IOSR Journal of Economics and Finance (IOSR-JEF)
e-ISSN: 2321-5933, p-ISSN: 2321-5925.Volume 8, Issue 6 Ver. I (Nov.- Dec .2017), PP 54-61
www.iosrjournals.org

A Merton Model Approach to Assessing the Default Risk: An Application on Selected Companies from BIST100[1]

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Abstract: *The main objective of this study is to show how the Merton Model approach can be used to estimate the default probabilities of selected BIST100companies. The inputs of the Merton model include stock returns volatility, the company's total debt, the risk-free interest rate andthe time. They are all known or computable parameters. Instead of the risk-free rate, one-year treasury constant maturity rate obtained from TUIK was used. In addition, distance to default and expected default frequencies of these companies are calculated and their correlation with total debt are examined.*

Key words: *Merton Model, Black& Scholes, Default probability.*

Date of Submission: 13-10-2017 Date of acceptance: 30-11-2017

I. Introduction

Credit risk is perceived as the oldest and most important risk of finance and the development of credit-risk modeling can be traced back to Beaver's (1966) based study, which illustrates significant differences in financial ratios between bankrupt and non-bankrupt companies. In other words, some statistical modelsdivide companies into two groups or clusters such as bankrupt and non-bankrupt. In addition, the prediction of company failure or bankruptcy has been well-researched using developed country data (Beaver 1966; Altman 1968; Deakin 1972; Ohlson 1980; Taffler 1983; Boritz). For instance, Ohlson selected 9 independent variables by thinking that they should be beneficial to forecast the bankruptcy situation, but did not provide a theoretical basis for selection of these variables.Ohlson then chose at least 3 years US stock exchange trading industrial companies for the period of 1970 and 1976.He ended up with 105 failed companies and 2000 non-failed companies. In this study, there were three models that had been estimated. The first model examines the failures within one year. The second examines the failures within two years and the last one examines the failures within one or two years. In these three models, to predict bankruptcyor the probability of failure, he used a logistic function.

Another type of credit-risk model is based on the option-pricing model of Black&Scholes (1973). For instance, Merton (1974) has shown that by using an option-pricing model, company's default probability can be estimated. Vassalou and Xing (2004) showed that using the Merton model, the default likelihood indicator could capture the default risk. In addition, they suggest that company size and book-to-market ratio could be seen as default-related factors. Moreover, Hillegeist, Keating, Cram and Lundstedt (2004) found that the performance of the Merton model was superior to that of accounting models such as Altman's Z-Score and Ohlson's O-score models, while explaining corporate bankruptcies.

One can also estimate default probabilities by using historical data, from bond prices and from credit default swap spreads or asset swaps. In this study, we choose the Merton model to calculate the default probabilities of non-failure companies chosen from BIST100.

II. Merton Model

A model for assessing the credit risk of a company by characterizing the company's equity as European call option, which is written on its assets, has been proposed by Robert Merton in 1974. Merton Model assumes that a company has a certain amount of zero-coupon debt that will become due at a future time. According to Jones (1984), the default risk for the Merton Model is so low that pricing ability for investment-grade bills is not better than a pure model that assumes no default risk.Afik et all investigates in their study that simplified applications of the Merton model have superior model power compared to more complex and computationalintensive methods (2016) and they recommend to use simple original model.

As inputs, Merton's model requires the current value of the company's assets (A_0), the volatility of the

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[1]This article is derived from PhD thesis "Estimating Bankruptcy Probability Using Fuzzy Logic: An Application to a Panel of US and Turkish Sectors", T.C Kadir Has University, 2012.

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company's assets (σ_A), the outstanding debt, and the debt to maturity. One way to implement the Merton model is to use the approach proposed by Jones et al. (1984) to calculate the present value of the company assets and the volatility of the asset from the market value of the company's own equity and the instant volatility of equity. A debt maturity date is selected and debt payments are matched to a single payment on the same date in some way. To sum up, Merton model generates the probability of default (PD) for each company in the sample at any given point in time. In this study, we use following notation, which is defined for variables that we did not mentioned before, that we use to construct Merton Model.

