KKR 2nd Interview

Credit Portfolio Modeling

Basics

- Upside is capped so downside protection is key: loss of income & loss of principal => probability of default & recovery rate
- Fixed income securities can be represented as cash flows (zero-coupon instruments) and can be combined by mapping (PV) to specific maturities
- Borrowers' credit states, borrower's PD and instrument characteristics impact the correlation in instrument values, which can be explained by the firms' relationships to a set of common factors, eg. systematic (industry, country, economic risk...) and idiosyncratic

https://www.msci.com/documents/10199/5915b101-4206-4ba0-aee2-3449d5c7e95a

https://www.moodysanalytics.com/-/media/whitepaper/2021/overview-of-modeling-credit-portfolios.pdf

CreditMetrics example: VaR due to credit

- Exposures: user portfolio -> market volatility -> exposure distribution
- Correlations: rating/equity series -> models (e.g. correlation) -> joint credit rating changes
- VaR due to credit: (1)credit rating -> rating migration likelihood (2)seniority -> recovery rate in default (3)credit spread -> present value reevaluation
- => std of value due to credit quality changes for a single exposure => VaR due to credit

https://www.youtube.com/watch?v=dG5now0gB2U

Credit model example: asset backed lending model

- Asset level input/assumption: interest rate, duration, payment frequency, payment type(principal/interest), prepayment and refinance, default rate,
- Fund level input/assumption: interest rate, advance rate (LTV), payment type (interest-only, fully amortizing, tranch payments...)
- Borrower model: build out the projected cash flows for different types of repayment schedules and then consolidated into a combined schedule
- Lender model: build out the lender's projected cash flow based on fund-level assumptions, to understand relative perform vs. lender's expectation (IRR)
- Scenarios analysis: stress test lender's IRR under various CDR multiples => our income will not be impacted as long as the IRR of the lender's cash flows is equal to the interest rate. Once it dips below the interest rate, our income is impacted; and once it dips below 0%, our

principal is impacted.
- Output: loss coverage ratio is the multiple on CDR that we can sustain before losing income or principal; also check it on absolute default terms

https://alibhamed.medium.com/how-to-build-a-credit-model-c39a8e7b31e5

Portfolio cash flow model example: Bank loan portfolio

- Framework: valued consumer and commercial bank loan portfolios using a discounted cash flow model under the income approach. This includes developing expected future cash flows on a loan-by-loan basis and discount the expected cash flows to present value at an appropriate risk-adjusted rate of return.
- Information gathering: this includes
  - [1 asset data] contractual loan terms (origination date, fixed interest rate or spread, base rate, maturity, payment frequency, etc.), borrower credit data (LTV), debt service coverage ratio, FICO, and the originator's internal risk rating;
  - [2 originator data] bank's historical experience of loan prepayments, losses, and recovery rates;
  - [3 market data] yield curves for base rates, historical and expected prepayment rates on broader loan pools, and expected default rates by credit metric (LTV, FICO, and DSCR).
- Asset level cash flow assumptions (adjust the cash flows for expected losses, prepayments, and recoveries prior to discounting them to present value):
  - (1)Prepayment Rates: typically express as a constant prepayment rate (CPR) on a monthly basis, which represents the percentage of outstanding principal balance prepaid in each period. For varying CPR, we build a "CPR curve" based on historical originator experience, historical market data and market participants' forward-looking expectations
  - (2)Default Rates: express default rates as a constant default rate (CDR), which is developed by examining the originator's historical default experience, the credit metrics(LTV, FICO...) of each asset in the portfolio, and market data related to expected default rates by certain credit metrics.
  - (3)Recovery Rates: alternatively expressed as a rate of "loss given default". These rates are a function of both originator and market data and the credit metrics of a given loan.
- Expected Cash flows: model future cash flows associated with each loan based on the contractual terms and the key assumptions described above. The analysis is performed on an asset-by-asset basis as opposed to "bucketing" or consolidating cash flows for pools of loans, as prepayment rates, default rates, and present value factors are generally not linear functions of the variables used to derive them

- Discount rate assumptions: apply appropriate discount rates to each loan, expressed as a base rate + credit spread. To determine credit spread, we can:
  - (1)look to the market for independent data related to appropriate pricing on comparable assets, or
  - (2)assume that the subject bank transacts at fair value and "extract" the appropriate credit spreads from contemporaneous loan originations or loan sales by the bank to third parties.
  - To employ (2) ~ calibrate to back-solve the NPV for the comparable asset to derive credit spread: we can select a group of assets for which we have a known fair price, develop expected cash flows for each asset using the same process and inputs for all the other loans in the portfolio, then solve for the appropriate credit spread that results in a net present value equal to the observed price of the asset

https://www.stout.com/en/insights/article/valuation-techniques-bank-loan-portfolios

