Stock Market Risk Analysis

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Credit Models

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Credit risk assessment is a fundamental component of financial analysis and banking practice. Financial institutions, investors, and regulators rely on quantitative models to evaluate the probability that a firm may default on its obligations. In this assignment, a credit risk decision framework is developed, one that integrates two well-established methodologies: the Altman Z-Score model and the Merton structural default model.

The Altman Z-Score provides an accounting-based measure of financial distress using key balance sheet and income statement ratios. In contrast, the Merton model derives the probability of default from a market-based structural framework, modeling a firm's equity as a call option on its assets. By combining these approaches, the system captures both accounting fundamentals and market-implied risk signals.

The implemented solution retrieves real financial and market data for publicly traded companies, computes the Altman Z-Score and the Merton-based probability of default, and produces a credit approval decision based on predefined risk thresholds. Additionally, it includes an interactive dashboard that visualizes results and allows for multi-company comparison.

Altman Z-Score

Altman Z-score model is a numerical measurement that is used to predict the chances of a business going bankrupt in the next two years. The model was developed by American finance professor Edward Altman in 1968 as a measure of the financial stability of companies (Corporate Finance Institute).

Its formula is written as follows:

$$Z = 1.2x_1 + 1.4x_2 + 3.3x_3 + 0.6x_4 + 1.0x_5$$

Where

$$x_1 : \frac{Working\ Capital}{Total\ Assets}$$

$$x_2 : \frac{Retained\ Earnings}{Total\ Assets}$$

$$x_3 : \frac{EBIT}{Total\ Assets}$$

$$x_4 : \frac{Market\ Value\ of\ Equity}{Total\ Liabilities}$$

$$x_5 : \frac{Sales}{Total\ Assets}$$

This version of teh model was chosen because it provides a simple, quantitative way to assess a company's financial health and predict bankruptcy risk over a two-year horizon. Its strength lies in combining multiple financial ratios, covering liquidity, profitability, leverage, market value, and operational efficiency, into a single score that is easy to interpret. Developed and tested since 1968, the model has a strong historical track record and is widely recognized in finance, making it a reliable tool for credit risk assessment and early warning of financial distress. Its numerical output allows analysts to quickly categorize companies as safe, distressed, or at risk, supporting objective and consistent decision-making.

Merton Model:

The KMV Merton model is a credit risk model that Kealhofer, Merton, and Vasicek developed to estimate the probability of default (PD) and the expected loss given default (LGD) for a company or a portfolio of companies. It incorporates market-based information and company-specific financial data to estimate the likelihood of default and potential losses (Mehta et al., 2023).

It is calculated as follows:

$$distance\ to\ default = \frac{\ln\left(\frac{V}{D}\right) + \left(r + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}$$

Where:

