KMV model replicate

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Research Framework

- The entire framework is devided into two parts: validation and research.
  - We select the data which is similar to the paper to validate whether our model is correct or not.
  - Research: We selected the top 14 banks in America from 2005 to 2021 based on asset size and market capitalization size to see their distance to default in different years.

Sample Description

- Validate: We select the data of 20 listed companies in Shanghai and Shenzhen A share market between 2005 and 2012. This period matches our main validation target of world's economic crisis of 2008.
- Main purpose: We selected the top 14 banks in America from 2005 to 2021 based on asset size and market capitalization size.

Sample Description

Table 2.1: China's data - I

Date	Type	Assets	Liabilities	Equity	Name
2005-03-31	A	1.809956e+10	1.143824e+10	6.661321e+09	万科 A
2005-06-30	A	1.887858e+10	1.198151e+10	6.897070e+09	万科 A
2005-09-30	A	2.119836e+10	1.418953e+10	7.008836e+09	万科 A
2005-12-31	A	2.199239e+10	1.341117e+10	8.581223e+09	G 万科 A
2006-03-31	A	2.427262e+10	1.406068e+10	1.021193e+10	G 万科 A
2006-06-30	A	2.872782e+10	1.711082e+10	1.161700e+10	G 万科 A
2006-09-30	A	4.224511e+10	3.046972e+10	1.177539e+10	G 万科 A
2006-12-31	A	4.850792e+10	3.150192e+10	1.700600e+10	万科 A
2007-03-31	A	5.017858e+10	3.222737e+10	1.795121e+10	万科 A
2007-06-30	A	6.367034e+10	4.543295e+10	1.823739e+10	万科 A

Sample Description

Table 2.2: China's Data II

DD	DP	IV	EA1	Name
9.605137e+09	0.372440	1.728327e+10	1.192817	万科 A
1.004909e+10	0.363859	2.063995e+10	1.410228	万科 A
1.222840e+10	0.350231	2.477453e+10	1.445938	万科 A
1.213547e+10	0.374194	1.903442e+10	0.968605	G 万科 A
1.344719e+10	0.380563	2.714407e+10	1.325930	G 万科 A
1.532350e+10	0.374144	2.574300e+10	1.081805	G 万科 A
2.758942e+10	0.286249	4.154807e+10	1.173675	G 万科 A
2.669345e+10	0.349601	5.095757e+10	1.362018	万科 A
2.603126e+10	0.360986	5.344019e+10	1.420802	万科 A
3.746758e+10	0.312383	6.018121e+10	1.208199	万科 A

Sample Description

Table 2.3: America's data - I

Date	Assets	Liabilities	Equity	Name
2005/1/1	531379.0	504491.0	26888.0	GS
2006/1/1	706804.0	675638.0	31166.0	GS
2007/1/1	838201.0	802415.0	40545.0	GS
2008/1/1	1119796.0	1069731.0	50065.0	GS
2009/1/1	884547.0	819084.0	66012.0	GS
2010/1/1	848942.0	777268.0	71674.0	GS
2011/1/1	911332.0	833104.0	78228.0	GS
2012/1/1	923225.0	851396.0	71829.0	GS
2013/1/1	938555.0	862331.0	76224.0	GS
2014/1/1	911507.0	832714.0	78793.0	GS

Sample Description

Table 2.4: America's data - II

DP	IV	Name
464143.0	0.355191	GS
625634.5	0.353634	GS
727927.0	0.349143	GS
970994.0	0.345802	GS
725970.5	0.351396	GS
679124.0	0.346814	GS
738980.5	0.355977	GS
760534.0	0.358113	GS
774196.0	0.362213	GS
748469.5	0.364429	GS

Models

- KMV model

$$E = AN(d_1) - Le^{-rT}N(d_2)$$

Where L is Default Point (DP) which equals to $STD + 0.5 \times LTD$

- Distance to Default (DD)

$$DD = \frac{E(A_1) - DP}{E(A_1)\sigma_A}$$

Where

$$E(A_1) = A \times (1 + g)$$

and

$$\sigma_A = \sigma_E \times \frac{E}{A} N(d_1)$$

Steps

- Use KMV model to estimate the value of companies' equity E
- Use Newton method[1] to estimate σ_E and transfer to σ_A
- Calculate the Distance to Default of each company and time

Empirical Results

After calculating the DD of each company, we have the same result with the paper we've read, that is, **KMV model doesn't have the ability to separate companies with high default risk or not**[2].

