CUATS Coding Session

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Part 1: Credit Presentation

Presentation Plan

A. Credit Overview
B. Bond Maths and Credit Valuation
C. Quant Credit / Factor Investing in Corporate Bonds

Part A: Credit Overview

What is credit?

- *The provision of money, goods, or services with the expectation of future payment* [1]
- Extending credit means the creditor lends to the debtor (borrower) with the expectation to be repaid (with interest) in the future
- Debt instrument can be a loan, a bond, a promissory note,...
- Fixed Income: largest asset class ($ 200 T) with sovereign bonds by far the biggest part.

(1): Merriam-Webster's Dictionary definition

What is corporate credit?

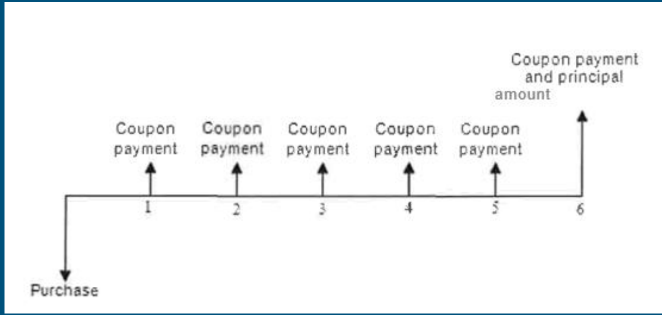
- 2 standard ways for a company to raise funds:
  - Raise **Equity**
  - Issue **Debt**
- Different exposure to cash flows:
  - Full upside for shareholders, higher risks, higher rewards
  - No upside for debtholders beyond coupon payments
- Debt Priority of Claims Rule / Waterfall structure:
  - Secured Creditors
  - Unsecured Creditors
  - Subordinated or Junior Debt
  - Preferred Stockholders
  - Common Stockholders

The "C"s of Credit for Lenders

- **Character**: In effect, the firm's willingness to repay their obligations
- **Capacity**: The ability of the firm to repay their / its obligations
- **Capital**: The underlying assets that a company has
- **Collateral**: What assets secure a potential borrowing, or already existing ones
- Conditions – what is the anticipated use of loan proceeds
- Credit Rating – akin to a personal Credit Score for a firm

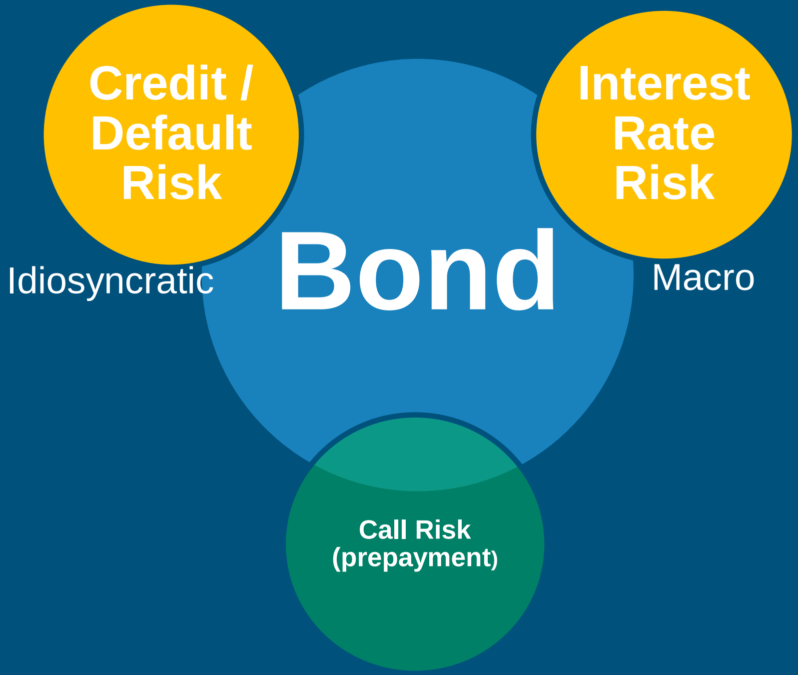
Bond Basics

- **Cash Flows:**



- **Bond Price = NPV of Cash Flows**
- **Yield = IRR of the bond**
- **“Yield up, Bond down”**
- **Dirty Price = Clean Price + Accrued Interest**