Cash flow analysis example: cash flow modeling for ABF

- Prepare data for cash flow forecasting and PD prediction based on account behavior data (payment history), borrower's attributes, and economic data.
- Forecast cash flow (interest & repayment) using econometric model that associates borrower's payment history with account/economic data
- The forecasted cash flows in general will be adjusted with the borrower's credit quality (charge-offs & delinquency) and estimated credit losses.
- Predict PD with borrower's history, attributes and repayment capacity using logistic regression model
- Generate key indicators using predicted PD: (1)yield = interest + fee / principal balance (2)principal payment rate = repayment / principal balance (3)Charge-offs = uncollected loan balances removed from a bank's books (4)pool stability = beginning outstanding balance – principal payment – credit losses / beginning outstanding balance (5)the account-level PD can be used to estimate pool-level (joint) PD using default correlation
- Cash flow allocation: securitization pools typically are allocated to the tranches based on seniorities (waterfall) and pre-specified rules (maturity, coupon…)
- Simulation techniques (such as historical, Monte Carlo, or scenarios) are used to create various market states to show how values of pool receivables are impacted by changes in related market risk factors. It also consider default correlation at account, pool, or tranche levels to enhance simulation.

https://www.lexjansen.com/nesug/nesug11/fi/fi05.pdf

Credit model inputs example: CLO multi-sector fixed income cash flow model

- Asset portfolio default and recovery rate assumptions
- Asset portfolio characteristics including amortization profile, margin and interest-rate distribution
- Asset portfolio exposure to voluntary termination and residual value risk assumptions
- Transaction liability structure
- Transaction derivative hedging arrangements
- Interest rate trend assumptions (rising, stable and decreasing)
- Default timing assumptions (front-loaded, evenly-loaded and back-loaded)
- Asset prepayment rate assumptions (low and high)
- Asset recovery timing assumptions

https://www.fitchratings.com/structured-finance/multi-asset-cash-flow-model#overview

Portfolio cash flow model example: PE fund cash flow model

- Inputs (fund level): equity contributions, debt ratio, fund life, commitment period, expenses, hurdle rate, investor-wise management fees, promote structure
- Along with these assumptions, a capital drawdown schedule is provided to track the timeline of investments during the commitment period.
- Specific assumptions are provided for availing debt and the returns to be generated from each portfolio investment and its holding period
- Performance Metrics: for each LP and the GP, presented in nominals and IRR/Cash on Cash Multiples
- Fund Cashflows: It tracks total capital contributions (derived from each LP capital and debt principal) and the take-outs in the form of fees, expenses, and transaction fees. The net remains (or net invested capital) is then invested in portfolio investments. Portfolio cashflows are provided for each individual investment as well along with the NAV calculation. The cash inflow from the portfolio is first used to pay off scheduled debt payments (interest and principal), then fees and expenses. The remaining cash flows are used for waterfall distributions based on the hurdle, catch-up, and carry assumptions between LP/GP

https://www.efinancialmodels.com/downloads/private-equity-fund-model-investor-cashflows-180441/

Loan Modeling

- Basic model: required payment = PMT(rate/12, term*12, -principal) => principal repayment = required payment - principal*rate

- Ballon payment: payment = required payment + extra payment + if(last period, ballon payment, 0) => goal seek(ending principal = 0, extra payment)
- Dynamic interest rate: after N initial periods, new rate = APR/12 - rate reduction => req payment = PMT(new rate, remaining months, beginning principal)

https://www.youtube.com/watch?v=wXUrygioSUQ&list=PL7zo_gA9cuyK0ou_35Mh33IQC-xJ118xo&index=9

