Credit Risk Management - Assignment #1

Adam Miller, Andrew Narang, Xiaofeng Cao
Demetra Koumatos, Xiaojun Guo, Ziyuan Zhao

1. Do the Z scores agree with public ratings? What would you change based on this information?

GE public rating: Baa1, Z-score: 1.405 → $Z < 1.8$, bankruptcy risk is high
Its Z score does not agree with its public rating since a Baa1 rating indicates only moderate credit risk.
AAPL public rating: Aa1, Z-score: 5.49 → $Z > 2.8$, bankruptcy risk is low
Its Z score does agree with its public rating since a Aa1 rating indicates low credit risk.
TSLA public rating: B3, Z-score: 2.19 → $1.8 < Z < 2.8$, bankruptcy risk is moderate
Its Z score does not agree with its public rating since a B3 rating indicates high credit risk.
MSFT public rating: Aaa, Z-score: 8.64 → $Z > 2.8$, bankruptcy risk is low
Its Z score does agree with its public rating since a Aaa rating indicates low credit risk.
GS public rating: A3, Z-score: 0.809 → $Z < 1.8$, bankruptcy risk is high
Its Z score does not agree with its public rating since a A3 rating indicates low credit risk.

Altman's Z score takes into account the company's underlying financial strength but does not take into account the character or integrity of the borrower which affects its real-life PD, the borrower's individual ability to service an obligation, or the terms of the credit transaction. Based on this info, you should evaluate a company's probability of default using both its credit rating and its Z score and look into the reasons for this difference. For example, Goldman Sachs credit rating of A3 indicates low credit risk because of its reputation and history of fulfilling its obligations, but its capital structure indicates that it might be at risk for bankruptcy.

2. Perform Merton model analysis on each of the issuers, calculate their DD's and implied PD's over 5 years

The distance to default and probability of default for AAPL over 5 years based on Merton model are as indicated in the table below.

	AAPL_DD	AAPL_PD
1	1.655543	0.048907
2	3.538627	0.000201
3	3.500492	0.000232
4	2.985291	0.001417
5	2.623718	0.004349

The distance to default and probability of default for GE over 5 years based on Merton model are as indicated in the table below.

	GE_DD	GE_PD
1	1.061965	0.144126
2	0.278735	0.390224
3	0.648054	0.258475
4	0.284237	0.388114
5	0.362907	0.358337

The distance to default and probability of default for TSLA over 5 years based on Merton model are as indicated in the table below.

	TSLA_DD	TSLA_PD
1	1.323417	0.092848
2	1.197055	0.115642
3	1.298511	0.097056
4	1.125645	0.130158
5	0.914486	0.180231

The distance to default and probability of default for MSFT over 5 years based on Merton model are as indicated in the table below.

	MSFT_DD	MSFT_PD
1	1.834817	3.326638e-02
2	5.001355	2.846446e-07
3	4.685931	1.393451e-06
4	4.021675	2.889283e-05
5	3.564194	1.824880e-04

The distance to default and probability of default for GS over 5 years based on Merton model are as indicated in the table below.

	GS_DD	GS_PD
1	1.153468	0.124359
2	0.262644	0.396413
3	2.401721	0.008159
4	1.843275	0.032644
5	1.547714	0.060846

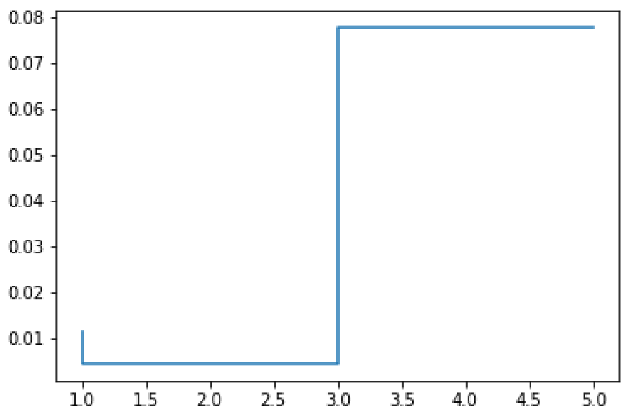
The distance to default and probability of default for AAPL, GE, TSLA, MSFT, GS over 5 years based on the Merton model are as indicated in the table below.

