11th MALAYSIA STATISTICS CONFERENCE 2024
Data and Artificial Intelligence: Empowering the Future
Sasana Kijang, Bank Negara
19th September 2024

ANALYSING THE DEFAULT RISK PROFILES OF FIRMS' BUSINESS SECTORS USING SELECTED RISK INDICATORS AND KMV-MERTON MODEL

Muhammad Nur Hakim bin Mohamed Rosli[1]; Maisharah binti Ben[2]; Nurul Assyura binti Abu[2]; Norliza binti Muhamad Yusof[2]

[1] Institut Maklumat dan Analisis Pasaran Buruh (ILMIA)
[2] Universiti Teknologi MARA (UiTM) Cawangan Negeri Sembilan Kampus Seremban

Abstract:
The COVID-19 epidemic caused a significant economic downturn in Malaysia. As a result, many investors take safety measures before investing. Default risk management is necessary in this situation to prevent additional loss. In this study, the KMV-Merton model and six selected risk indicators are used to analyse the default risk of 50 Malaysia firms from non-financial sectors. The selected risk indicators are leverage ratio, liquidity ratio, firm size, return on assets, cash and volatility. Probability of default of the firms estimated using the KMV-Merton model and selected risk indicators is within the range of the actual MARC ratings. Firm with relatively high liquidity ratio, return on assets (ROA), cash and big firm size is inclined to have lower default risk. Meanwhile, leverage and volatility does not reflect firm's default risk. This study also constructs risk profiles for few sectors, which include construction and engineering, casinos and gaming, iron and steel, and all sectors. We find that the predicted rating match with the actual rating from MARC Berhad. Since leverage ratio and volatility have inconsistent range of values, the risk profiles constructed is yet to be improved by further researchers. However, the number of data can be minimized as the smaller the scope, the easier the calculation. Anyhow, many other models also can be employed in addition to the KMV-Merton model, for instance the Moody's KMV model, Altman Z-Score model, or the Merton model.

Keywords:
Probability of Default; Default Risk Management; Credit Rating; Return on Assets (ROA); Volatility

1. Introduction:
The COVID-19 epidemic caused a significant economic downturn in Malaysia. As a result, many investors take safety measures before investing. Default risk is concerned about a company's ability to pay its debts and liabilities. It is impossible to tell which companies will default and which ones will not (Crosbie & Bohn, 2019). Default risk management is necessary in this situation to prevent additional loss. The aims of this study are to analyse the default risk of firms using KMV-Merton model and the selected risk indicators according to credit rating categories. Another one is to construct the risk profiles of firms

according to their business sectors using the analysis of the first objective. The selected risk indicators are leverage ratio, liquidity ratio, firm size, return on assets, cash and volatility. This study will focus on predicting firms' level of default risk using the KMV-Merton model and the selected risk indicators. Based on the firms' data accessibility, several firms will be chosen, which was gathered via Thomson Reuters Data Stream, Refinitive Eikon, and the annual reports of the companies. This study was done through purposive data collection, which was limited to Malaysia due to the course requirement's low cost and emphasis on non-financial firms. This study will also create a default risk profile for each different sectors and for overall sectors. The result of default prediction is validated by credit ratings.

2. Methodology:

The methodology utilised in this study is explained in depth in this chapter. The flowchart in Figure 2.1 outlines the procedures from data collecting until constructing firm risk profiles according to their sectors based on the KMV-Merton model and the selected risk indicators. This study will use an approach from Yusof et al. (2021) to estimate the probability of default (PD) of firms. There are five steps required to estimate the probability of a default of firms.