Empirical Results - China

Table 4.1: KMV model results

ST company	DD	Non-ST company	DD
ST donghang	1.605	shangcai	1.632
ST guofa	0.864	shanghaijichang	1.415
ST nanfang	0.872	zhongtian	1.036
ST guotong	0.862	yunwei	0.918
ST xincai	0.773	fosu	1.257
ST hehua	0.757	hongda	0.905
ST meili	1.142	hengfeng	0.912
ST changyou	1.078	wuzhong	1.652
ST lubei	2.243	shuini	1.341
ST heihua	0.467	baiyun	1.915

Empirical Results - China

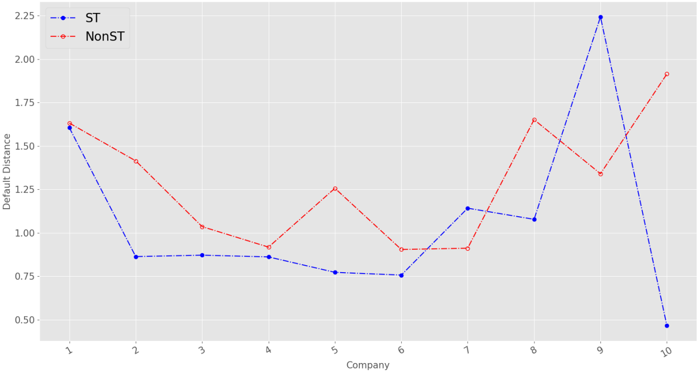

Figure 4.1: DD between ST and non-ST companies

Empirical Results - China

In the below figure, we can see that during 2008-01-01 to 2009-01-01, the average default to distance of all companies has drop sharply. This is because those companies are suffering Economic crisis.

Empirical Results - China

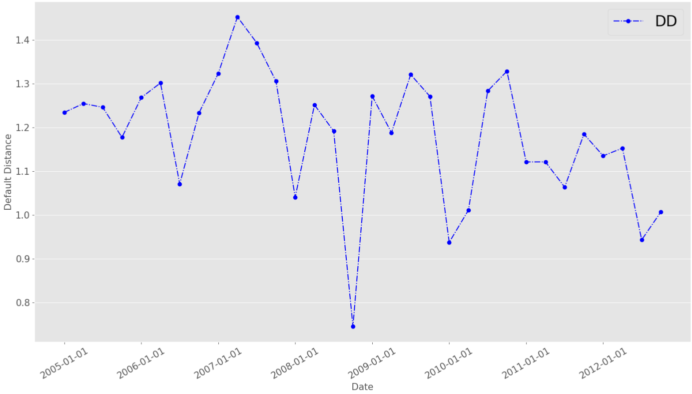

Figure 4.2: Average DD with different date - China

Empirical Results - USA

Table 4.2: KMV model results - USA

Company	**DD**	**Company**	**DD**
GS	1.464	BK	0.257
MS	0.419	WFC	0.693
JPM	0.361	NYCB	0.198
Citi	0.483	NTRS	0.224
BAC	0.519	PNC	0.307
WBS	0.446	SVB	0.358
AXP	0.499	SCHW	0.433

Empirical Results - USA

- During 2008 to 2009, the average DD of all banks had dropped sharply, banks are suffering Economic crisis.
  $\Rightarrow$ Endogenous instability of the financial system
- Period during the COVID-19 pandemic, average DD had not dropped dramatically.
  $\Rightarrow$ Exogenous impact of natural disasters on the real economy.

