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Development of a Distance to Default (DTD) Calculator

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Abstract

This report presents the development of a Distance to Default (DTD) Calculator, a Python-based system designed to estimate the credit risk of firms using market and balance sheet data. The tool implements the Merton structural model, where equity is modeled as a European call option on the firm's assets, and Distance to Default is computed as the standardized distance between asset value and liabilities. The system numerically estimates the Implied Asset Value (AV) through inversion of the Black-Scholes formula and subsequently computes DTD. A web interface is developed using Flask to enable CSV file uploads and real-time result visualization. The report also discusses the financial significance of DTD and AV, implementation challenges, and future enhancement opportunities. The DTD Calculator offers a scalable and accessible approach to market-based credit risk assessment for financial institutions, analysts, and researchers.

1 Introduction

This report presents the development of a Distance to Default (DTD) Calculator, a tool that estimates the implied asset value (AV) and DTD of firms using market and balance sheet data. The system is based on the Merton structural model and is implemented in Python with a Flask web interface. The link of the website is https://aidf-cri-dtd-calculator.onrender.com/ The github of the DTD calculator is https://github.com/wilbur20074925d/AIDF-CRI.git

2 Project Objectives

- Compute Implied Asset Value (AV) using the Black-Scholes framework.
- Compute Distance to Default (DTD) based on estimated AV and liabilities.
- Build a user-friendly web interface for uploading and processing financial data.
- Enable batch processing of multiple firms via CSV upload.
- Provide result visualization and allow data export.

3 System Overview

- **Frontend:** HTML interface generated with Flask for file upload and results display.
- **Backend:** Python logic using Pandas, NumPy, SciPy, and the Black-Scholes model.
- **Deployment:** Render-compatible configuration for cloud hosting.

4 Computation Methodology

4.1 Step 1: Effective Liability Calculation

$$L = \text{Short Term Debt} + 0.5 \times \text{Long Term Debt} + w \times \text{Other Liability}$$

Where $w = 0.3466$ is an empirically determined weight.

4.2 Step 2: Implied Asset Value Estimation

Assuming the equity is a European call option on the firm's assets V, we define:

$$d_1 = \frac{\ln\left(\frac{V}{L}\right) + \left(r + \frac{1}{2}\sigma^2\right)T}{\sigma\sqrt{T}}, \quad d_2 = d_1 - \sigma\sqrt{T}$$

$$E = V \cdot N(d_1) - L \cdot e^{-rT} \cdot N(d_2)$$

Where:

- E: Market capitalization (observed)
- L: Effective liabilities
- $\sigma = 4.6940$: Fixed asset volatility
- r: Annualized risk-free rate
- $T = 1$: Time horizon

The equation is solved numerically using the Newton-Raphson method.

4.3 Step 3: Distance to Default (DTD)

Once V is estimated:

$$\text{DTD} = \frac{\ln\left(\frac{V}{L}\right)}{\sigma\sqrt{T}}$$

This gives the number of standard deviations between the firm's current asset value and the default threshold.

5 User Guide

5.1 Web Application Usage

1. Launch the app using `python app.py`.
2. Open `http://localhost:5000` in a browser.
3. Upload a CSV file with the following columns:
   - Market Capitalization
   - Short Term Debt
   - Long Term Debt
   - Other Liability
   - Total Asset
   - Daily Risk-Free Rate
4. Results will be displayed in a table on the same page.

5.2 Command-Line Usage

```
python dtd_calculator.py
```

6 Understanding of DTD and Implied Asset Value

6.1 Distance to Default (DTD)

Distance to Default is a quantitative measure of credit risk. It assesses how far a firm's asset value is from a predefined default point, typically its debt obligations. A higher DTD indicates lower risk of default, while a lower DTD signals financial distress. DTD is widely used in structural credit risk models and is integral to Moody's KMV model.

6.2 Implied Asset Value (AV)

Implied Asset Value is the theoretical value of a firm's assets, inferred by reversing the Black-Scholes model using observable market data. Unlike book value, AV reflects real-time market expectations and risks. It connects equity pricing and firm fundamentals, providing a dynamic view of solvency.

6.3 Realistic Significance

Both AV and DTD are vital tools for risk managers, investors, and regulators:

- Support real-time monitoring of firm health
- Facilitate early-warning systems for bankruptcy prediction
- Aid in portfolio credit risk modeling and pricing of CDS
- Bridge accounting and market-based risk perspectives

Their market-sensitive nature makes them more adaptable to current conditions than traditional credit scoring methods.

6.4 Challenges and Limitations

While the computation of DTD and AV offers valuable insights into a firm's creditworthiness, there are several challenges and limitations to consider in practical implementation:

- **Assumption of Constant Volatility:** The model assumes a fixed asset volatility (σ), which may not reflect changes in market conditions or firm-specific risks over time.
- **Model Sensitivity:** DTD is highly sensitive to inputs such as market capitalization, debt levels, and risk-free rates. Small changes in these variables can significantly affect the outcome.
- **Simplified Capital Structure:** The model reduces complex capital structures to a simplified liability threshold. In reality, firms may have varying seniority and covenants that affect default probabilities.
- **Use of the Black-Scholes Framework:** The approach models equity as a European call option, which assumes frictionless markets, no arbitrage, and log-normal asset returns—assumptions that may not hold in practice.

7 Screenshots

Figure 1: CSV Upload Interface

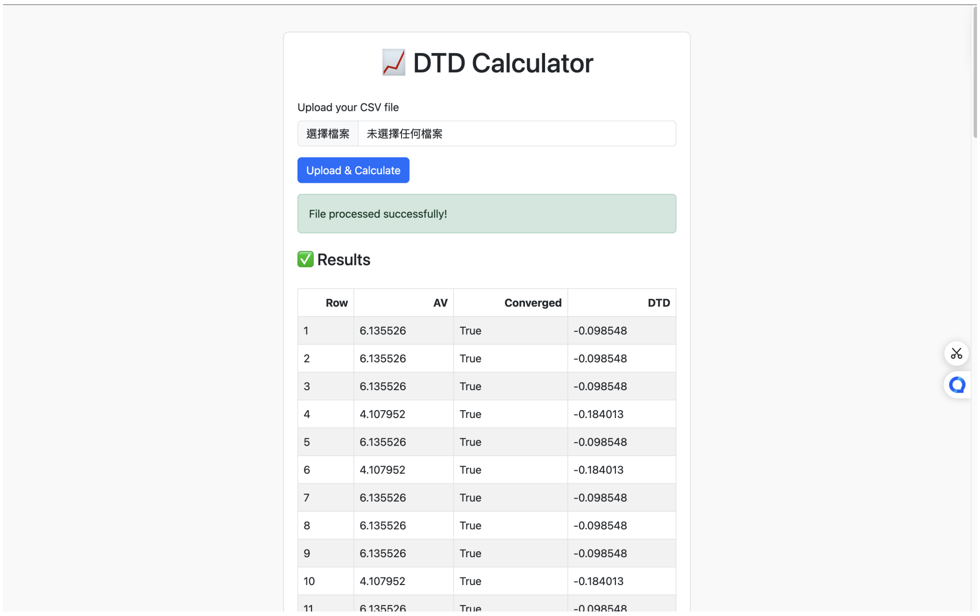

Figure 2: Computed AV and DTD Output Table

8 Conclusion

This project successfully demonstrates the use of market-based models to estimate asset value and credit risk. The modular Python implementation, user-friendly interface, and mathematical rigor make the DTD Calculator suitable for integration into broader financial systems.