A_t : Value of company's assets at time t

D^T : Debt repayment due at time T

E_0 : Value of company's equity today

E_T : Value of company's equity at time T

σ_E : Instantaneous volatility of equity

If the value of company's assets is worth less than the promised debt repayment at time T, the company defaults. In other words, model assumes that the company promises to pay D^T to the bondholders at maturity T. If this payment is not met, that is, if the value of the company's assets at maturity is less than D^T , the bondholders take over the company and shareholders receive nothing.

The equity of the company can be seen asa European call option on the assets of the company with maturity T and strike price can be seen equal to the face value of the debt. Notice that default can be triggered only at maturity and this happens only when $A_T < D^T$ .In other words, the payoff of equity holders is equivalent to European call option on the assets of the company with a strike price D^T and maturity T.

$$E_T = \max(A_T - D^T, 0)$$

The payoff of debt holdersis equivalent to a portfolio, which consists of a European put option and debt. The strike price of the European put option is D^T with maturity T and written on the assets of the company. So, its value at time T is $\min(A_T, D^T)$, which is equal to $D^T - \max(D^T - A_T, 0)$ and Table 1 summarizes this situation and illustrates the value of portfolio at maturity.

Table 1: The Value of Portfolio

	At Time 0	**At Time T**	
		$D^T > A_T$	$D^T < A_T$
Equityholders	European Call Option	**Not Exercised**	$A_T - D^T$
Debtholders	European Put Option+Debt	$D_T - A_T$	**Not Exercised** + D^T

The model assumes that the underlying value of each company follows a geometric brownian motion and that each company has issued just one zero-coupon bond. TheBlack & Scholes pricing modeland also Merton model assumes that there are no transaction costs, no taxes, no dividends, the risk-free interest rate is constant and same for all maturities. The remaining assumption of the model is that security trading is continuous function. At the end, the price follows a geometric brownian motion with constant drift parameter and volatility.One of the important assumptions and weakness of the model that the company can default only at time T. Merton's approach should be avoided if the debt can be recovered in the case of a debt, if the value of the company falls to a minimum level before the maturity of debt. To cope with this difficulty the problem can be handled by constructing the model on barrier option.

2.1 Forecasting Default Probabilities with KMV Merton Model

The KMV-Merton model adapts Merton' study in 1974, in which the equity of the company is a European call option on the underlying value of the company with a strike price equal to the face value of the company's debt. The model recognizes that the volatility of the company and its underlying value can not be directly observed. According to the model's assumptions both of these values can be subtracted from equity value, the volatility of equity and other observable variables by solving two nonlinear simultaneous equations. After these values are calculated, the model indicates that the PD is the normal cumulative density function of a Z-score based on the underlying value of the company, volatility of the company and the face value of the company's debt. The Merton model has two important assumptions. The first is that the total value of a company is assumed to follow geometric brownian motion,

$$dV = \mu V dt + \sigma_V V dW$$

where,

V: the total value of the company.
σ_V: the volatility of the company value.
μ: the expected return on V.
dW : standard Weiner Process.

The second assumption of the Merton model is that the company has exported a discount bond maturing during the T period. Under these assumptions, the company's equity is a call option on the company's underlying value with a strike price equal to the face value of the company's debt and time to maturity T. And the value of equity as a function of the total value of the company can be defined by the Black-Scholes-Merton Formula. Withthe help of put-call parity (relationship between price of call and put option), we can say that the value of the company's debt is equal to the value of a risk-free discount bond minus the value of a put option (European type) written on the company, again with a strike price equal to the face value of debt and a time-to-maturity of T. The Merton model stipulates that the equity value of a company today, which is denoted by E_0 , satisfies the equation (1).

$$E_0 = A_0 N(d_1) - e^{-rT} D^T N(d_2) \qquad (1)$$

where $d_1 = \dfrac{\ln\left(\dfrac{A_0}{D^T}\right) + \left(r + 0.5\sigma_A^2\right)T}{\left(\sigma_A \sqrt{T}\right)}$, $d_2 = d_1 - \sigma_A \sqrt{T}$

and N is the cumulative density function of the standard normal distribution, r is the risk-free rate of interest in continuous terms.The equation (1), express the value of a company's equity as a function of the value of the company and time. Now, consider d_1 :