$$V\text{: } Market\ value\ of\ a\ company's\ assets$$

$$D\text{: } Market\ value\ of\ a\ company's\ debt$$

$$r\text{: } Risk\ free\ interest\ rate$$

$$\sigma\text{: } Volatility\ of\ thecompany'sasset\ value$$

$$T\text{: } Time\ measured\ in\ years$$

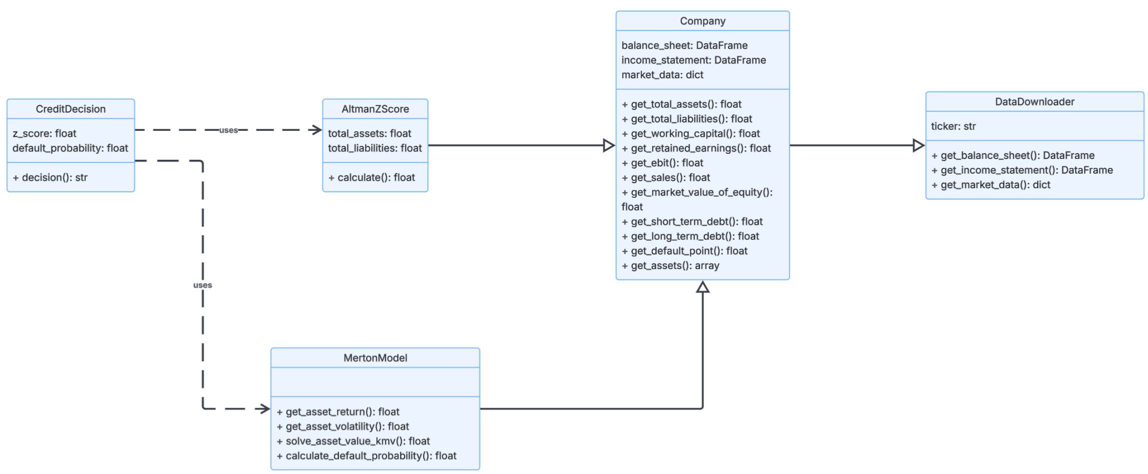
It should be noted that for the the analysis made the following variables and assumptions were used:

Market value of a company's debt: In this model, total liabilities were used instead of only interest-bearing debt to better reflect the firm's overall financial obligations. Default does not occur only when formal debt cannot be repaid, but when the company is unable to meet all contractual commitments, including short-term payables and other liabilities.

Using total liabilities therefore provides a more comprehensive and conservative measure of the default threshold. This approach is consistent with the economic definition of insolvency, where default occurs when the value of assets falls below the firm's total claims (Merton, 1974).

Risk-free rate: In this implementation, the expected asset return was estimated using the historical mean of asset log returns instead of the risk-free rate. This choice reflects a credit risk perspective rather than an option-pricing perspective. While the risk-free rate is appropriate under strict risk-neutral valuation assumptions, estimating default probability focuses on the firm's real economic performance. Using the mean asset return captures the firm's actual growth dynamics and operating risk, providing a more realistic measure of the probability that asset values will fall below the default threshold. This approach is commonly adopted in practical applications of the KMV model, where empirical asset behavior is emphasized over theoretical risk-neutral assumptions (Crosbie & Bohn, 2003).

An object-oriented program (OOP) was implemented for the analysis, as illustrated in the diagram below.



The framework begins by fetching financial data for a company using the DataDownloader superclass. The Company class, which inherits from DataDownloader, then organizes this data and calculates key financial metrics. Afterwards, the models classes, AltmanZScore and MertonModel, inherit from Company to assess credit risk using the Altman Z-Score and the Merton/KMV model, respectively. Finally, the CreditDecision class uses these outputs to make a credit approval decision.

The credit decision in the model is taken by evaluating two key financial indicators: the borrower's z score and their default probability. The z score reflects the financial health of the borrower, with higher scores indicating lower risk of bankruptcy, while default probability estimates the likelihood of the borrower defaulting, with higher values indicating higher risk. A borrower is approved if their z score is above the distress threshold of 1.8 and their default probability is below the maximum allowed 0.15 (15%), or if their z score exceeds the safe threshold of 3, regardless of default probability. Conversely, a borrower is denied if their z score falls at or below 1.8 or their default probability exceeds 0.15. The decision is considered over a 1-year time horizon, combining measures of financial stability and default risk to produce a structured and consistent credit assessment.

