Linking Equity & Credit Risk

Northfield Information Services Seminar
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Outline

- Which Models out there link Equity & Credit?
- What can we @ Northfield do to contribute?
  - A crude test - Is there any evidence of Northfield's Equity risk forecasts having any predictive power on Creditworthiness?
- Next Steps

Existing Models

- Merton, “On the Pricing of Corporate Debt: the risk structure of interest rates” - Journal of Finance, Volume 29, Issue 2, May 1974
- Leland, “Debt Value, Bond Covenants and Optimal Capital Structure”
- Gray, Merton & Bodie; “Contingent Claims Approach to Measuring and Managing Sovereign Credit Risk”

Merton Model

- Collectively, shareholders can be said to have:
  - A) a call option on ownership of a firms assets (by paying off the firm's debt);
  - B) a put option – by defaulting, forcing the company's creditors to take the firms assets in exchange for payment.
- Putting this in an option pricing framework yields...

Merton Model (via Black Scholes)

$$C(S,t) = SN(d_1) - Ke^{-r(T-t)}N(d_2)$$

$$d_1 = \frac{\ln(\frac{S}{K}) + (r + \frac{\sigma^2}{2})(T-t)}{\sigma\sqrt{T-t}}$$

$$d_2 = d_1 - \sigma\sqrt{T-t}.$$

- C(S,t) = price of the call option – in this case, equity market cap;
- K = strike price – in this case the amount of debt outstanding;
- S = spot price – present value of the assets – equity + debt;
- Sigma = Asset vol – approx. by E[equity vol] deflated by debt;
- Solve for (T-t) = option implied life of the debt;

Merton Model Limitations

- Assumes a constant riskfree rate of interest r – therefore underestimating asset volatility;
- Assumes bankruptcy proceedings cost nothing;
- Assumes a uniform body of vanilla discount, option-less, perpetually rolling debt;
- Can only be applied to Corporate issuers;
- The model is Robust however as it can be extended to address most of these issues

Merton Model Extensions

- Merton extended his own model to handle coupons & callable bonds;
- Leland (94) extends the model to handle more complex corporate structures including subordinated debt, incorporating bankruptcy cost, taxes – e.g. debt restructuring
- Gray Merton & Bodie extend the model to apply it to sovereign debt

Where Northfield fits in...

- One of the main inputs (the only one that needs estimation) to all the models discussed is Asset Volatility – As this, in practice is approximated by E[equity vol] deleveraged by the amount of debt an issuer has – this variable IS Northfield's core business...
- The question that needs answering is “what would the equity vol be if the issuer has no debt” - Northfield's in a unique position to address this question

Proove it - A Crude Test

- Is there any empirical evidence of Northfield's Equity models being able to forecast creditworthiness?
- Or, what happens when you've got:
  - 20 years of Equity risk model exposures;
  - A graduate student; and
  - A library...

The Data

- 17 years of weekly issuer level ratings changes (moodys, S&P, Duff & Phelps, Fitch) reported by Barrons, as collected by our intern, Steve Dyer (without whom this presentation would be a lot more boring) over 3 months; a total of 8956 entries.
- 20 years of the NIS Fundamental model continuous factor exposures, stock specific risk & total risk.

Fundamental Model

$$R_{i,t} = R_{f,t} + B*(R_{m,t} - R_{f,t}) + \Sigma^{66} E_{i,k,t} * A_{k,t} + E_{(i,t)}$$

where

$$\Sigma^{66} E_k * A_k = \Sigma^{11} E_{fund} * A_{fund} + \Sigma^{55} E_{ind} * A_{ind}$$

- The 11 fundamentals:
  - Earnings/Price
  - Book/Price
  - Div Yield
  - Trading Activity
  - 12 month Rel Strength
  - Log Mrkt Cap
  - Earnings Var
  - EPS Growth Rate
  - Revenue Price
  - Debt / Equity
  - Price Vol

The Method (data prep)

- Transform all upgrades / downgrades to a numeric scale
  - Moody's
    - +1 for a full upgrade: B1 to Ba1
    - +.33 for every subgrade: B2 to B1
  - S&P
    - +1 for a full upgrade: A to AA
    - +.5 for a subgrade: AAA to AAA+
- Normalize Beta, stock specific & total risk fields in the fundamental model

The Method (straight regressions)

- Limit sample to 1265 independent Moody's ratings changes;
- Perform cross sectional regressions, one per factor exposure, with the codified ratings changes (Y) as the dependent variable & the corresponding, lagged factor exposure as the independent variable, for example...
  - Y(t) = a + b*Price to book(t-lag) +e
- Increase the lag & see what happens to the numbers

Straight Regression Results (0 Lag)

inDepVar	a	b	t-a	t-b	r2
beta	-0.1	-0.12	-6.08	-7.08	0.04
earningsToPrice	-0.1	0.06	-6.04	4.21	0.01
bookToPrice	-0.02	-0.13	-1.27	-12.48	0.11
dividendYield	-0.1	-0.12	-6.27	-7.33	0.04
tradingActivity	-0.09	-0.06	-5.42	-3.11	0.01
relativeStrength	-0.03	0.24	-1.61	17.76	0.2
logOfMarketCap	-0.08	0.09	-5.03	7.17	0.04
earningsVariablility	-0.05	-0.17	-2.71	-10.41	0.08
epsGrowthRate	-0.09	0.07	-5.34	3.73	0.01
revenueToPrice	0.02	-0.14	0.92	-13.22	0.12
debtToEquity	-0.07	-0.05	-3.92	-3.64	0.01
priceVolatility	-0.05	-0.12	-2.93	-9.36	0.06
ssRisk	-0.1	-0.19	-6.28	-11.79	0.1
totalRisk	-0.1	-0.2	-6.31	-12.4	0.11

The “Straight” Story...