$$d_1 = \frac{\ln\left(\frac{A_0}{D^T}\right)}{\left(\sigma_A\sqrt{T}\right)} + \frac{\mathrm{rT}}{\left(\sigma_A\sqrt{T}\right)}\frac{0.5\sigma_A^2 T}{\left(\sigma_A\sqrt{T}\right)} = \frac{\ln\left(\frac{A_0}{D^T}\right)}{\left(\sigma_A\sqrt{T}\right)} + \frac{\ln \mathrm{e}^{\mathrm{rT}}}{\left(\sigma_A\sqrt{T}\right)} + 0.5\sigma_A\sqrt{T} = \frac{\ln\left(\frac{A_0 e^{rT}}{D^T}\right)}{\left(\sigma_A\sqrt{T}\right)} + 0.5\sigma_A\sqrt{T}$$

Let $L = \dfrac{D^T e^{-rT}}{A_0}$, which denotes Leverage. Since $E_0 = A_0 N(d_1) - e^{-rT} D^T N(d_2)$, with replacement of the value of leverage, $E_0 = A_0 N(d_1) - LA_0 N(d_2)$.Consider the inverse of Leverage: $L^{-1} = \left[\dfrac{D^T e^{-rT}}{A_0}\right]^{-1} = \dfrac{A_0 e^{rT}}{D^T}$.

Since $d_1 = \dfrac{\ln\left(\dfrac{Aoe^{rT}}{D^T}\right)}{\left(\sigma_A\sqrt{T}\right)} + 0.5\sigma_A\sqrt{T}$, $d_1 = \dfrac{-\ln(L)}{\left(\sigma_A\sqrt{T}\right)} + 0.5\sigma_A\sqrt{T}$ and $d_2 = d_1 - \sigma_A\sqrt{T}$.

Shown by Jones, Masan, Rosenfeld (1984), equity value is a function of asset value. By Ito's Lemma, $E_0\sigma_E = \dfrac{\partial E}{\partial A} A_0 \sigma_A$. Since σ_E is the instantaneous volatility of the company's equity at time 0.

$$\sigma_E = \frac{\frac{\partial E}{\partial A} A_0 \sigma_A}{E_0} = \frac{\frac{\partial E}{\partial A} A_0 \sigma_A}{A_0 N(d_1) - LA_0 N(d_2)} = \frac{N(d_1)\sigma_A}{N(d_1) - LN(d_2)}.$$

If the variables E_0, σ_E, L, T are known, A_0, σ_A. can be estimated.

When we consider the volatility of the equity $\sigma_E = \dfrac{\frac{\partial E}{\partial A} A_0 \sigma_A}{E_0}$, $\dfrac{\partial E}{\partial A}$ is the delta of the call option and equal to $N(d_1)$ and $\dfrac{\partial E}{\partial A}\dfrac{E_0}{A_0}$ is elasticity of the company's equity against the value of the assets.

In the KMV-Merton model, while the value of the call option is observed as the total value of the company's own capital (equity), the value of the underlying asset can not be directly observed. So, if V needs to be removed, E is easy to observe in the market by multiplying company stocks by the current share price. Similarly, in the KMV-Merton model, the volatility of equity (σ_E) can be estimated but the volatility of the underlying company (σ_A) must be inferred. PD is equal to $N(-d_2)$. As we mentioned before, probability of not defaulting occurs when $A_T \geq D^T$, this happens with probability of $N(d_2)$. This means, PD= 1 - $N(d_2)$= $N(-d_2)$.

Since d_2 is equal to $d_1 - \sigma_A\sqrt{T}$ and if we try to express d_2 in terms of Leverage, the following equation holds.

$$d_2 = \frac{-\ln(L)}{(\sigma_A\sqrt{T})} + 0.5\sigma_A\sqrt{T} - \sigma_A\sqrt{T} .$$

In other words, to find the values of PD, we need to calculate the Leverage (L), volatility of the assets (σ_A) and set a value tothe maturity (T).