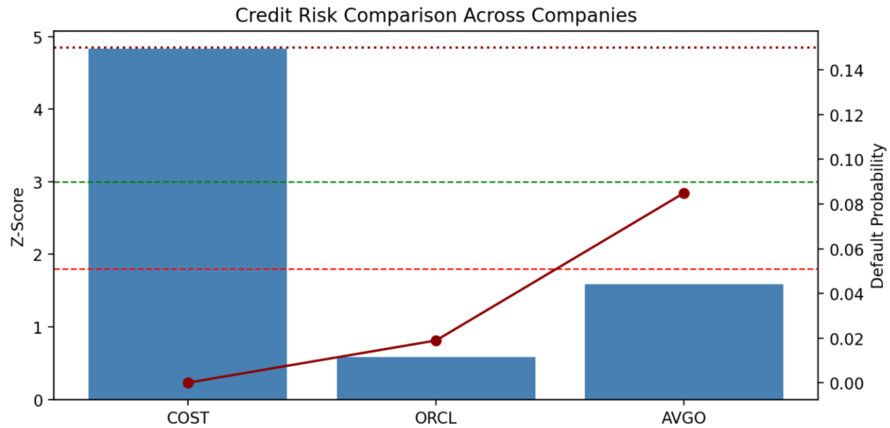
The thresholds were selected based on standard financial risk benchmarks and empirical studies. The z score of 3 represents a conservative “safe” level of financial stability, indicating very low risk of distress. The distress threshold of 1.8 reflects a point below which a firm is considered at significant risk of bankruptcy. The default probability limit of 0.15 (15%) corresponds to an acceptable maximum likelihood of default for credit approval, balancing risk and lending opportunities. These values ensure the model captures both extreme safety and moderate risk in a structured manner.

For the analysis, both Altman’s Z-score model and the Merton model were applied to three different companies—COST, ORCL, and AVGO—to observe how the framework performed with different datasets. The results are shown first in a summary table, showing both models and the final credit decisión. After this, other types of visualization tools are used to further explain the decision.

Summary Table

Ticker	Z-Score	Default Probability	Credit Decision
COST	4.84	0.00%	APPROVED
ORCL	0.59	1.89%	DENIED
AVGO	1.59	8.49%	DENIED

Cross-Company Comparison



The graph above shows the results from both models, for each of the companies used. The graphs below offer a more detailed explanation of the results of both models, showing both the z score obtained and the default probability.