Bond Risks



Credit / Default Risk
Interest Rate Risk
Idiosyncratic
Bond
Macro
Call Risk (prepayment)

Part B: Bond Maths and Credit Valuation

Yield Model (1/3)

present value of expected cash flows discounted at the yield

$$
\begin{aligned}
TFV &= \left(\frac{C}{1+i} + \frac{C}{(1+i)^2} + \ldots + \frac{C}{(1+i)^N} \right) + \frac{M}{(1+i)^N} \\
&= \left(\sum_{n=1}^{N} \frac{C}{(1+i)^n} \right) + \frac{M}{(1+i)^N} \\
&= C \left(\frac{1-(1+i)^{-N}}{i} \right) + M(1+i)^{-N}
\end{aligned}
$$

where:

$F =$ par value

$i_F =$ contractual interest rate

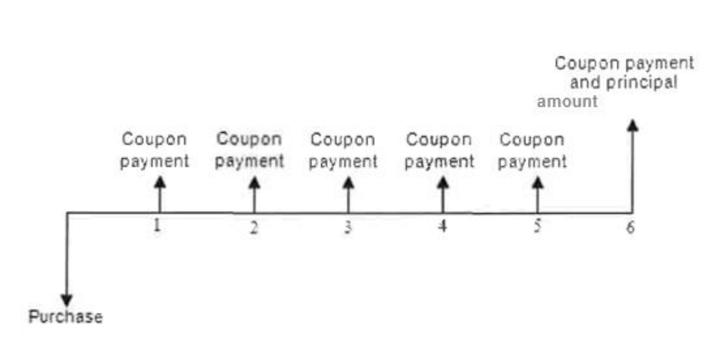
$C = F * i_F =$ coupon payment (periodic interest payment)

$N =$ number of payments

$i =$ market interest rate, or required yield, or observed / appropriate yield to maturity

$M =$ value at maturity, usually equals par value

$TFV =$ theoretical fair value



Yield Model (2/3)

Duration:

- bond's sensitivity to yield changes
- weighted average of the times to maturity of each coupon, or principal payment, made by the bond
- DV_01 = dP / dy
- Duration = - DV_01 / P

$$D = \frac{\sum_{t=1}^{N} \frac{t \cdot C_t}{(1+r)^t}}{\sum_{t=1}^{N} \frac{C_t}{(1+r)^t}}$$

where:

D = The bond's MacAulay duration

T = The number of periods until maturity

i = The i^{th} time period

C = The periodic coupon payment

r = The periodic yield to maturity

F = The face value at maturity

Convexity:

- measure of the curvature of the changes in the price of a bond, in relation to changes in interest rates

$$C = \frac{f''(B(r))}{BDr^2}$$

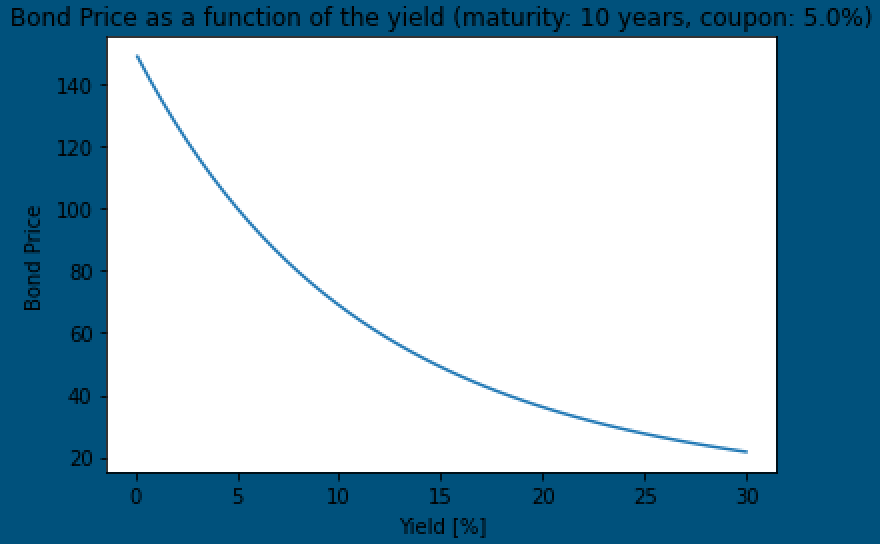
where:

