Project 1  Optimal hedge ratios for credit / equity trades

**Project background:** one common strategy within the capital structure relative value umbrella is trading credit versus equity. Credit and equity are both claims on the assets of a company. Debt securities typically pay a fixed coupon to the holder as long as the company does not default, but offers no additional upside if the company’s performance improves and its assets become more valuable. On the other hand, equity offers a residual claim on the assets of the company once debt-holders are paid, in addition to potentially offering cash flows in the form of dividends. As a company’s overall performance deteriorates, the prices of its equity and debt fall, as its future earnings potential falls and its probability of default rises. Investors who trade credit versus equity use theoretical and empirical models to think about both the “right” price of debt versus equity (and hence, when to put on a long equity, short credit trade or vice versa) and about appropriate hedge ratios for those trades.

One way to approach trading credit against equity is to model debt securities as short out-of-the-money put option positions on the company’s assets (you earn a fixed premium, unless the company’s performance is very poor, in which case you take losses) and equity securities as long in-the-money call option positions on assets (you get all the upside from increased asset value, with downside limited to the money you put in). This “structural modeling” approach generates fair-value relationships and hedging relationships between credit, equity and volatility, and captures the underlying nonlinearities in credit-equity relationships (specifically, the increase in sensitivity of credit to equity as a company’s financial leverage increases). An alternative is a more reduced-form statistical approach, in which the investor estimates mean-reverting statistical relationships between credit and equity and use hedge ratios based (for example) on regressions of credit spread changes on changes in equity prices and implied volatility.

**Project objective:**

- Evaluate the performance of one of our basic structural model implementations in predicting relative moves in credit as a function of moves in equity and implied volatility.
- Compare performance of model-predicted credit/equity/vol sensitivities evaluated at the implied credit spread, implied equity volatility and implied leverage (*more detail below*)
• Benchmark performance of model sensitivity predictions against purely statistical predictions of expected credit moves conditional on equity moves and volatility moves

• Use results to design framework for optimizing hedge ratios for credit / equity and credit / equity / option trades

**Implementation guide:**

• For reference, start with the standard CreditGrades model and the paper by Finger et al. We will guide you on the customizations we think it makes sense to apply and what assumptions to use.
  - For example, how to calibrate the stochastic default barrier, and how to choose a theoretically appropriate volatility assumption

• Our basic structural model implementations define equilibrium relationships between equity prices, credit spreads, debt and volatility (which are translated into variables relating to the asset value process). Thus, the models produce:
  - implied credit spreads as a function of equity price, debt and equity volatility
  - implied volatility as a function of equity price, debt and credit spread
  - implied equity price as a function of debt, equity volatility and credit spread
  - Greeks for each variable versus the others, at each implied value
    - Example 1: credit delta (= bps change in credit per $ change in stock price)
    - Example 2: credit vega (= bps change in credit per 1% change in volatility)
    - Note that nothing about the theory tells you which market is mispriced, or if they are all mispriced, or which points to use to evaluate the hedge ratios!

• Example: Ryland Group, 3/15/2011
  - 5-year senior unsecured CDS spread = 236 bps
  - Equity price $16.13, debt per share $20.19
  - Volatility assumption (based on 2-year F put options and 5-year SPX put options): 50.0%
  - Implied spread = 473 bps, equity delta @ implied spread = 43 bps / $
  - Implied equity = $24.34, equity delta @ implied equity = 26 bps / $
  - Implied equity volatility = 35.9%, equity delta @ implied volatility = 30 bps / $
• Using a dataset on US companies since 2003 (when CDS data started to become available), measure the performance of the structural model for predicting credit moves as a function of equity and volatility moves
  o For example, you could use a linear regression specification at the one-week frequency:
    \[
    \Delta \text{MarketSpread}_{it} = \alpha_0 + \alpha_1 \Delta \text{ModelSpread}_{it} + \epsilon_{it}
    \]
  o At the implied spread, we have
    \[
    \Delta \text{ModelSpread}_{it} = \text{ModelSpread}(\text{MktEquity}_{it}, \text{MktVol}_{it}, \text{DebtPerShare}_{it}) - \text{ModelSpread}(\text{MktEquity}_{it-1}, \text{MktVol}_{it-1}, \text{DebtPerShare}_{it-1})
    \]
    - At the implied volatility, you’d have the same type of thing but you’d use the structural model implied volatility at time t-1 and then change it by the observed % change in equity volatility
    - At the implied equity price, you’d use the model-implied equity price at time t-1 and then change it by the observed % change in the equity price
  o We want to better understand how well the model performs
    ▪ Overall
    ▪ Comparison over time
    ▪ Comparison between predictions at implied spread, equity and volatility
    ▪ Comparison to simple statistical models
    ▪ Comparison across credit spread levels (e.g. < 200 bps versus > 200 bps)