2.3 Simplification of Distance to Default (DD)

The simplified expression contains only observable parameters and DD can be computed without solving nonlinear equations. The simplification is based on three assumptions, such as the value of $N(d_1)$ is close to 1, the limit of the drift term is equal to 0, instead of leverage ratio book value should be taken.

$$DD = d_1 - \sigma_A\sqrt{T} = \frac{\ln(A_0 / D^T) + (r + \frac{1}{2}\sigma_A^2)T}{\sigma_A\sqrt{T}} - \sigma_A\sqrt{T} = \frac{\ln(A_0 / D^T) + (r - \frac{1}{2}\sigma_A^2)T}{\sigma_A\sqrt{T}}$$

Now, since the drift term is so close to the zero, then $(r - \frac{1}{2}\sigma_A^2)T = 0$.If we rewrite the explanation of the volatility of the assets using Ito's Lemma, we have the following expressions.

$$DD = \frac{\ln(A_0 / D^T)}{E_0\sigma_E\sqrt{T}A_0}$$

Since L (leverage ratio) is equal to $\frac{D^T}{A_0}$ and T=1, $DD = -\frac{\ln(L)}{E_0\sigma_E A_0}$.

The DD is simply the number of standard deviations of a company that is away from the default point within a specified time horizon. Companies with smaller DD values are more likely to have greater probability of default. It can be used to rank different companies according to their creditworthiness. Expected default frequencies (EDF) can be calculated by the help of DD and basic calculations.

III. Application

We have examined 50 companies from BIST100 for five years period. The total debt of the company, the risk-free interest rate and the volatility of stock returns andthe maturity to debt are input variables of the Merton model. They are all known or computable parameters. For the risk-free rate; the one-year treasury constant maturity rate from TUIK has been used and maturity to debt was accepted as 1 year.

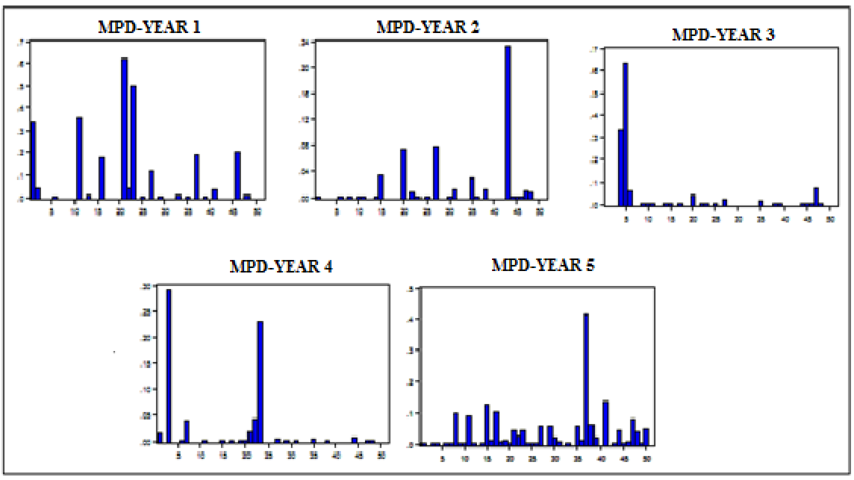
As a first step, the volatility of BIST100 stocks is calculated by using the return data retrieved from BIST100 website. In this calculation, logarithmic returns are used.Later the unobservable parameters were calculated simultaneously using equations derived from the Ito's Lemma and Put-Call Parity.To solve these equations excel goal seek function has been used. Having all these parameters, the value of N(-d_2)is calculated. All these calculations are repeated for each company for a period of five years.At the end of the first step, all MPD values of each company over the five year period had been calculated and Table 1 illustrates the results of this step, in other words it represents MPD values of BIST100 companies.

