in credit risk price discovery for a non-investment grade obligor;*

Merton Structure

The trigger of the default event of a company is that the asset value (A) of a company falls below the face value (D) of all debt obligations. The face value of the debt is the exercise price of the put option of the equity. If the firm's liabilities are approximated as a single issue of pure discount debt with face value D maturing at date T, then the boundary condition for the equity (E) of the firm at date T is $E_T = max\{0, A_T - D\}$which is identical to the boundary condition for a call option. This shows that equity is a call option on the assets of the firm with exercise price equal to the face value of its debt obligations (D).

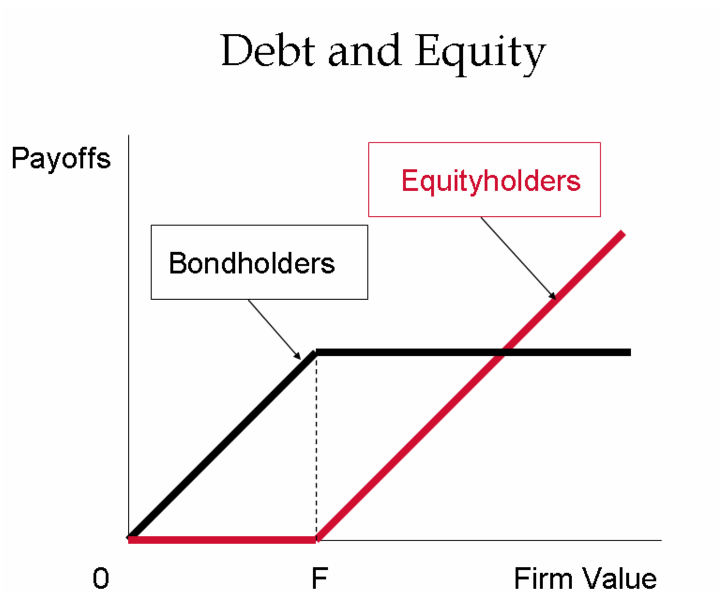

Figure 2 Merton Model

Let $E_0$and A_0be the values of equity and asset today and ET and AT are their values at time$T$, assuming the asset value a lognormal diffusion process then the current equity price is therefore

$$E_0 = E_0 N(d_1) - De^{-rT} N(d_2)$$

Where,

$$d_1 = \frac{\ln(\frac{A_0 e^{\frac{r}{T}}}{D})}{\sigma_A \sqrt{T}} + 0.5\sigma_A \sqrt{T}$$

$$d_2 = d_1 - \sigma_A \sqrt{T}$$

This is exactly the BS call option pricing equation. $\sigma_A$is the volatility of the asset value, and r is the risk-free rate, both of which are assumed to be constant.

Now, define$D^* = D_e r^{-T}$ as the present value of the face value of the debt obligations and let $L = D^*/A$ be the measure of leverage, then using these definitions the equity value is $E_0 = A_0[N(d_1) - LN(d_2)]$

Where,

$$d_1 = \frac{\ln(L)}{\sigma_A \sqrt{T}} + 0.5\sigma_A \sqrt{T}$$

$$d_2 = d_1 - \sigma_A \sqrt{T}$$

Because the equity value is a function of the asset value (Jones et al 1984), we can determine the instantaneous volatility of the equity from the asset volatility

$$E_0 \sigma_E = \frac{\partial E}{\partial A} A_0 \sigma_A$$

Where σ_E is the instantaneous volatility of the company's equity at time zero.

Thus,

$$\sigma_E = \frac{\sigma_A N(d_1)}{N(d_1) - LN(d_2)}$$

The distance to default (DD) can be calculated by$DD = (A - D)/\sigma_A$, which isd_1. Then the risk-neutral probability P that the company will default by time T is the probability that shareholders will not exercise their call option to buy the assets of the company for D at time$T$. The probability of default (PD) is given by

$$PD = 1 - P(DD) = 1 - N(d_1) = N(-d_2)$$

The probability of default (PD) depends on the leverage L, the asset volatility σ_A and the time to maturity$T$.

Implied credit spread of the risky debt from Merton model.

We can use Merton model to derive the yields on the risky debt securities. Define $B_0$the market price of the debt at time zero. The value of the assets at any time equals to the total value of the debt financing and equity.

$$B_0 = A_0 - E_0$$

Further simplifying,

$$B_0 = A_0[N(-d_1) - LN(d_2)]$$

The yield to maturity on the debt is defined implicitly by

$$B_0 = De^{-yT} = D^* e^{(r-y)T}$$

Using $A_0 = D^*/L$ gives the yield to maturity y as

$$y = r - ln\left[N(d_2) + \frac{N(-d_1)}{L}\right]/T$$

The credit spread a s implied by the Merton model is therefore

$$s = y - r = -ln\left[N(d_2) + \frac{N(-d_1)}{L}\right]/T$$

Same as the risk-neutral probability of default (PD), the implied credit spread depends only on leverage$L$, the assetsσ_A, and time to maturity T.

Conclusions and recommendations

In this research paper price discovery for credit risk for stock and bond markets has been explored and investigated for certain defined time. And it can be concluded that, the stock market facilitates approximately more than 80% of price discovery contribution in case of credit risk and even this financial market dominates the bond market too.

For the short term lead-lag relationship, stock market is leading both the investment grade and high yield bond market rating segments. The causality tests between the stock market and both investment grade and high yield bond rating segments are not significant. Also no leading-lag relationship is found between the investment grade and high yield bond rating segments. The short term leading-lag relationship between the stock market and bond market rating segments confirms that stock market is leading the bond market.

Finally, it is found from this study that the liquidity factor plays a significant role in the financial market's credit risk price discovery, which is consistent with the liquidity and trading cost explanations of other previous price discovery research. Future research can be extended in several ways. First, this study tests the influences of the liquidity, transaction cost, maturity and credit ratings influence on credit risk price discovery. According to the Merton model, the asset volatility is also a factor that affects the default risk. We can extend this present study to test the financial market's credit risk price discovery under different market conditions, such as normal, volatile and stress periods. Second, current research empirically examines credit derivative market influences on the credit risk price discovery within the Merton structural framework. Third, the credit risk price discovery research can be extended from the stock market and bond market to credit securitized market, such as collateral debt obligation (CDOs) market, collateral loan obligation (CLOs) market, and asset backed securities (ABS) market. Fourth, this research studies financial markets' price discovery for corporate borrowers. The future studies could also include the consumer's credit risk price discovery in financial markets.

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