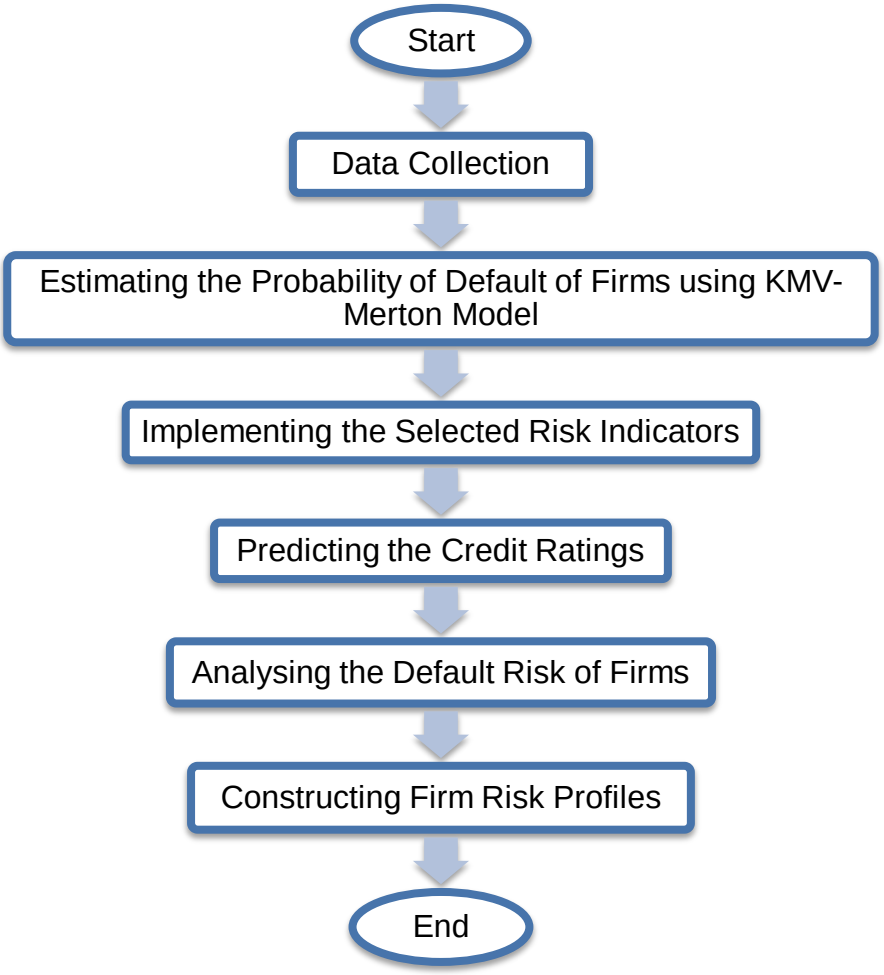

Figure 2.1: Flowchart of the Research Study

Firstly, multiplying each of the daily stock prices with the outstanding share to get the daily market value of a firm’s equity. Next, calculate the daily book value of liabilities, by defining it as a total borrowing of the short term plus half of the long-term borrowings. Furthermore, the daily asset's market value is calculated based on the sum of the firms' book value of liabilities and market value of equity. The fourth step is to generate the daily natural log of

the assets' market values returns to get the average return and the standard deviation. Since asset returns follow the random walk properties and the probability of default is assessed annually, this daily volatility is annualized by multiplying it with the square root of trading days, which is in a normal year is 252 days (Glenn, 2018). The fifth and last step is calculating the distance to default, d, with equation (1), where P_t is the default probability by time t and N is the standard cumulative probability distribution functions for a normal distribution d that is defined as equation (2), which is used to estimate the annual default probability of the firms.

$$P_t = N[-d] \tag{1}$$

$$d = \frac{ln(\frac{V}{X_t}) + (\mu - \frac{1}{2}\sigma_v{}^2)t}{\sigma_v\sqrt{t}} \tag{2}$$

Firm's default risk can also be analysed using the selected risk indicators, which are the leverage ratio, liquidity ratio, firm size, return on assets, cash and volatility for the year 2010 to 2020 to be calculated. Leverage ratio is calculated using equation (3) where the total equity is obtained by subtracting the total assets with the total liabilities. Liquidity ratio represented by the current ratio can be calculated using equation (4). Firm size is calculated by defining it as the log of total assets (Comment and Schwert, 1995). ROA is calculated by dividing the net income after tax with the total assets (Hargrave, 2022). Cash is calculated by dividing the sum of firm's annual cash and cash equivalents data with the total assets (My Accounting Course, 2022). Lastly is the volatility that is obtained according to the approach used in calculating the PD, where the standard deviation of asset log returns times the square root of the trading days (Glenn, 2018). Firm is predicted to have high default risk when it has high leverage, low liquidity ratio, small firm size, low cash, small ROA and high volatility.

$$\text{Debt} - \text{to} - \text{Equity Ratio} = \frac{\text{Total Debt}}{\text{Total Equity}} \tag{3}$$

$$\text{Current Ratio} = \frac{\text{Current Assets}}{\text{Current Liabilities}} \tag{4}$$

Based on the PD data estimated, the credit rating of the selected firms is predicted according to Historical Pattern MARC Default Rate (MARC, 2021). For instance, if a firm's PD value is 3.17E-57, the firm is anticipated to receive AAA rating since the number is inside the range for that grade. Excel's descriptive analysis function is used to analyse the DD, PD and the selected risk indicators for each rating predicted. Hence, the mean, minimum, and maximum values for both are extracted as analysis of this study on default risk.