Table 1: TheMPD Values of Selected BIST100 Companies

	Year-1	Year-2	Year-3	Year-4	Year-5		Year-1	Year-2	Year-3	Year-4	Year-5
C1	*0.3401*	*0.0008*	*0.0000*	*0.0164*	*0.0001*	**C26**	0.0000	0.0000	0.0000	0.0000	0.0005
C2	0.0414	0.0000	0.0000	0.0000	0.0000	**C27**	0.1160	0.0778	0.0240	0.0041	0.0571
C3	0.0000	0.0000	0.0000	0.2906	0.0001	**C28**	0.0000	0.0000	0.0000	0.0000	0.0000
C4	0.0000	0.0000	0.3371	0.0000	0.0007	**C29**	0.0000	0.0000	0.0000	0.0000	0.0561
C5	0.0000	0.0000	0.6349	0.0000	0.0000	**C30**	0.0000	0.0000	0.0000	0.0000	0.0222
C6	0.0005	0.0005	0.0582	0.0023	0.0017	**C31**	0.0000	0.0127	0.0000	0.0001	0.0081
C7	0.0000	0.0000	0.0000	0.0394	0.0039	**C32**	0.0000	0.0000	0.0000	0.0000	0.0000
C8	0.0000	0.0000	0.0000	0.0000	0.0966	**C33**	0.0109	0.0000	0.0000	0.0000	0.0000
C9	0.0000	0.0000	0.0000	0.0000	0.0015	**C34**	0.0000	0.0000	0.0000	0.0000	0.0000
C10	0.0000	0.0011	0.0000	0.0000	0.0019	**C35**	0.0001	0.0302	0.0138	0.0031	0.0577
C11	0.3573	0.0003	0.0003	0.0012	0.0875	**C36**	0.0000	0.0000	0.0000	0.0000	0.0116
C12	0.0000	0.0000	0.0000	0.0000	0.0001	**C37**	0.1886	0.0000	0.0000	0.0000	0.4152
C13	0.0114	0.0000	0.0000	0.0000	0.0000	**C38**	0.0000	0.0122	0.0000	0.0000	0.0616
C14	0.0000	0.0004	0.0002	0.0000	0.0033	**C39**	0.0000	0.0000	0.0019	0.0000	0.0210
C15	0.0000	0.0352	0.0000	0.0000	0.1251	**C40**	0.0000	0.0000	0.0000	0.0000	0.0000
C16	0.1775	0.0000	0.0000	0.0000	0.0110	**C41**	0.0323	0.0000	0.0000	0.0000	0.1366
C17	0.0000	0.0000	0.0003	0.0020	0.1014	**C42**	0.0000	0.0000	0.0000	0.0000	0.0000
C18	0.0000	0.0000	0.0000	0.0000	0.0063	**C43**	*0.0000*	*0.2314*	*0.0000*	*0.0000*	*0.0007*
C19	0.0000	0.0000	0.0000	0.0008	0.0135	**C44**	0.0000	0.0018	0.0003	0.0059	0.0450
C20	0.0000	0.0727	0.0388	0.0001	0.0020	**C45**	0.0000	0.0002	0.0004	0.0000	0.0027
C21	0.6178	0.0000	0.0000	0.0180	0.0451	**C46**	0.2023	0.0002	0.0007	0.0000	0.0072
C22	0.0414	0.0084	0.0018	0.0417	0.0252	**C47**	0.0000	0.0101	0.0733	0.0000	0.0809
C23	0.4991	0.0001	0.0000	0.2285	0.0427	**C48**	0.0080	0.0069	0.0004	0.0000	0.0410
C24	0.0000	0.0000	0.0000	0.0000	0.0000	**C49**	0.0000	0.0000	0.0000	0.0000	0.0000
C25	0.0031	0.0000	0.0024	0.0000	0.0014	**C50**	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0465*

As can be seen from Table 1; in the first year, the MPD value of C1 is equal to 0.34 and after one year, the default probability decreases rapidly to 0.0008. In the third year, it remains nearly the same or so close to zero. In addition, the same type of issue happens for C43. Although the MPD value of C43 was 0.2314 in the second year, it was observed that the value one year ago and one year later is very close to zero. When these values were examined, similar cases were frequently found for different companies. Since companies are selected from BIST100, we are expecting that the values of MPD so close to 0, like C49. Since the values are too close to each other (or 0), it prevents us to see the differences. In the light of this information, since the MPD values of the non-failure companies are very close to each other or close to zero, we can not comment or compare according to their bankruptcy situation.

Graph 1:MPD of Selected BIST Companies



As seen from Graph 1, MPD values are so close to zero or one. It also changes rapidly within one year. We think that it is not accurate to say that a company X may default to about 100%, after one year later it may default to about 0.00%. Also, from Graph 1 we can see whether the MPD values have not increased or decreased over time, which also gives the information that they does not seem as a continuous function. It changes rapidly and nonsense.Table 2 shows DD values of each company for all years.As can be seen from Table 2, the DD value for C46 is 0.9871. Based on this model, for the first trading year we can say that C46 is less than 1 (real value: 0.9871) standard deviation away from its default. This indicates that C46 was closer to a default than it looks. For instance, the DD value for C38 is 28.4669, which means for the trading year 1, 28.4669 standard deviation to be precise and one year later its DD value is 1.3660. Since DD values are derived from Merton model, similar problems as in MPD values are examined.