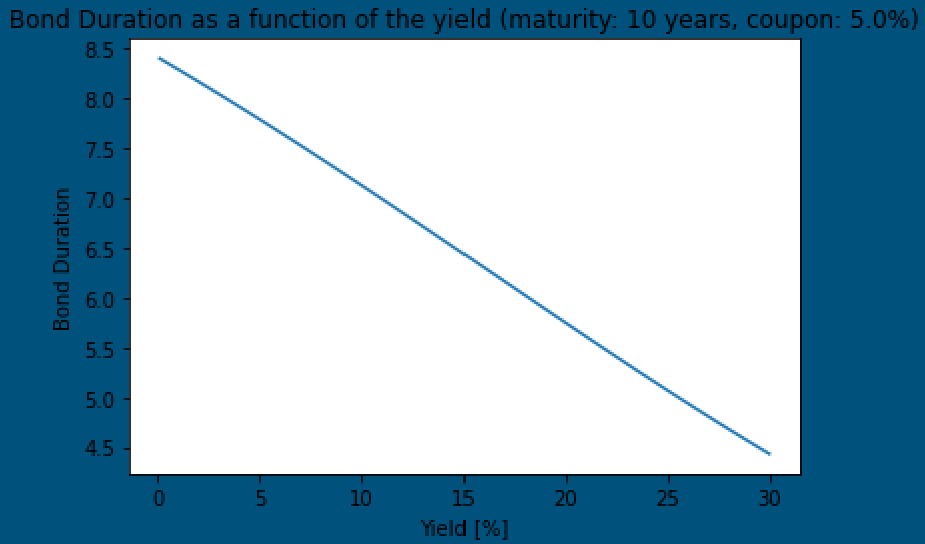
f'' = Second order derivative

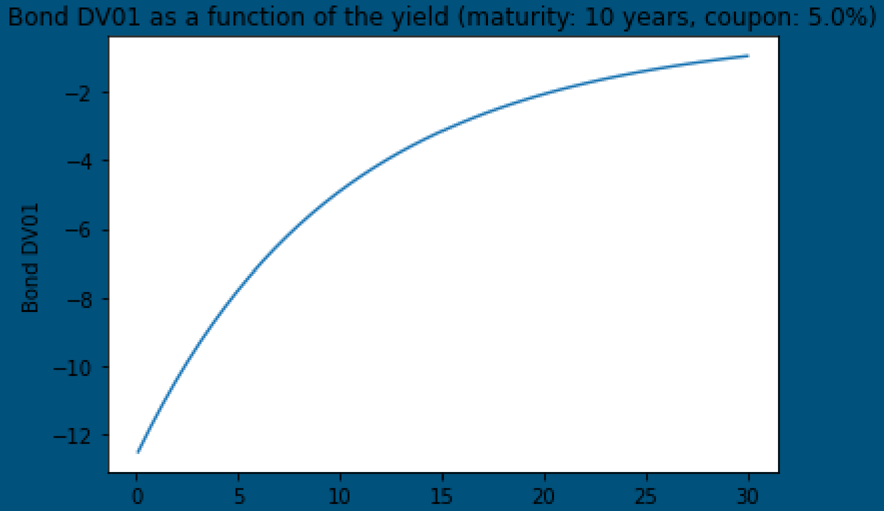
B = Bond price

r = Interest rate

D = Duration


Bond Price as a function of the yield (maturity: 10 years, coupon: 5.0%)
Bond Price
Yield [%]
140
120
100
80
60
40
20
0
5
10
15
20
25
30