- Increasing the lag for these regressions DECREASES explanatory power
- Strongest factor is Relative strength a measure of whether the stock price has risen or fallen faster than the market over 12 months
  - a positive number means the stock is doing well & an upgrade is close on its heels -
  - Note the implied 1 year lag in the composition of the variable itself...
- Strong results for Total Risk and Stock Specific risk – logical – the riskier a company, the more likely a credit downgrade

“Straight” Story (contd.)

- Relative strength being stronger than revenue to price than book to price suggests that market forces are more important than company fundamentals in predicting ratings changes (!)
- Rsquared numbers are relatively low / T stats very high... How do we interpret these numbers? More on that later...

The Method (delta regressions)

- More cross sectional regressions... this time the price to book example looks like this:
  - $Y(t) = a + b * [P/B\ (t-1) - P/B\ (t)]$
- Increase lag & see what happens

Delta Regressions (9 month lag)

depVar	a	b	t-a	t-b	r2
beta	-0.11	-0.14	-6.42	-8.37	0.05
earningsToPrice	-0.1	0.06	-6.02	4.65	0.02
bookToPrice	-0.08	-0.11	-4.82	-7.02	0.04
dividendYield	-0.1	-0.12	-5.89	-3.78	0.01
tradingActivity	-0.1	-0.07	-5.46	-3.57	0.01
relativeStrength	-0.1	0.08	-5.51	5.38	0.02
logOfMarketCap	-0.06	0.52	-3.67	16.15	0.18
earningsVariablilit	-0.1	-0.18	-5.96	-8.23	0.05
epsGrowthRate	-0.11	0.03	-6.41	1.99	0
revenueToPrice	-0.07	-0.21	-3.91	-11.14	0.09
debtToEquity	-0.11	-0.04	-6.27	-2.04	0
priceVolatility	-0.07	-0.14	-3.93	-9.23	0.06
ssRisk	-0.11	-0.16	-6.46	-9.28	0.07
totalRisk	-0.11	-0.17	-6.49	-9.99	0.08

The Delta Story ...

- Here Log of Market Cap is the dominant factor – increase in Market cap forecasts positive ratings change – same as relative strength argument in previous regression
- Very strong T-Stats for stock specific & total risk – if the risk models estimate INCREASES, the likelihood of a downgrade increases

Aside on Credit Agency Diligence

- Credit rating agencies don't review ratings more often than quarterly since that is how often interim financial statements are issued.
- Full annual reports are only issued once a year, so a reasonable guess for frequency of reviews might be an average of every six months, if the rating agencies are being diligent.
- Our results show that these changes are somewhat predictable, even with a time lag of 9 months which implies that Credit Agencies are behind
- In the interim, why not use a different measure of default probability that can be estimated at any time & be current?

Problems with the Method

- There are no records for all the credit upgrades / downgrades that didn't happen which amounts to a kind of survivorship bias
  - Even so, if we were to adjust for this bias by assuming say 30,000 “0” events we can still say that T stats in the 5+ range are significant – we have many results in this range...
- We are using regression to estimate a discrete dependent variable – this almost certainly deflates our R2 measures.

Fixing the Problems

- Insert dummy records for all the times we think a credit rating agency looked at an issuer and left the rating unchanged:
  - Count the number of issuers each month whose level of debt would have warranted an investigation, subtract the number of actual changes & insert that resulting number of “0” records...
- Use discrete statistics such as Chi^2 contingency tables to estimate goodness of fit in addition to our traditional R^2

How can Northfield use these results?

- Conditioning (backward looking) transition matrix data with model forecasts,
  - e.g. if the historic probability of downgrade is 1 % and our model predicts %1.5 this could be a big deal (50% increase in bad events) for investors;
- Provides an intellectual basis for using the Merton Model (with Northfield asset volatility forecasts) for future forecasting;
- Start calculating & reporting issuer specific risk for EE problems;
- Improve credit risk estimation at the individual bond level in the EE Model...

One Final Thought

- Relationships in reverse...
- What can Debt risk say about credit?
- Is a change in OAS linked to Equity volatility?
  - Similar type of analysis, in reverse... set up a cross sectional regression with delta OAS as the independent variable and Equity returns or vol as the dependent variable...
  - Could work because OAS are perhaps the most liquid indications of what market perception of issuer creditworthiness...

big thanks to Steve Dyer ...