Table 2: The DD Values of Selected BIST100 Companies

	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**		**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
C1	0.7820	1.8645	0.1882	0.3106	-12.1122	**C26**	6.1855	4.1083	3.9172	13.0768	3.0025
C2	1.9130	4.6354	4.4418	10.7553	5.0830	**C27**	-17.6451	-23.2083	-28.0075	-32.2577	1.6626
C3	6.6760	5.8626	1.7813	0.5655	1.2225	**C28**	8.3193	11.4588	10.2467	14.2190	11.1770
C4	10.2374	6.0936	0.7135	6.5240	2.4472	**C29**	3.8540	4.9754	7.1989	1.1723	-0.0985
C5	5.9498	5.7318	0.7842	13.2675	4.4321	**C30**	3.0299	3.3185	7.5200	3.9785	1.6552
C6	1.6276	1.6276	-0.0449	0.7090	1.0082	**C31**	7.1974	2.0842	4.8636	3.4374	2.2491
C7	4.4208	3.5366	2.6609	0.8972	0.0501	**C32**	5.1457	5.9615	6.6150	14.6239	6.1476
C8	12.1741	3.7320	9.3941	10.9506	1.8649	**C33**	2.5383	5.4359	5.0033	10.0143	4.2288
C9	7.0194	4.0880	2.0732	4.8166	2.3852	**C34**	7.2201	6.5421	30.5370	12.2752	13.6705
C10	2.0282	2.4154	2.8915	6.4978	2.7986	**C35**	-4.8132	-13.3920	-28.4253	-16.7535	-3.7979
C11	0.4325	1.0680	1.3232	1.5483	-4.1883	**C36**	4.9431	4.2494	4.4045	4.1476	1.2350
C12	7.3573	5.2600	9.8937	8.2861	3.8453	**C37**	1.0594	14.5642	8.8672	8.2181	1.1309
C13	1.9443	7.2438	6.4341	20.4941	5.7919	**C38**	*28.4669*	*1.3660*	*2.1887*	*0.4972*	*-9.4179*
C14	16.0748	2.3664	2.9366	11.6846	2.2905	**C39**	2.7205	5.9720	2.8964	6.1214	0.5468
C15	1.6466	-1.3672	-1.5107	-0.4800	-1.1720	**C40**	8.8708	10.3643	6.0016	9.4457	7.2592
C16	1.5329	5.9413	8.3713	11.9882	2.6463	**C41**	2.0924	9.5007	7.8673	12.6525	1.7492
C17	5.4600	7.3758	1.6731	-1.2834	-11.7706	**C42**	15.2403	8.5849	16.9193	33.6296	5.3103
C18	10.6772	5.3307	7.6411	5.0637	1.0389	**C43**	16.6018	1.3153	8.1293	5.2110	3.1641
C19	9.2172	6.0727	5.2884	2.2871	1.0085	**C44**	4.0674	0.6160	-3.2534	-0.8353	-0.2276
C20	-0.8463	0.2344	0.8702	1.9913	2.2245	**C45**	-36.3628	2.9622	3.2335	13.0020	2.6676
C21	0.7579	3.7025	3.5941	1.6194	0.6073	**C46**	0.9871	2.3937	2.2190	5.0002	1.8768
C22	-1.7581	-0.6139	-0.5966	0.3143	0.2167	**C47**	2.9866	-29.1463	-22.4933	-48.8560	-21.6965
C23	-3.0367	-0.2330	-1.5207	-1.0700	-6.5729	**C48**	-16.3521	-3.5726	-9.7183	-1.3283	-2.3254
C24	4.2042	6.0133	5.9330	6.1574	3.4119	**C49**	-4.0383	5.1352	5.6189	8.1364	3.8301
C25	2.4662	4.0494	2.2961	4.2601	2.8169	**C50**	1.9012	4.0051	1.0609	3.3169	0.4204

If we examine the DD values in detailed,we found out that some companies have negative values for all years. Positive DD values increases and negative DD values decreases each year, which means that absolute DD values increases. This outcome is expected because companies, which have been examined, are selected from BIST100.