Bond Duration as a function of the yield (maturity: 10 years, coupon: 5.0%)
Bond Duration
Yield [%]
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
0
5
10
15
20
25
30

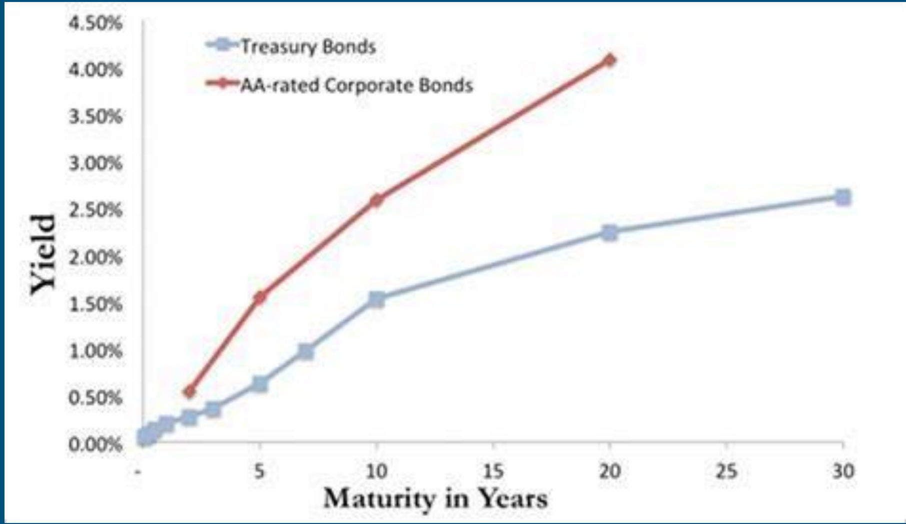

Bond DV01 as a function of the yield (maturity: 10 years, coupon: 5.0%)
Bond DV01
−2
−4
−6
−8
−10
−12
0
5
10
15
20
25
30

Yield Model (3/3)

- **Yield Curve**

- **Credit Spread** is the extra yield earned over the government bond yield (aka risk-free rate)

- **Drawbacks**:
  - Yield combines both interest rate and credit spread
  - Assumes 0 recovery in case of default
  - Constant



Defaultable Bond Model (1/4)

3 Parameters:

- **Interest Rate curve** for discounting
- **Default Probability curve:**
  - The **reduced-form** approach models default probabilities as stochastic process
  - The **structural** approach in which debt is a derivative of the firm's asset value
- **Recovery Rate** for payment in case of default

The default intensity λ is related to the spread and the recovery rate by the relationship: $\lambda = \frac{Spread}{1-RecoveryRate}$

The Survival Probability P(t) and Default Probability PD(t) verify by: $P(t) = 1 - PD(t) = e^{\int_0^t -\lambda(t)*dt}$

The Discount Factor DF(t) is given by: $DF(t) = e^{\int_0^t -r(t)*dt}$

The price of the bond is then the sum of 3 terms:

- The coupon term: $Coupon. \int_0^T P(t). DF(t)dt$
- The recovery term: $recoveryRate. \int_0^T P(t). DF(t). \lambda(t)dt$
- The notional term: $Notional. P(T). DF(T)$

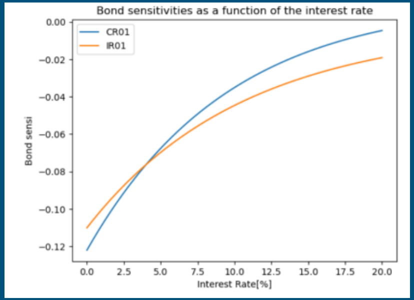
Defaultable Bond Model (2/4)

Reduced Form model:

- *Interest rate can be deterministic or stochastic*
- *Hazard rate can be deterministic or stochastic*
- *0, 1 or 2 factor model (0 or negative correlation between rates and credit spread)*
- *Close form formula assuming constant spread and interest yields the result*

$$Price = \frac{Coupon}{r+\lambda}.(1-e^{-(r+\lambda).T}) + \frac{recoveryRate.\lambda}{r+\lambda}.(1-e^{-(r+\lambda).T}) + Notional.P(T).DF(T)$$