	AAPL_DD	AAPL_PD	GE_DD	GE_PD	TSLA_DD	TSLA_PD	MSFT_DD	MSFT_PD	GS_DD	GS_PD
1	1.654048	0.049059	1.062058	0.144105	1.322353	0.093025	1.818720	3.447708e-02	1.153027	0.124450
2	3.533419	0.000205	0.281759	0.389064	1.194176	0.116205	4.939881	3.908522e-07	0.262835	0.396339
3	3.497389	0.000235	0.647976	0.258500	1.296019	0.097484	4.647886	1.676767e-06	2.401765	0.008158
4	2.982676	0.001429	0.289726	0.386013	1.123891	0.130530	3.988797	3.320456e-05	1.843467	0.032630
5	2.621380	0.004379	0.364619	0.357698	0.913058	0.180606	3.534820	2.040268e-04	1.547918	0.060821

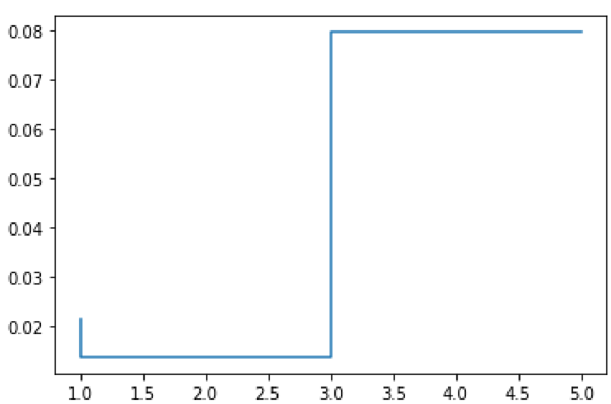
3. Obtain credit spreads for each of the issuers, calculate and draw default intensity step term structure (using Hull approach) – is it different from above steps, why?

The calculations for this step were completed via C++ using a program built out of the code in the folder “HW1_Narang_Andrew_impliedPDsHull” enclosed within this submission folder. These outputs were used to create the default intensity step term structures in Python, which were generated in the similarly enclosed file "HW1_CRM.ipynb" and are as follows:

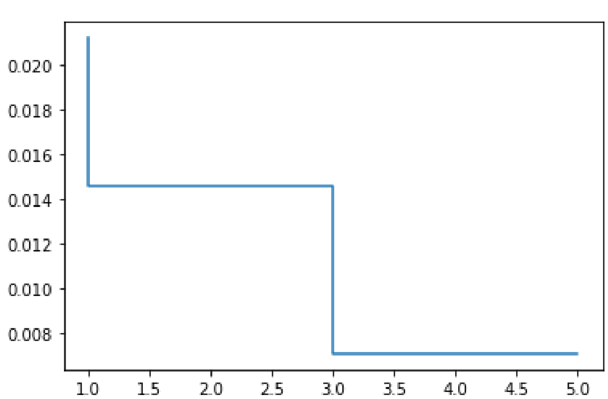
AAPL:



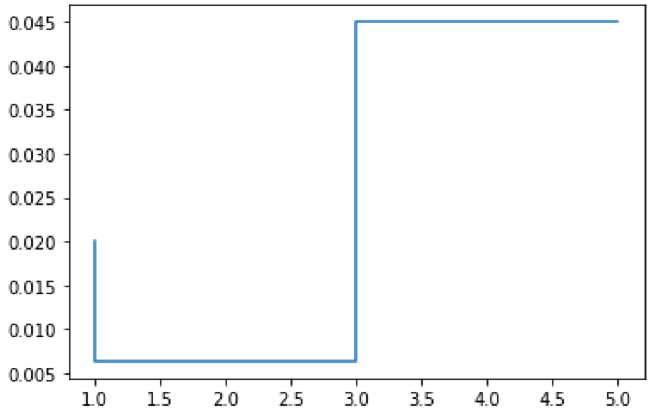
GE:



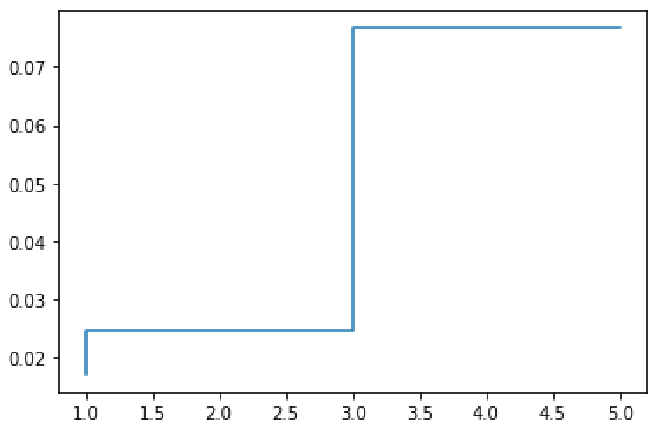
TSLA:



MSFT:



GS:



These default intensities are different because they are generated via a reduced-form model approach - the previous default intensities were derived via analysis of the company and its specific qualities. However, these default intensities were derived purely from the market valuations of debts issued by these companies. They were computed using comparisons with the corresponding risk-free rates for those maturities via Treasury yields. There are numerous different assumptions involved here, which could lead to issues with relying on this method alone. For one thing, the implied rates are calculated using theoretical bond prices based on the market yield and risk-free rates, but these rates do not only account for credit risk. The yield of a bond accounts for various other sources of risk, such as liquidity risk, that may counted as credit risk using this approach. The market yields themselves may not be accurate - if the bond is illiquid, as many corporate bonds are, then the pricing information and the corresponding yield might not properly represent the market's perception of the issuer's default probability with respect to these bonds. Such a situation could render this approach to determining the market's evaluation of a bond issuer's credit worthiness ineffective and misleading. Also, it does not account for differences in coupon rates, which could lead to different implied default probabilities by the same issuer and for the same maturity.