The risk profile is created using the data from PD and selected risk indicators. The PD and selected risk indicators will be arranged according to the business sectors of the firms, as well as an overall risk profile for all sectors included. The credit ratings are divided into 3 different level of default risk, consisting of low (AAA / AA / A), medium (BBB / BB) and high (B / C). Firm that has predicted credit rating of AAA, AA, and A is categorized as low. Next, firm with predicted credit rating of BBB and BB is categorized in medium level while firm with predicted credit rating of B and C is categorized as high level of default risk. In the risk profile, the predicted rating, MARC probability of default rate, and estimated probability of default rate were included for direct comparison. The minimum and

maximum values for PD and selected risk indicators were employed for the range of each level of risk.

3. Result:

Based on our findings, using KMV-Merton model, distance-to-default (DD) and probability of default (PD) is estimated for each firm from the year 2010 to 2020. The result shows that the firms' PD is in the range of MARC probability of default rate.

We compute a table that displays the descriptive analysis for DD values. We found that the rating AAA has the greatest mean value of DD, while the rating C has the lowest mean value of DD. As the rating declines, the average values of DD fall. This is due to the fact that when DD drops, the firm's capability to pay interest on time drops as well, which lowers the rating. Consider that DD refers to the difference between expected asset value and debt value. Higher DD levels thus show that the firm's asset worth is greater than its debt value. As a result, the firm is considered capable of making timely loan repayments. This indicates that there is very little chance of the firm defaulting. This suggests that DD and PD have an inverse relationship. This is due to the fact that when DD value rises, PD value falls. The descriptive statistic of PD for each rating group is also displayed in the table constructed. The range of PD for each grade was determined using the minimum and highest PD values. We found that the mean of the PD values is rising from AAA to C. As the rating declines, the average PD values rise. This demonstrates that there is an inverse relationship between default risk and credit rating. The results of this investigation clearly show that ratings for mean estimated probabilities of default and non-default are consistent.

Larger PD values are thought to imply a higher likelihood of a firm defaulting, which is supported by the maximum and minimum PD values for each rating category. This is done in order to make it apparent that firms (borrowers) with ratings of A and above indicate that they have a very high capacity to repay interest and principal on time or sooner. Based on the minimum and maximum values of PD determined for the grades A, AA, and AAA, it is unlikely that the firm would default. The borrower has sufficient to scarce financial resources to repay the principal and interest on time if the grade is BBB or below (up to rating C). As a result, there is a strong possibility that the firm will go out of business, which is supported by the lowest and maximum PD values derived for the ratings BBB, BB, B, and C.

Next, default risk is also determined using leverage ratio, liquidity ratio, firm size, return on assets (ROA), cash and volatility. We also compute tables that display the descriptive analysis of the selected risk indicators. We found out that a high value of leverage ratio could indicate that a firm is defaulting. Next, our finding shows that a low liquidity ratio could imply that the firm is incapable of liquidate its current liabilities. Higher liquidity ratios decrease default risk because it means that firms can pay its short-term commitment. In our result, we also found out that the greater the firm size, the smaller the PD. It is also shown from our finding that a high value of ROA shows the firm's efficiency in utilizing its assets to increase profits. Most of the firms with the rating BB has low efficiency in generating income by over-invested its assets (Hargrave, 2022). Thus, the smaller the ROA, the smaller the distance-to-default of a firm. For cash, according to our finding, the highest value for this indicator only reaches 0.380844 in the rating AAA. If it exceeds 1, it would be ideal as it implies that the firm has the ability to fulfill its short-term commitments while still having a good amount of cash available (Kenton, 2021). We also found out that the firms with rating C have the lowest average value for cash therefore implying that they

are incapable to pay off its short-term obligations. Hence, this could expose them to default risk. Lastly, high volatility is suggested to lead to a higher PD.

For our next finding, a risk profile for all sectors involved is created as seen in Table 3.1. The predicted PD rating is in the range of MARC probability of default rate. However, the range of leverage ratio is inconsistent. Thus, leverage is unable to determine firm's default risk. Based on the risk profiles, firm categorized in the high level has less liquidity ratio, small ROA value, small firm size, and low cash. This corresponded to previous studies. However, leverage and volatility does not necessarily reflect firm's default risk.