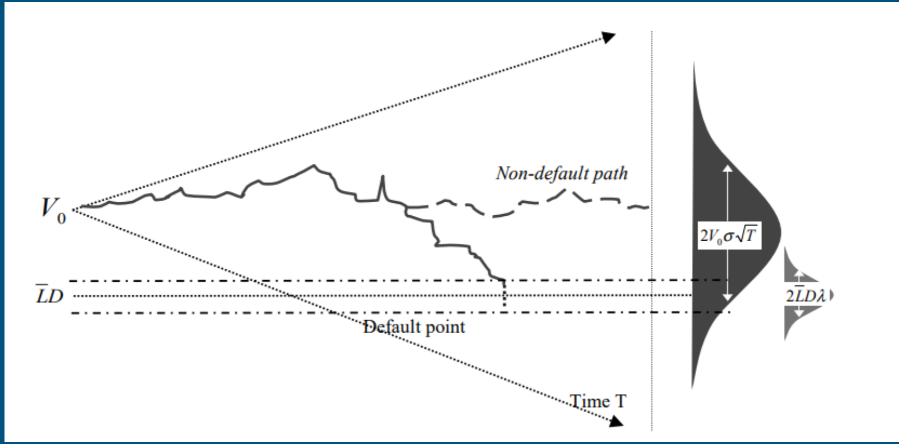
- CR01 (sensitivity with respect to credit spread)
- IR01 (sensitivity with respect to interest rate)



Defaultable Bond Model (3/4)

Structural model (aka Firm Value Model or Merton Model):

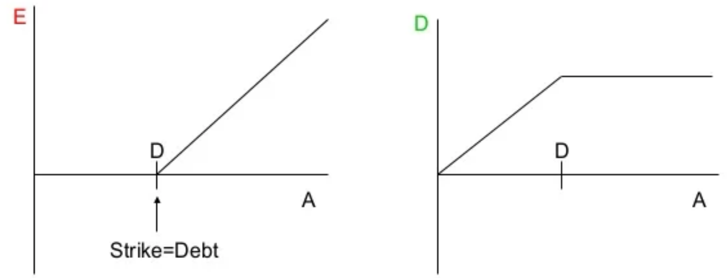
- Default occurs if assets of the company fall below a **default threshold**
- Asset value follows a Geometric Brownian Motion
- Default barrier uncertain and depends on debt amount



Defaultable Bond Model (3/4)

Structural model (aka Firm Value Model or Merton Model):

- **Equity** is a (default and out) **call on asset value** (long firm value , long asset vol)
- **Debt** is short a **put on the asset value** (long firm value, short asset vol)
- Close form formula for survival probability:



Equity interpreted as long call on firm´s asset value.

Debt interpreted as combination of short put and riskless bond.

$$P(t) = \Phi\left(-\frac{A_t}{2} + \frac{\log(d)}{A_t}\right) - d \cdot \Phi\left(-\frac{A_t}{2} - \frac{\log(d)}{A_t}\right),$$

$$\begin{aligned} d &= \frac{V_0 e^{\lambda^2}}{LD}, \\ A_t^2 &= \sigma^2 t + \lambda^2. \end{aligned}$$

Part C: Quant Credit & Factor Investing in Corporate Bonds

Factor Investing

- **Definition:**
  An investment strategy that involves selecting securities based on specific factors or characteristics that are believed to drive asset returns
- **Common factors:**
  - **Value**: undervalued securities tend to outperform over time
  - **Momentum**: expectation that trend will continue
  - **Size**: smaller companies may outperform larger ones over the long term
  - **Quality**: financially stable companies, strong balance sheets, consistent earnings
  - **Low Volatility**: favor assets with lower volatility for better risk-adjusted returns
- **Historical perspective:**
  - Academic research of 1960-1970 (CAPM), Fama-French 3 factors model (1992)
  - Growth of quantitative investing and widespread adoption beyond equities (some adjustments required depending on the asset class)