• Use the results to propose a methodology for optimize hedge ratios for credit versus equity trades
  o A classic trade example would be buying $10 million notional 5-year CDS protection and buying equity against it. We might do this, for example, if the fair credit spread implied by the equity price, debt and our equity volatility assumption is considerably higher than the spread observed in the market. [And if we did some more homework!]
  o We would choose a hedge ratio (e.g. a number of shares of stock to buy against the $10 million CDS position) at least partly based on the structural model deltas we estimate
    ▪ To illustrate hedge construction, suppose the stock price was $10, the delta we use is -20 bps / $, and the credit spread is 200 bps.
    ▪ To find the estimated dollar PnL on the $10 million CDS position per $1 change in the stock price, multiply the delta (which is in units of bps per $ stock move) by the CS01 of the CDS position (or the change in the market value of the CDS contract per 1 bp change in the spread). For 10mm of a 200-bp 5-year spread, the CS01 is about $4,300, so a $1 increase in the stock price would yield a loss of
4300 * 20 = $8,600 on the CDS position. To hedge this, we would buy 8,600 shares of stock.

- The key input here is the delta to use... hence the usefulness of statistical comparison among the predictive power of the deltas at different implied values!
  - We might also sell some long-dated, downside put options against the CDS in order to hedge the (structural model implied) vega. But start with the simple credit / equity.
Project 2  Credit, equity and volatility at the index level

Project background: there are (and should be) strong economic relationships between credit, equity and equity-implied volatility in large, liquid index markets, much as there are at the individual company level. For example, the CDX IG and CDX HY indices of 5-year investment-grade and high-yield credit default swaps correlate strongly with the S&P 500 index and the implied volatility of long-dated SPY and SPX put options. The underlying economic relationships at work are theoretically just the aggregation of the individual-company-level credit/equity/volatility relationships which are the bread and butter of capital structure arbitrage investors. However, in practice credit indices and equity indices do not overlap perfectly – for example, there are only 125 names in the CDX IG versus 500 in the S&P 500, and some of the CDX names are private companies – which complicates theoretical analysis.

These index products are relatively liquid and efficient. However, because they are the first place investors go to adjust their overall market exposure, they have complex dynamics around stress periods as investors frantically add or take off risk. This potentially creates relative value opportunities. This project suggests an exploration of the statistical and theoretical relationships among US credit, equity and volatility indices (CDX, VIX, SPX, SPX option-implied volatility etc.)

Project objectives:

- Summarize the day-to-day and week-to-week joint distribution of returns among the S&P, the implied volatility of 1- and 2-year out-of-the-money put options on the S&P and the CDX indices. How has this changed over time? (Note that 2007 was a weird period for these relationships.)
- Test some of the hypotheses one would naturally take from structural modeling:
  - Is high-quality credit less strongly correlated with equity than lower-quality credit?
  - As risk increases and credit spreads widen over time, do credit spreads should become more strongly correlated with equity?
  - Do changes in the implied volatility of longer-dated, out-of-the-money put options on equity indices predict changes in credit index spreads better than changes in the implied volatility of shorter-dated options and upside (OTM call) options?
  - How consistent is the relationship among index credit spreads, index volatility, and aggregate debt/leverage over time?
o Can you identify statistical equilibrium/cointegration relationships that hold up out of sample?

- If one was to “pretend” that the S&P 500 was a single company, with equity price equal to the SPX level, and debt per share equal to the total debt of the constituents, and credit spread equal to the CDX IG index spread, one could then apply a standard structural model (using implied volatility on long-dated put options) and estimate fair relative relationships and hedge ratios between the equity, credit and volatility indices. The S&P consists of large-cap, mostly investment grade companies, so this is not a crazy thing to try as a comparison, but the overlap in companies between SPX and CDX is quite imperfect (500 names versus 125, and the latter has some private companies with no traded equities). How do the results compare to statistical approaches in terms of predictive power for one index on the basis of others?