Company: COST

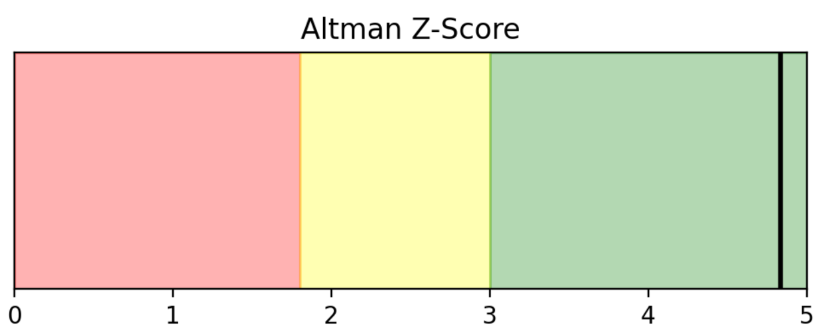
Altman Z-Score

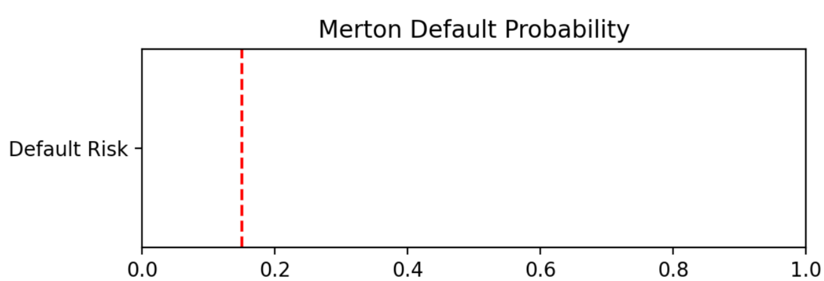
4.84

Default Probability

0.00%

CREDIT APPROVED

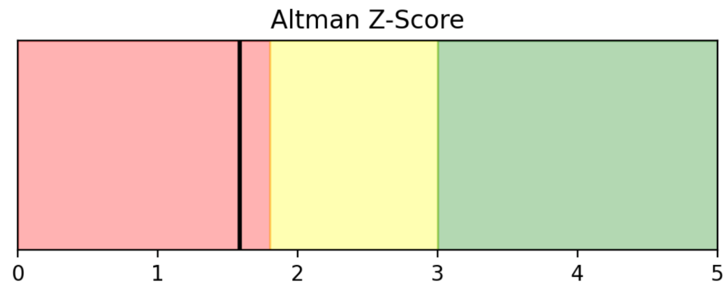


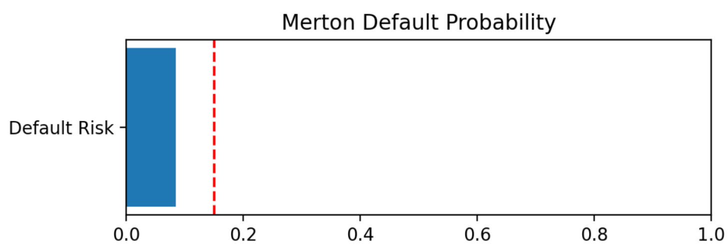


Company: AVGO

Altman Z-Score	Default Probability
1.59	8.49%

CREDIT DENIED





Company: ORCL

Altman Z-Score	Default Probability
0.59	1.89%

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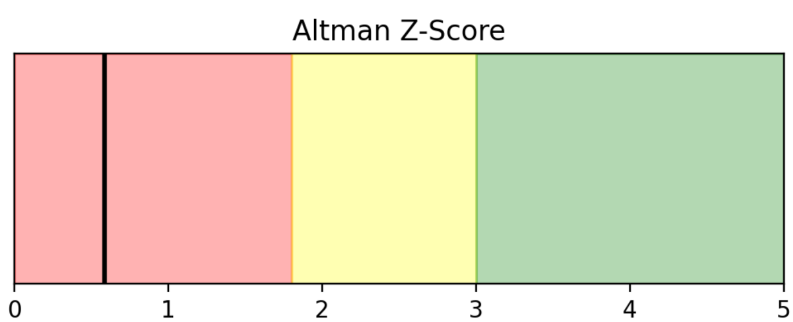

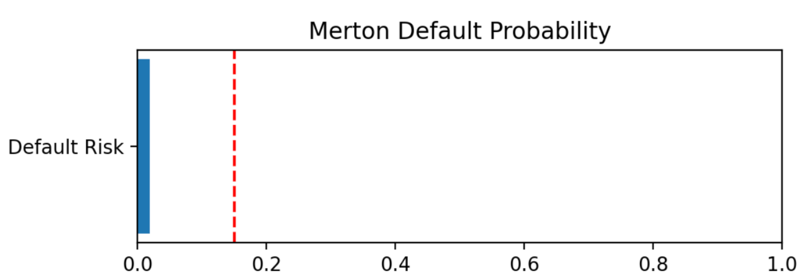

The results provide a clear illustration of how the credit decision model operates. For the first company, COST, the Altman Z-Score exceeded the safe threshold of 3, signaling a very low risk of financial distress, and thus supporting credit approval without concern for default probability. In contrast, for ORCL and AVGO, the situation was more complicated. Although the estimated probability of default for both companies never exceeded the maximum allowable limit of 15%, their Altman Z-Scores fell into the distress zone, indicating higher financial risk. This demonstrates how the model balances both indicators: a company can have a relatively low probability of default yet still be flagged due to weak overall financial health, ensuring that credit decisions account for both stability and default risk. By combining these measures, the model provides a structured and consistent approach to assessing borrower risk.

Sources:

Corporate Finance Institute. (n.d.). *Altman's Z-Score Model – Overview, formula, interpretation*. Corporate Finance Institute. https://corporatefinanceinstitute.com/resources/commercial-lending/altmans-z-score-model

Mehta, K., Srivastav, A., & Vaidya, D. (2023, July 19). *KMV model – What is it, application, significance, how to calculate*. WallStreetMojo. https://www.wallstreetmojo.com/kmv-model/

Crosbie, P., & Bohn, J. (2003). *Modeling default risk*. Moody's KMV. https://www.moodysanalytics.com/-/media/whitepaper/2003-02-25-modeling-default-risk.pdf