COMMON FACTORS IN CORPORATE BOND RETURNS

Ronen Israel[a,c], *Diogo Palhares*[a,d] *and Scott Richardson*[b,e]

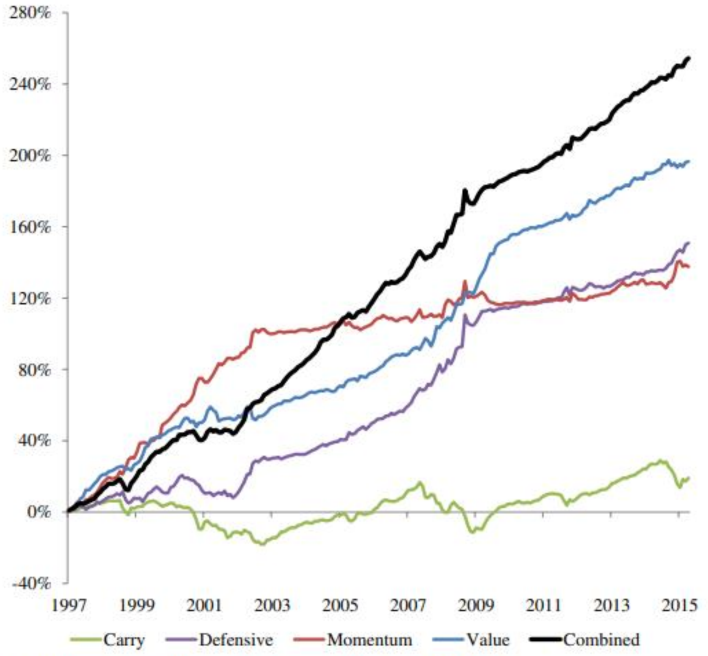


Figure 1 Cumulative style factor returns (January 1997–April 2015).

The figure shows cumulative arithmetic returns for each of the carry, defensive, momentum, value and combined style factors (as defined in the text).

Factor Investing in Corporate Bond Markets: *Enhancing Efficacy Through Diversification and Purification!*

Thomas Heckel, Zine Amghar, Isaac Haik, Olivier Laplénie, and Raul Leote de Carvalho

List of Credit Factors Classified into Styles

Factor Style	Description	Factor	Prefer High/Low Factor Values
Value	Prefer cheaper firms	Spread relative to distance to default	High
	Avoid value traps	Book to price	Low
		Cash-flow to price	Low
		Reported earnings to price	Low
		IBES earnings forecast to price	Low
		Sales to price	Low
Quality	Prefer firms capable of covering debt with generated income	Cash-flow to debt	High
		Free cash-flow to debt	High
		Gross profit to debt	High
		EBITDA to debt	High
		EBITDA to interest expenses	High
		Accruals (Op) to total assets	Low
		Accruals (Fr) to total assets	Low
	Avoid aggressive issuers	Capital expenditures relative to total assets	Low
		Change of debt relative to total assets	Low
		Financing cash to debt	Low
		Annual percentage change in total assets	Low
Low Risk	Preferless in debted firms	Leverage	Low
		Distance to default	High
	Prefer less risky firms	Stock beta (historical 3-year weekly returns)	Low
		Stock volatility (historical 3-year weekly returns)	Low
Momentum	Prefer firms with stronger medium-term equity momentum and weaker short-term equity momentum	12 months – 1 month momentum	High
		12 months – 1 month alpha	High
		12 months – 1 month information ratio	High
		12 months – 1 month Jensen information ratio	High
		6 months – 1 month momentum	High
		Momentum relative to the 52 weeks high	High
		1 month reversal momentum	Low
	Prefer firms with stronger fundamental momentum	6 months momentum in earnings revision	High
		12 months momentum in earnings revision	High
		Annual change in standardized IBES long term earnings growth forecast	High
		Annual change in standardized earnings	High
		Annual change in standardized free cash-flow	High

- **Excess return** (over risk free rate) rather than **total return**
- Results improved when weighting equally individual factors into a Factor Style (Value, Quality, Low Risk, Momentum)
- Results further improved when combining individual Factor Styles
- **Factors are normalized for:**
  - Sector
  - Region
  - Credit Spread
  - Duration
  - Size

