Shopify Inc. Credit Risk Analysis

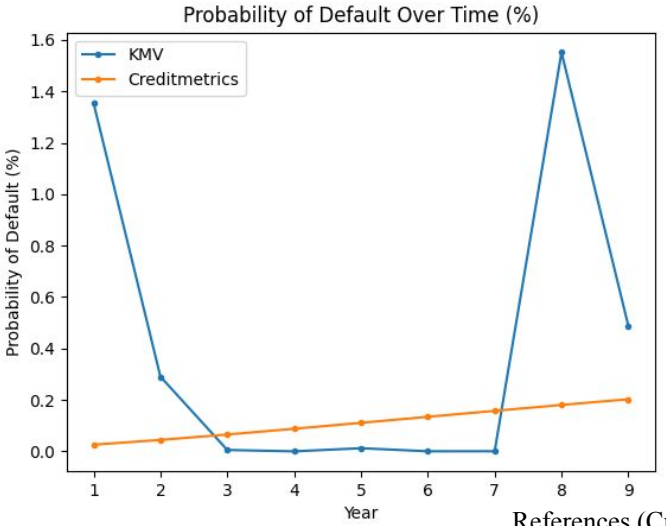
Raw Data: Collected from Shopify's annual report from 2015 to 2023. https://investors.shopify.com/financial-reports/default.aspx

Year	Assets	Long-term debt	Short-term debt	Expected volatili	Risk-free interes	Stock value	Equity	Asset volatility	Return of asset
2015	243,712	11,158	37,237	64.30%	1.62	231,452	195,317	62.41%	-11.10%
2016	490,558	13,550	66,532	59.10%	1.32	468,494	410,476	58.01%	-9.60%
2017	1,113,564	17,710	94,754	56.00%	1.85	1,077,477	1,001,100	55.65%	-5.00%
2018	2,254,785	25,329	138,688	50.70%	2.72	2,215,936	2,090,768	50.54%	-3.80%
2019	3,489,479	157,363	316,382	54.20%	2.25	3,256,284	3,015,734	53.54%	-4.30%
2020	7,762,905	923,850	438,332	46.40%	1.04	6,115,232	6,400,723	45.38%	5.70%
2021	13,340,172	1,504,098	702,733	53.10%	0.71	8,040,099	11,133,341	52.09%	27.60%
2022	10,757,151	1,662,254	856,008	63.30%	2.9	8,747,432	8,238,889	60.54%	-28.70%
2023	11,299,000	1,335,000	898,000	68.00%	4.39	9,201,000	9,066,000	66.03%	1.20%

KMV Model Formula & Parameters:

$$PD = \phi\left(\frac{\log(D_T/A_0) - (r - \sigma_A^2/2)T}{\sigma_A\sqrt{T}}\right).$$

D_T: Amount of debt
A_0: Initial value of asset = **Default point** = short term debt + 0.5*long term debt
r (or mu): Expected return
Sigma_A: Expected volatility of asset
T: Number of periods
Phi: Cumulative distribution of the standard Gaussian distribution
Note that all values of these parameters can found in the raw data. The increase in the probability of default also corresponds to th decrease in the bond price in 2022.



Reference (KMV Model):
https://www.tnpconsultants.com/wp-content/uploads/2023/06/Merton-Model-in-Credit-Risk-Modelling-version-2023.pdf

Creditmetrics Model

Matrix of Migration Probabilities

Table 1.8
One-year transition matrix (%)

Initial rating	Rating at year-end (%)							
	AAA	AA	A	BBB	BB	B	CCC	Default
AAA	90.81	8.33	0.68	0.06	0.12	0	0	0
AA	0.70	90.65	7.79	0.64	0.06	0.14	0.02	0
A	0.09	2.27	91.05	5.52	0.74	0.26	0.01	0.06
BBB	0.02	0.33	5.95	86.93	5.30	1.17	0.12	0.18
BB	0.03	0.14	0.67	7.73	80.53	8.84	1.00	1.06
B	0	0.11	0.24	0.43	6.48	83.46	4.07	5.20
CCC	0.22	0	0.22	1.30	2.38	11.24	64.86	19.79

Source: Standard & Poor's CreditWeek (15 April 96)

Note that to make this an 8*8 matrix, [0,0,0,0,0,0,0,100] is added to the 8th row.
The algorithm takes the nth power of the matrix to find the probability of default.
For example, to find the probability of default for the 5th year, the matrix is multiplied by itself 5 times.
Also assume recovery rate = 50%.

References (Creditmetrics):
https://www.glynholton.com/notes/default_model/
https://thequantmba.wordpress.com/2017/01/05/creditmetrics-in-python/