- Can you develop and back-test a robust systematic strategy for triggering index trades (short volatility / short credit, long equity / short credit, long equity / long volatility, and the reverses) on the basis of reversion to statistical equilibrium relationships or reversion to structural model equilibrium relationships?
Project 3. Recovery rate estimation

Project background: the distribution of debt within a company’s capital structure is quite important in determining the recovery rates on the various pieces of debt in the event of default, and hence in determining the credit spreads investors should receive on that debt. In a corporate bankruptcy situation, under the strict legal priority of claims, holders of senior secured debt (bank loans, secured bonds) must be paid in full before senior unsecured debtholders, who must in turn be paid in full before subordinated debtholders. As a result, an upside-down capital structure (with a high percentage of senior debt) will tend to generate much lower recovery rates for senior debtholders than a capital structure with a low percentage of senior debt.

In practice, settlements in bankruptcy strongly reflect this principle of priority, though they do not usually follow it exactly (for example, senior debtholders may agree to give a higher recovery to junior bondholders than they would otherwise receive in order to speed up the resolution process). Fundamental credit analysts estimating workout values for defaulted debt securities typically carry out detailed analysis of the company’s assets and liabilities, considering different scenarios for overall asset coverage and the resulting waterfall of cash flows down through the capital structure.

A natural quantitative analog to this approach would be to model an explicit distribution of overall recovery on the bankrupt company’s assets, then derive expected recovery rates via the priority of claims – e.g. at each point in the probability distribution of aggregate recovery, the senior secured debtholders are paid back until they are made whole, then cash starts flowing to senior unsecured debtholders, and so forth until the pool of recovered assets is exhausted. Company-specific and macroeconomic covariates could enter the overall recovery function. (See my notes on this…)

Project objectives:

• Implement a structural model of recovery rates based on a parameterized distribution of overall recovery rates on company assets and a strict priority of claims in the capital structure

• For comparison / benchmark, implement a reduced-form econometric recovery rate estimation model (for example, patterned after Moody’s LossCalc), which relates the conditional expectation of recovery rates to a set of covariates related to the security, the issuing company and the macroeconomic environment at the time of default
• For both models, estimate the model parameters using default events prior to 2010, and then assess the power of the model for explaining recovery in default events in 2010. Consider the model’s relative power in explaining:
  o variation in dollar-weighted average recovery rates across default events for a given tier of debt
  o variation in dollar-weighted average recovery rates across tiers of debt for a given default event
• Compare the performance of the two models. Does one strictly dominate, or is one model better for explaining variation across default events and the other better at explaining variation across tiers of debt?
• How well do both models’ predicted recovery rates for performing (non-defaulted) credit securities explain their current credit spreads?

References:
• My notes on modeling recovery in the context of the bankruptcy process
• Unal, Madan and Guntay (2003), “Pricing the risk of recovery in default with absolute priority rule violation”
• Schlafer and Homburg (2009), “Estimating market implied recovery rates from credit default swap premia”
• Schuermann (2004) “What do we know about loss given default?”
• Moody’s LossCalc (2002)
• Keisman and Van de Castle (1999) “Recovering your money”
• Jacobs and Karagozoglu (2010) “Modeling ultimate loss given default on bonds and loans”
• Altman et al (2005) “The link between default rates and recovery rates”
Project 4. Optimal hedging of interest rate exposure given credit correlation

**Project background:** fixed income and credit instruments have exposure to interest rate risk, typically measured at a first approximation by rho or DV01 (change in value for a 1 basis point parallel shift in the yield curve). A relative value portfolio involving credit instruments will generate some residual interest rate exposure, often short DV01 (e.g. losing money as the yield curve shifts upward), because trade-level hedge ratios are typically chosen to neutralize other sources of risk (credit risk, relative credit / equity risk, etc). As a result, we need to hedge portfolio interest rate risk.

One way to approach hedging interest rate risk is to add up DV01 across the entire portfolio and short enough treasuries or enter enough interest rate swaps to reduce total DV01 to zero. This is a pure “Greeks” based risk management approach – note that the correlation between interest rates and other market prices plays no role. The danger here is that, in periods of market stress, flight-to-safety effects take hold and the correlation between treasury bond prices and risky asset prices becomes sharply negative (treasury yields fall when credit spreads rise, and vice versa)\(^1\). As a result, when there is a panic and your credit positions are taking losses, you are also losing money on your interest rate hedges, exacerbating downside volatility of portfolio PnL. However, in more normal periods, correlations between risk-free yields and credit spreads are more moderate, and can even be positive, depending on the underlying sources of the movements in the two asset classes.

As a result, interest rate risk management must be quite dynamic and responsive to the macroeconomic environment, and hedges must be structured to balance the risk of rising interest rates on the one hand versus market stress events and tail risk on the other hand.