Performance and Risk of Long-Only Portfolio Strategies Built from Factor Scores

	US IG		Euro IG		US HY*	
	Portfolio	Benchmark	Portfolio	Benchmark	Portfolio	Benchmark
Gross						
Annualized Excess Return Over Cash	6.01%	4.12%	3.50%	2.97%	7.73%	6.37%
Sharpe Ratio	1.06	0.77	1.10	0.88	0.98	0.80
Alpha	1.88%		0.86%		1.59%	
Information Ratio	1.03		0.80		0.93	
Net						
Annualized Excess Return Over Cash	5.52%	3.95%	3.24%	2.85%	6.71%	5.79%
Sharpe Ratio	0.97	0.74	1.02	0.85	0.86	0.73
Alpha	1.56%		0.71%		1.14%	
Information Ratio	0.86		0.66		0.66	
Beta	1.00	1.00	0.89	1.00	0.96	1.00
Volatility	5.69%	5.36%	3.17%	3.35%	7.83%	7.90%
Tracking Error	1.82%		1.07%		1.73%	
Turnover (one way)	73%	29%	73%	33%	107%	56%

Note: *US BB-B Nonfinancial HY.

Questions & Answers

Part 2: Implementation

Strategy:
Value and Momentum Factors across Asset Classes

Strategy

- **Momentum strategy**

  Buy assets with the strongest past return (12-month or 1-month) and expect them to outperform assets with the lowest past return

- **Value strategy**

  Buy fundamentally cheap assets and intend to gain on the assets' reversion to their long-term means.

- Market neutral
- Using several asset classes increases robustness

Strategy Implementation

- **Create an investment universe containing investable asset classes**

US large-cap, mid-cap stocks, US REITS, UK, Japan, Emerging market stocks, US treasuries, US Investment grade bonds, US high yield bonds, Germany bonds, Japan bonds, US cash

- **Find good tracking vehicle for each asset class**

Best vehicles are ETFs or index funds. Momentum ranking is done on price series. Valuation ranking is done on adjusted yield measure for each asset class. E/P (Earning/Price) measure is used for stocks, and YTM (Yield-to-maturity) is used for bonds.

- **Adjust yields for unbias**

US, Japan, and Germany treasury yield are adjusted by -1%, US investment-grade bonds are adjusted by -2%, US High yield bonds are adjusted by -6%, emerging markets equities are adjusted by -1%, and US REITs are adjusted by -2% to get unbiased structural yields for each asset class.

- **Rank each asset class by 12-month momentum, 1-month momentum, and by valuation and weight all three strategies**

(25% weight to 12m momentum, 25% weight to 1-month momentum, 50% weight to value strategy).

- **Go long top quartile portfolio and go short bottom quartile portfolio.**

TODO 1: Imports and Set Date

```
#region imports
# ... (Import AlgorithmImports)
# ... (Import data_tools)
#endregion

class ValueandMomentumFactorsacrossAssetClasses(QCAlgorithm):

    def Initialize(self): # LINK 2
        self.SetStartDate(...) # Set Start Date to 1st January 2013
        self.SetCash(100000)
```

TODO 1 Solution

```
#region imports
from AlgorithmImports import *
import data_tools
#endregion

class ValueandMomentumFactorsacrossAssetClasses(QCAlgorithm):

    def Initialize(self):
        self.SetStartDate(2013, 1, 1)
        self.SetCash(100000)
```

TODO 2

```
### TODO 2
... # Create a dictionary called data
... # Set a variable called period to the number of months in 21 years
... # Warmup for a duration period
```

TODO 2 Solution

```
self.data = {}
self.period = 12 * 21
self.SetWarmUp(self.period)
```

```
### TODO 3
for symbol, yield_symbol, yield_access, _, _ in self.assets:
      # investable asset
      if ... : # check if yield access is the same as QuantpediaBondYield
from data_tools
      ... # Add data from QuantpediaFutures in data_tools, with our given
symbol, at a Daily Resolution, and store it in the data variable
      else:
      ... # Add the equity with our given symbol at a Daily Resolution, and
store it in the data variable

      # yield
      if ... : # check if yield access is different to None type
              ... # Add data with parameters of yield access and the yield's
symbol, at a Daily Resolution

      self.data[symbol] = RollingWindow[float](self.period)

      ... # Set the Fee Model to CustomFeeModel
      ... # Set the leverage to 5

... # Set the variable recent_month to -1
```