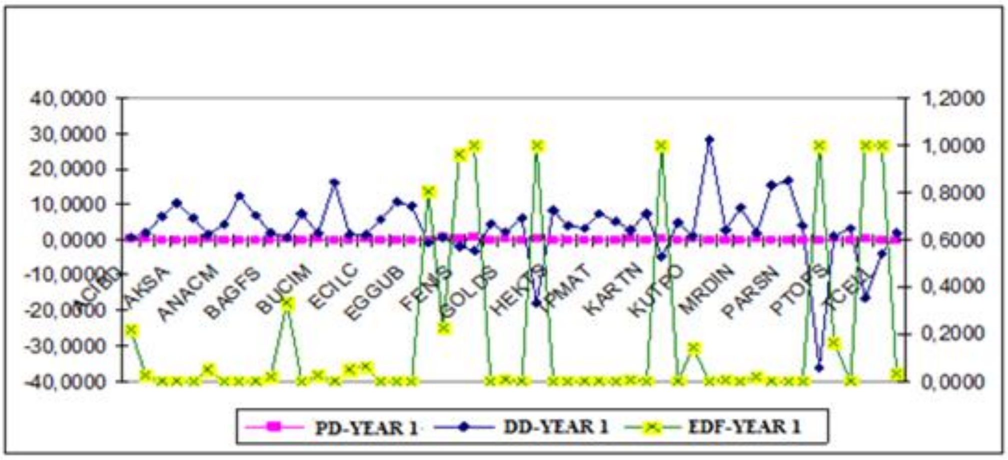
However, before drawing our results, we need to be able to examine the expected default frequencies of companies. The EDF values of each company are given in Table 3.

Table 3: TheEDF Values of Selected BIST100 Companies

	Year 1	Year 2	Year 3	Year 4	Year 5		Year 1	Year 2	Year 3	Year 4	Year 5
C1	0.2171	0.0311	0.4253	0.3780	1.0000	**C26**	0.0000	0.0000	0.0000	0.0000	0.0013
C2	0.0279	0.0000	0.0000	0.0000	0.0000	**C27**	1.0000	1.0000	1.0000	1.0000	0.0482
C3	0.0000	0.0000	0.0374	0.2859	0.1108	**C28**	0.0000	0.0000	0.0000	0.0000	0.0000
C4	0.0000	0.0000	0.2378	0.0000	0.0072	**C29**	0.0001	0.0000	0.0000	0.1205	0.5392
C5	0.0000	0.0000	0.2165	0.0000	0.0000	**C30**	0.0012	0.0005	0.0000	0.0000	0.0489
C6	0.0518	0.0518	0.5179	0.2392	0.1567	**C31**	0.0000	0.0186	0.0000	0.0003	0.0123
C7	0.0000	0.0002	0.0039	0.1848	0.4800	**C32**	0.0000	0.0000	0.0000	0.0000	0.0000
C8	0.0000	0.0001	0.0000	0.0000	0.0311	**C33**	0.0056	0.0000	0.0000	0.0000	0.0000
C9	0.0000	0.0000	0.0191	0.0000	0.0085	**C34**	0.0000	0.0000	0.0000	0.0000	0.0000
C10	0.0213	0.0079	0.0019	0.0000	0.0026	**C35**	1.0000	1.0000	1.0000	1.0000	0.9999
C11	0.3327	0.1428	0.0929	0.0608	1.0000	**C36**	0.0000	0.0000	0.0000	0.0000	0.1084
C12	0.0000	0.0000	0.0000	0.0000	0.0001	**C37**	0.1447	0.0000	0.0000	0.0000	0.1290
C13	0.0259	0.0000	0.0000	0.0000	0.0000	**C38**	0.0000	0.0860	0.0143	0.3095	1.0000
C14	0.0000	0.0090	0.0017	0.0000	0.0110	**C39**	0.0033	0.0000	0.0019	0.0000	0.2923
C15	0.0498	0.9142	0.9346	0.6844	0.8794	**C40**	0.0000	0.0000	0.0000	0.0000	0.0000
C16	0.0627	0.0000	0.0000	0.0000	0.0041	**C41**	0.0182	0.0000	0.0000	0.0000	0.0401
C17	0.0000	0.0000	0.0472	0.9003	1.0000	**C42**	0.0000	0.0000	0.0000	0.0000	0.0000
C18	0.0000	0.0000	0.0000	0.0000	0.1494	**C43**	0.0000	0.0942	0.0000	0.0000	0.0008
C19	0.0000	0.0000	0.0000	0.0111	0.1566	**C44**	0.0000	0.2689	0.9994	0.7982	0.5900
C20	0.8013	0.4073	0.1921	0.0232	0.0131	**C45**	1.0000	0.0015	0.0006	0.0000	0.0038
C21	0.2243	0.0001	0.0002	0.0527	0.2718	**C46**	0.1618	0.0083	0.0132	0.0000	0.0303
C22	0.9606	0.7304	0.7246	0.3767	0.4142	**C47**	0.0014	1.0000	1.0000	1.0000	1.0000
C23	0.9988	0.5921	0.9358	0.8577	1.0000	**C48**	1.0000	0.9998	1.0000	0.9080	0.9900
C24	0.0000	0.0000	0.0000	0.0000	0.0003	**C49**	1.0000	0.0000	0.0000	0.0000	0.0001
C25	0.0068	0.0000	0.0108	0.0000	0.0024	**C50**	0.0286	0.0000	0.1444	0.0005	0.3371