**Project objective:**

- Specify a few dynamic statistical models of the relationship between risk-free yields and credit spreads that captures the changing correlation. Examples:
  - Regime-switching model (normal period, stress period)
  - Time-varying correlation model (correlation coefficient follows a stochastic process)

\(^1\) In addition, during stress periods you also see increases in cash-synthetic basis (or the difference in credit spreads between credit default swaps and cash debt securities like bonds). This often exacerbates losses for relative value funds, which will often short credit synthetically (using CDS) but get long credit through cash securities for liquidity reasons.
- Correlated jumps model
- Latent multivariate factor model with or without jumps

- Using data on credit indices and yield curves, estimate the parameters of the various models and compare their predictive power
- Using a dataset of a portfolio’s theoretical credit spread exposure and interest rate exposure, design an optimal dynamic interest rate exposure hedging strategy for the portfolio based on each of the statistical models you implement (based on minimizing a combination of volatility and a measure of tail risk), and compare out-of-sample results
- Can you use multiple models simultaneously to improve performance, or does one model dominate?
Project 5. M&A and credit

Warning: this one is earlier-stage from our perspective and may require a bit more contextual knowledge about capital markets plus willingness to experiment!

Project background: the implications of M&A activity for equity have been thoroughly studied and there is an active investment community focused on merger ‘arbitrage’ in equity markets. In some types of M&A situations – especially leveraged buyouts (LBOs) – there are also substantial implications for credit markets. Typically the target company’s CDS spreads widen when an LBO is rumored or announced, reflecting the market’s belief that a successful LBO will result in significant increases in the company’s leverage. Bond spreads can rise or fall depending on the type of protective covenants they have. For example, Hilton’s 5-year CDS spread rose from 125 to 250 basis points on July 5 2007 upon the announcement of a Blackstone-led buyout, while their 7.5% 2017 bonds dropped in price from 104 to 94.65. The bonds subsequently recovered and traded all the way up to 120 in early October as the CDS spread came back into 200 bps at the merger completion, then subsequently as the subprime crisis worsened the credit spreads on both the bond and the CDS exploded.

Other types of M&A seem to have ambiguous implications for credit depending on the relative leverage and cash flow of the acquirer and the target companies, the nature of the merger, etc.

Relative to equity markets, much less systematic analysis has been devoted to movements in credit markets around M&A activity. Both from a risk management perspective and a relative value investing perspective, it would be valuable to better understand and quantify the behavior of CDS spreads and bond prices around M&A situations.

Objectives:

- Characterize the probability distribution of senior unsecured CDS and bond spread moves triggered by the announcement of a potential M&A transaction
- What about pre-announcement? Is there systematic evidence of pre-announcement rumors and speculation on spreads?
- Split analysis by major deal types (LBO, all-cash acquisition, all-stock acquisition, mixed cash/stock acquisition)
- Characterize the change in the dynamics of credit spreads after a merger announcement
o How does the volatility and jump behavior of credit spreads change?

o For deals that are eventually successfully completed, what does the convergence path of credit spreads look like as the deal nears completion? What happens just after deal completion? How is this different for CDS, cash bonds without change-of-control protection in their covenants, and cash bonds with change-of-control covenants?

o For deals that are eventually terminated, what is the distribution of bond spread moves triggered at the termination date? Over one week and one month prior? Sometimes a deal breaks on a “jump” in information (e.g. an antitrust ruling) but usually the markets

• What is the relationship between the behavior of credit spreads in an M&A situation and the probability of deal success implied by the merger arbitrage spread in the equity market? For example, does the credit richen or become more volatile as the implied probability of deal success drops?

• Based on your findings, how might you propose measuring the risk of a CDS or bond position on a company that enters a new potential M&A situation? Consider the following types of risk:
  o Price / spread volatility risk throughout merger deal proceedings
  o Deal completion risk
  o Deal-break risk

• Based on your findings, how would you evaluate potential credit / equity merger arbitrage strategies?
  o Trading equity versus buyout-protected bonds after a deal announcement?
  o Trading buyout-protected versus non-buyout-protected bonds after a deal announcement based on the equity-implied probability of deal success?
  o Depending on relative moves in CDS spread versus equity at deal announcement, either
  o Can the equity-implied probability of deal success inform trading strategies involving credit instruments?

References:

• Moore, Risk Arbitrage  -- from equity investor perspective

• I’ll give you a couple obscure papers too