Portfolio Analytics

Basics

- Portfolio analysis is a quantitative technique that is used to determine the specific characteristics of an investment portfolio.
- This involves several stages, typically comparing the portfolio against a benchmark, including performance, risk metrics, attribution, and positioning.
- The goal of analyzing an investment portfolio is to help investors decide whether it has achieved its objectives and identify areas that can be optimized.
- Performance analysis describes the absolute or relative performance vs. a benchmark, for example alpha, Sharpe, upside/downside capture
- Portfolio positioning describes how assets are spread across various asset classes, geographies, sector, styles, durations, credit quality and factors.
- Portfolio characteristics compare a style-biased portfolio to a benchmark, such as valuation (P/E, P/B…), market cap, earnings growth rate, cash flow…
- Return attribution is used to assess the sources of portfolio returns, using factors like asset allocation, security selection, market, macroeconomics…
- Risk contribution decompose the portfolio volatility with factors such as market, country, macroeconomics(rates, forex, spreads…), sector, specific…
- Scenario analysis shows the statistical estimate of a portfolio's reaction to hypothetical/historical market event based on estimated exposure to risk factors

https://www.fe.training/free-resources/portfolio-management/portfolio-analysis/

Performance Attribution

- Performance attribution can be divided into Relative Attribution and Absolute Attribution. The former measures the excess return of a portfolio against its benchmark into the active decisions; the later explains the sources or key factors of return/risk of a portfolio.
- Three types of attribution

    - (1)Holdings(position)-based attribution: analyze the underlying beginning-period holdings of the portfolio only, allowing for shorter periods analysis
    - (2)Transaction-based attribution: use both the holdings and the transactions that occurred during the evaluation period.
    - (3)Returns(factor)-based attribution: decompose historical returns into factors (regression), such as fundamental, macroeconomic, market factors…
- Relative Attribution: Both Holdings-based and Transaction-based attribution are "asset-grouping", reflecting the need of positions and variance from benchmark. For example, The Brinson-Fachler Model decomposes a portfolio's excess returns into allocation, selection and interaction (by sector)
    - Allocation effect = (Wpi - Wbi) * (Rbi - Rb)
    - Selection effect = Wbi * (Rpi - Rbi)
    - Interaction effect = (Wpi - Wbi) * (Rpi - Rbi)
- Absolute Attribution: Returns-based or regression-based attribution does not necessarily require the composition of the portfolio. It is a direct descendant of Fama-French three-factor model. There are four types of factor models:
    - (1)Implicit factor model: some factor analysis (e.g., PCA) is performed to statistically extract the factors from the return's time series
    - (2)Explicit macro factor model: macroeconomic variables are used as factors.
    - (3)Explicit micro factor model: microeconomic attributes are used as factors.
    - (4)Explicit index factor model: stock market indexes (including style indices) are used as factors.
- Fixed-Income Attribution
    - No single, standardized way of defining fixed-income attribution exists, but some of the typical fixed-income attribution effects are:
    - (1)*carry* represents the return resulting from the passage of time: *coupon* payments, accrued interest, and *rolling down* the yield curve (the pull-to-par effect as the instrument approaches maturity).
    - (2)*yield-curve* factor represents the changing shape of the yield curve, *parallel shift* (the impact of a parallel move of the yield curve), *twist* (a change in slope of the yield curve), and *curvature* (change in the curvature of the yield curve). Often, twist and curvature are combined and described as nonparallel changes in the yield curve or *curve reshape*.
    - (3)*Spread* is the return that comes from the widening or narrowing of credit spreads.
    - (4)*Selection* effects include *convexity*, any *optionality* in the

payment of future coupons (important with mortgage-backed securities because mortgages can be prepaid), and a *residual*. Normally quite small, residuals are classified by Dias (2017) as caused by the model or caused by data errors and systematic or random effects.
    - (5)In the *other* category, the *price* effect captures the difference in price sources between the bonds in the portfolio and bonds in the benchmark. This is a non-management effect that is a particular problem for fixed income. The *trading effect* measures the impact of intraday trading. *Currency* captures the impact of independent currency management

https://www.cfainstitute.org/-/media/documents/book/rf-lit-review/2019/rflr-performance-attribution.ashx
https://cran.r-project.org/web/packages/pa/vignettes/pa.pdf

Regression

- Example:
    - US 10y yield : 3m OIS, 5y5y inflation swap, FFR, CESI, ETF+CFTC
    - S&P 500 : earnings growth, 3m yield, credit spread, term spread
    - Gold: 5y yield, JPY, inflation, ETF+CFTC
- Use correlation or stepwise regression to select variables
- Diagnosis: overall model fit (F-test), multicollinearity(VIF), stationarity(ADF), residuals autocorrelation(Durbin-Watson), non-linearity and heteroscedasticity of residuals(scatter plot, White test), normality of residuals(QQ plot)
- What if multiple regression: non-stationary(differencing), naughty residual(transform variable: normalize, %change, log), heteroscedasticity or autocorrelation(GLS), autocorrelation(lag), multicollinearity(remove variables, PCA)