We should also consider the fact that default probabilities that are impacted by risk-neutral calculations can be higher because in the risk-neutral world, there is no extra return for extra risk, so your distance to default is smaller. This makes for generally higher probabilities of default.

4. Calculate implied JT-model π's from the generic issuer with the same rating (i.e. look at generic 5-yr spread for issuer in the same rating category, solve back for π using 5-year cumulative transition matrix), apply those π's to your issuers PD's calculated from Hull above, then – what should their 5-year credit spreads be? Are they consistent with the market pricing? Why yes, or why no?

PI outputs from JT model

	aapl	ge	gs	msft	tsla
1Y Pi	0.707059	0.621023	0.621023	0.891119	0.066235
2Y Pi	0.387102	0.332669	0.332669	0.475813	0.052709
3Y Pi	0.196042	0.167216	0.167216	0.238906	0.031716
4Y Pi	0.154107	0.132334	0.132334	0.182176	0.038530
5Y Pi	0.129959	0.112067	0.112067	0.150821	0.049161

Probability of Defaults * PIs

pis * pds

	aapl	ge	gs	msft	tsla
0	0.034580	0.089427	0.077230	2.958514e-02	0.006150
1	0.000778	0.129816	0.131874	1.354164e-07	0.006095
2	0.000045	0.043221	0.001364	3.320797e-07	0.003078
3	0.000218	0.051361	0.004320	5.263072e-06	0.005015
4	0.000565	0.040158	0.006819	2.744949e-05	0.008860

Model Output Credit Spreads 1 Year - 5 Year

	aapl	ge	gs	msft	tsla
1Y Spread	0.020748	0.053656	0.046338	1.775108e-02	0.003690
2Y Spread	0.000467	0.077889	0.079125	8.124981e-08	0.003657
3Y Spread	0.000027	0.025933	0.000819	1.992478e-07	0.001847
4Y Spread	0.000131	0.030816	0.002592	3.157843e-06	0.003009
5Y Spread	0.000339	0.024095	0.004091	1.646969e-05	0.005316

You can see in the above picture what the 5 Year credit spreads should be in the bottom row of the table.

Market Pricing 5 - Year Credit Spreads Vs. Model 5 - Year Spreads

	aapl	ge	gs	msft	tsla
Market 5-year Spread	0.002970	0.012601	0.006377	0.003915	0.015600
Model 5-Year Spread	0.000339	0.024095	0.004091	0.000016	0.005316
Difference	0.002631	-0.011494	0.002286	0.003899	0.010284

As you can see from the above table the spreads are not consistent with market pricing. This is due to our risk-neutral assumption. In the real risky world investors want to be compensated for the risk they take on resulting in higher yields (spreads) than those implied by the risk-neutral world.

5. Compare PD's from each of the steps above; write about how you would you use these estimates together

The results from the models are somehow consistent. For example, for MSFT, AAPL and GS, PDs from Merton and PDs from JT move consistently. However, for TSLA and GE, PDs from Merton and JT departs.

Merton:

	AAPL_PD	GE_PD	GS_PD	MSFT_PD	TSLA_PD
1	0.049059	0.144105	0.124450	3.447708e-02	0.093025
2	0.000205	0.389064	0.396339	3.908522e-07	0.116205
3	0.000235	0.258500	0.008158	1.676767e-06	0.097484
4	0.001429	0.386013	0.032630	3.320456e-05	0.130530
5	0.004379	0.357698	0.060821	2.040268e-04	0.180606

JT:

pis * pds

	aapl	ge	gs	msft	tsla
0	0.034580	0.089427	0.077230	2.958514e-02	0.006150
1	0.000778	0.129816	0.131874	1.354164e-07	0.006095
2	0.000045	0.043221	0.001364	3.320797e-07	0.003078
3	0.000218	0.051361	0.004320	5.263072e-06	0.005015
4	0.000565	0.040158	0.006819	2.744949e-05	0.008860

Altman’s Z only works on predicting bankruptcy risk in one year. It does not work with private, financial, or foreign companies, in our case, Goldman Sachs. However, this model will work very well for people who only need a quick result. The Merton model links capital structure to options involving many Black-Scholes assumptions. It works better for companies with simpler debt structures. Both Hull’s approach and JT-model obtain information from the market and assumes the market is complete and no-arbitrage (Risk-Neutral World). When we use all of these models to estimate PDs together, we need to understand the assumptions and to know what information we have. And then focus on the model that is more applicable to the real-life story.