Table 3.1: The Risk Profile for Firms for All Sectors

	LEVEL OF RISK		
Firm Risk Indicators	**Low**	**Medium**	**High**
Predicted Rating	AAA/AA/A	BBB/BB	B/C
MARC Probability Of Default Rate (%)	PD ≤ 2.7092	3.7413 ≤ PD ≤ 34.8192	PD ≥ 42.3306
Estimated Probability Of Default Rate (%)	9.6234E-260 ≤ PD ≤ 2.66	4.05 ≤ PD ≤ 37.53	50.47 ≤ PD ≤ 73.31
Leverage Ratio	0.0019 ≤ LEV ≤ 316.389	-29.1769 ≤ LEV ≤ 12.6269	-4.5101 ≤ LEV ≤ 106.223
Liquidity Ratio	-6.12 ≤ LIQ ≤ 79.72	0.18 ≤ LIQ ≤ 2.63	0.15 ≤ LIQ ≤ 2.25
Firm Size	7.3954 ≤ FS ≤ 11.2587	7.9847 ≤ FS ≤ 10.8305	7.8559 ≤ FS ≤ 11.0687
ROA	-3.8134 ≤ ROA ≤ 0.1788	-0.5194 ≤ ROA ≤ 0.0654	-0.3196 ≤ ROA ≤ 0.0731
Cash	0.0453≤ CASH ≤ 0.2350	0.0005 ≤ CASH ≤ 0.2526	0.0031 ≤ CASH ≤ 0.1673
Volatility	0.00026≤ VOL ≤ 1.0901	0.0009 ≤ VOL ≤ 1.0565	0.0456 ≤ VOL ≤ 2.6321

4. Discussion and Conclusion:

The ultimate objective for this study in the future is to forewarn selected firms about their financial standing and to assist future investors in choosing the best firms to put their money in not only in the scope of Malaysia and non-financial firms, but in the direction of bigger scope as a whole. The default risk prediction is crucial for a promised future of the firms. The risk profiles that we constructed shows that the predicted rating for each category is compatible with the actual rating. This shows that our calculation for the predicted rating has high accuracy. However, the risk profiles constructed shows that there are firms that have high leverage and high volatility but has low PD and vice versa. Due to them having inconsistent range of values, it is a little challenging to understand how it can impact default risk. Thus, leverage ratio and volatility do not always indicate the default risk of a firm. All in all, the knowledge attained by everybody in this study could be the medium for better decision making. In the end, it is own responsibility to choose what is the best for the coming.

References:

1. Comment, R., Schwert, G.W., 1995. Poison or placebo? Evidence on the deterrence and wealth effects of modern anti-takeover measures. Journal of Financial Economics, 39, 3-43.
2. Crosbie, P., & Bohn, J. (2019). *Modeling Default Risk*. World Scientific. https://www.worldscientific.com/doi/abs/10.1142/9789814759595_0020
3. Glenn, S. (2018). *Volatility in Statistics and Markets: Simple Definition, Calculation*. Retrieved from Statistics: Elementary Statistics for the rest of us
4. Hargrave, M. (2022). *Return on Assets (ROA)*. https://www.investopedia.com/terms/r/returnonassets.asp
5. Kenton, W. (2021). Cash Asset Ratio. Investopedia. https://www.investopedia.com/terms/c/cash-asset-ratio.asp#:-:text=The%20cash%20asset%20ratio%20is%20a%20financial%20ratio%20that%20seeks,cash%20equivalents%20by%20current%20liabilities.
6. MARC. (2021). *MARC Definitive Rating Guide*. Retrieved from https://www.marc.com.my/images/Rating/MARC-Definitive-Rating-Guide-June-2021.pdf
7. My Accounting Course. (2022) *What is Cash Flow on Total Assets Ratio? - Definition | Meaning | Example*. https://www.myaccountingcourse.com/accounting-dictionary/cash-flow-to-total-asset-ratio.
8. Yusof, N. M., Alias, I. Q., Kassim, A. J. M., & Zaidi, F. L. N. M. (2021). Determining the credit score and credit rating of firms using the combination of KMV-merton model and financial ratios. *Science and Technology Indonesia*, *6*(3), 105–112. https://doi.org/10.26554/sti.2021.6.3.105-112

NOTE: THE REQUIRED NUMBER OF PAGES FOR PAPER IS SIX PAGES