Empirical Results - USA

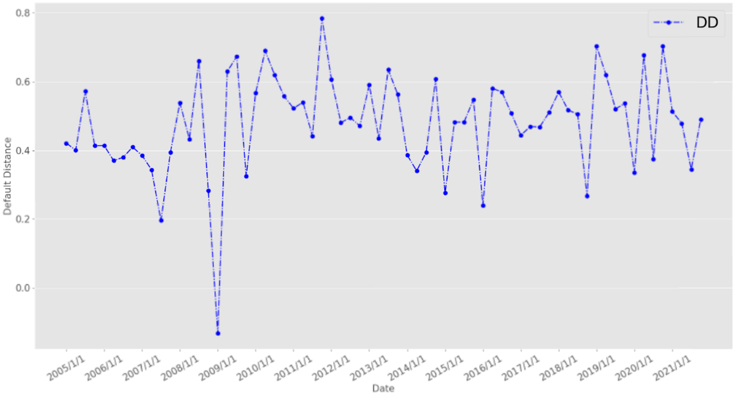

Figure 4.3: Average DD with different date - USA

Further Issue

- Bond default, 2018
  - During 2015-2016, some companies raised large amounts of capital, so the significant expansion of debt has raised the default risk
  - In 2017, China implemented deleveraging, but some companies had already expanded their borrowings significantly.
  - 2018 and 2019 is the period of concentration of payment. The narrowing funds in the stock market and the decrease in deposits from banks led to significant bond defaults.
- COVID-19, 2020
  - COVID-19 seems to have a small influence on companies' default probability.

Further Issue

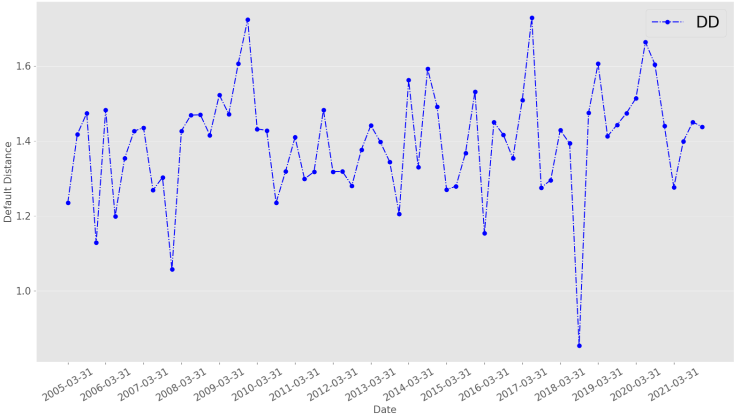

Figure 5.1: DD of 50 companies

References

[1] Chen, Y. and Chu, G. (2014). Estimation of default risk based on kmv model—an empirical study for chinese real estate companies. *Journal of Financial Risk Management*, 2014.

[2] Li, L., Yang, J., and Zou, X. (2016). A study of credit risk of chinese listed companies: Zpp versus kmv. *Applied Economics*, 48(29):2697–2710.

Appendix-A

```
## Estimate equity by KMV model
def Equity(A, L, r, sigma, T):
    d1 = (ln(A/L) + (r + 0.5*sigma**2)*T) / (sigma*sqrt(T))
    d2 = d1 - sigma*sqrt(T)
    return A*N(d1) - L*e(-r*T)*N(d2)
```

Appendix-B

```
## Estimate implied volatility by Newton Method
def vega(A, L, r, sigma, T):
    d1 = (ln(A/L) + (r + 0.5*sigma**2)*T) / (sigma*sqrt(T))
    firm_vega = A * N(d1) * sqrt(T)
    return firm_vega
iv = 0.5
def Newton(A, L, r, T, E, iv):
    Max_iter = 10000
    for i in range(Max_iter):
        iv -= ((Equity(A, L, r, iv, T)-E)/vega(A, L, r, iv, T))*0.001
    return iv
```

Appendix-C

```python
## Calculate Distance to Default
def d1(A, L, r, T, sigma):
    return (ln(A/L)+(r+0.5*sigma**2)*T)/(sigma*sqrt(T))
for i in Id_list:
    for j in range(len(d[{""}.format(i)])):
        d[{""}.format(i)]['IV'].iloc[j] = d[{""}.format(i)]['IV'].iloc[j] *
            d[{""}.format(i)]["Equity"].iloc[j] /
            d[{""}.format(i)]["Assets"].iloc[j] *
            d1(d[{""}.format(i)]["Assets"].iloc[j],
            d[{""}.format(i)]["Liabilities"].iloc[j],
            d[{""}.format(i)]["r"].iloc[j], T, d[{""}.format(i)]["IV"].iloc[j])
def DD(df):
    df['EA1'] = df['Assets'] * (1 + df['g'])
    return (df['EA1'] - df['DP']) / (df['EA1'] * df['IV'])
```