Risk analysis in Fixed Income

- Risk measure: VaR, expected loss (LPSD), expected shortfall(CVaR)
- Portfolio-referent risk: risk contribution (marginal contribution to portfolio std), tail risk contribution (marginal contribution to portfolio tail loss or VaR)
- Concentration/Diversification: single name, country, industry, sector
- Variation in instrument level inputs (e.g., holding amount, loss given default (LGD), tenure, contingencies, and fees).
- Variation in borrower level inputs (e.g. probability of default (PD), term structure of PD, size, industry, geography, retail product or property type)
- Correlation: geographical, sectoral, national and regional macroeconomic factors, intra- and inter-asset class

https://www.msci.com/documents/10199/5915b101-4206-4ba0-aee2-3449d5c7e95a

Scenario analysis / Stress test

- This shows the statistical estimate of a portfolio's reaction to hypothetical/historical market event based on estimated exposure to risk factors
- Hypothetical stress tests serve to illustrate potential portfolio movements during different scenarios based on a series of assumed market events.
- [Example scenario 1] Market Recovery: S&P 500 +15%, US 10y% + 6bp, crude +20%, volatility index -12%
- [Example scenario 2] Global Recession: S&P 500 -14%, US 10y% -30bp, crude -28%, volatility index +15%
- [Example scenario 1] Depression Fears: S&P 500 -30%, US 10y% -70bp, crude -50%, volatility index +50%

https://advisor.morganstanley.com/the-apex-point-group/documents/field/n/ne/neuman---embree-group/Sample%20Risk%20Analysis_Neuman%20Embree%20Group.pdf

My Exposure

SIAR: BDC modeling

- Financial ratios
  - Portfolio stats: NAV, P/B, NAV discount, dividend, WA yield, yields on funding/exit, spread, rate sensitivity, PIK income%
  - Earnings: NII, EBITDA, net interest margin, realized/unrealized P&L
  - Investment activity: origination, repayment, average size, portfolio company WA EBITDA/leverage/interest coverage
  - Asset allocation: floating rate%, first-lien/second-lien/subordinated/equity, sector allocation
  - Credit quality: portfolio FV/cost, watchlist companies FV/cost/%, non-accrual FV/cost/%, internal rating
  - Debt: net debt (borrowing+payable-cash-receivable), debt/equity, EBITDA/interest (coverage), maturity wall, secured/non-secured debt
- Research
  - Time series watch: trend (leverage, yield, origination, credit, FV/cost...)
  - Comparative analysis: outliers, pick the characteristics we favor (low leverage, low PIK%, high EBITDA/interest, high NIM, high first-lien%, large size)
  - Regression analysis (cross-sectional): low PIK%, high first-lien%, high FV/cost ~ high P/B
  - Compare with: management comments(concern on cyclical sectors...), macroeconomics(base rate, Fed...), credit market(HY spread, default...)
- Some findings

    - Leveraged loan and small-cap value equity returns explain 81% of BDC performance
    - Cross-sectional BDC returns are widely dispersed (15% diff between top/bottom quantile) and exhibit strong persistence in top- and bottom-quartile manager performance.
    - There's significant relationship between valuation (price-to-NAV) and performance, with BDCs with greater price-to-NAV premium (or smaller discount) outperforming those with a smaller premium (larger discount) by all return metrics.

ProTrend

- Credit market indicators
    - IG/HY credit spread
    - IG/HY/MBS/credit card... default rates
    - Distressed ratio (% >1000 bps)
    - Interest coverage
    - Debt/EBITDA
    - Bankruptcy filing
    - Fed lending standard
    - Business surveys
- Invest in: LQD, HYG, BKLN(Invesco Senior Loan ETF)

Portfolio analytics

- Private fund modeling
    - Modeling: NAV, adjusted net cost (cost-ROC distribution), P&L (NAV - adjusted net cost + income distribution), quarterly change => progression
    - Analytics: max dd, compare return/risk again benchmark (S&P/LSTA US Leveraged Loan index, CA PCI); benchmark VaR, Monte Carlo
    - PE/VC we already have data from previous rounds, so have data to model
- Public portfolio modeling
    - Morningstar for mutual fund, closed end fund
    - ETF/asset portfolio: factor model (eg. 10y yield regression), VaR/ES, scenario analysis (SPX, rates)