The companies, which have negative DD values, have greatest EDF values. It has been observed that the EDF values for almost every company in our study increase over time. Graph 2 shows three parameters (MPD, DD, and EDF) for the first year only.

Graph 2:MPD-DD-EDF of Companies: Year 1



From Graph 2 it can be easily seen that EDF has the highest value in a neighborhood interval when DD takes negative values. Once these values have been calculated, the relationship of the variables could be analyzed. To analyze this relation, the correlation coefficient of these variables was calculated and these values are listed in Table 4.

Table 4: Correlation Coefficient of Default Parameters

Time	Debt & MPD	Debt & DD	Debt & EDF	Debt & Equity
Year 1	**-0.06**	**-0.07**	0.06	0.73
Year 2	0.05	**-0.74**	0.54	0.74
Year 3	0.05	**-0.62**	0.47	0.71
Year 4	**-0.05**	**-0.71**	0.50	0.76
Year 5	0.08	**-0.31**	0.37	0.85

As seen in Table 4, the correlation coefficients between debt and equity increases by the time (except for the transition from the second year to the third year), and obtained values are so close to each other and one sowe can say that they are highly correlated. Since all values are positive, we can say that they are highly positively correlated. In other words, from these values it is clear that the companies with higher equities tend to have higher debt and vice versa.

For the five-year process, the correlation coefficient of DD and debt are always negative and for Year 1 and Year 5 the relation is weak. In the light of this information we can say that they are negatively correlated. If there is a negative correlation between the variables, if one of them increases, the other one decreases at the same time or vice versa. But we can not say which of the variables affects the other one.

IV. Conclusion

In this study, we examined 50 companies from BIST100 for consecutive five years period, which we did not expect to go bankrupt. The inputs of the Merton model include the volatility of stock returns, totaldebt of the company, the risk-free interest rate andthe time. In this study, one-year treasury constant maturity rate was used for risk free rate and instead of time variable we decided to use 1 year. The number of input variables used in this model was one of the reasons why we preferred. In most of the studies, the sample includes both failure and non-failure companies, non-failure companies chosen as a control group. However in this study, our objective is to see the efficiency of MPD and the other failure probabilities derived from them can be useful for financial market of Turkey. As a non-failure control companies, in consecutive years we faced withextreme values in the interval [0,1]. Also as expected we found positively strong relationship between debt and equity and between debt and expected default frequencies; negative relationship between debt and distance to default for five year time period. However, the correlation between debt and Merton probability default values was negative in the first and fourth year, positive in the other years but the relationship between them was negligible.

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Çiğdem ÖZARI A Merton Model Approach to Assessing the Default Risk: An Application on Selected Companies from BIST100." IOSR Journal of Economics and Finance (IOSR-JEF) , vol. 8, no. 6, 2017, pp. 54-61.