TODO 3 Solution

```
for symbol, yield_symbol, yield_access, _, _ in self.assets:
# investable asset
if yield_access == data_tools.QuantpediaBondYield:
	data = self.AddData(data_tools.QuantpediaFutures, symbol,
Resolution.Daily)
else:
	data = self.AddEquity(symbol, Resolution.Daily)

	# yield
	if yield_access != None:
		self.AddData(yield_access, yield_symbol, Resolution.Daily)

	self.data[symbol] = RollingWindow[float](self.period)

	data.SetFeeModel(CustomFeeModel())
	data.SetLeverage(5)

self.recent_month = -1
```

TODO 4

```
### TODO 4: If the variable recent_month is the same month as currently, then
we don't need to execute this function. Otherwise, set recent_month to our
current month
      ...
      ...
      ...
```

TODO 4 Solution

```
if self.Time.month == self.recent_month:
      return
self.recent_month = self.Time.month
```

TODO 5

```
### TODO 5: Create dictionnaries performance_1M, performance_12M and
valuation
...
...
...
```

TODO 5 Solution

```
performance_1M = {}
performance_12M = {}
valuation = {}
```

TODO 6

```
### TODO 6: if the variable reverse_flag is true, then set yield_value to the
inverse of itself
...
...
```

TODO 6 Solution

```
if reverse_flag:
      yield_value = 1/yield_value
```

TODO 7

```
### TODO 7: If the yield value is different to 0, set the valuation for a given symbol to the sum the yield value and bond adjustment
...
...
```

TODO 7 Solution

```
if yield_value != 0:
      valuation[symbol] = yield_value + bond_adjustment
```

TODO 8

```
### TODO 8: sort both performances and valuations by metrics into
sorted_by_p1, sorted_by_p12 and sorted_by_value
...
...
...
```

TODO 8 Solution

```
# sort assets by metrics
sorted_by_p1 = sorted(performance_1M.items(), key = lambda x: x[1])
sorted_by_p12 = sorted(performance_12M.items(), key = lambda x: x[1])
sorted_by_value = sorted(valuation.items(), key = lambda x: x[1])
```

TODO 9

```
 # rank assets
            ### TODO 9: Create a dictionary called score. For each symbol, set the score to be a quarter of its rank for 1-month momentum, 12-month momentum and value.
            ... #
            ... #
            ... #
            ... #
            ... #
            ... #
            ... #
```

TODO 9 Solution

```
# rank assets
score = {}
for i, (symbol, _) in enumerate(sorted_by_p1):
        score[symbol] = i * 0.25
for i, (symbol, _) in enumerate(sorted_by_p12):
        score[symbol] += i * 0.25
for i, (symbol, _) in enumerate(sorted_by_value):
        score[symbol] += i * 0.5
```

TODO 10

```
# sort by rank
### TODO 10: Sort score by rank, and create lists of symbols to long and
short
... #
... #
... #
... #
```

TODO 10 Solution

```
# sort by rank
sorted_by_rank = sorted(score, key = lambda x: score[x], reverse = True)
quartile = int(len(sorted_by_rank) / 4)
long = sorted_by_rank[:quartile]
short = sorted_by_rank[-quartile:]
```

TODO 11

```
### TODO 11: Liquidate symbol if the symbol is invested but it doesn't
feature in either long or short.
... #
... #
... #
```

TODO 11 Solution

```
for symbol in invested:
        if symbol not in long + short:
                self.Liquidate(symbol)
```

TODO 12

```
### TODO 12: Long and Short holdings equally for all symbols in long and
short lists.
... #
... #

... #
... #
... #
... #
```

TODO 12 Solution

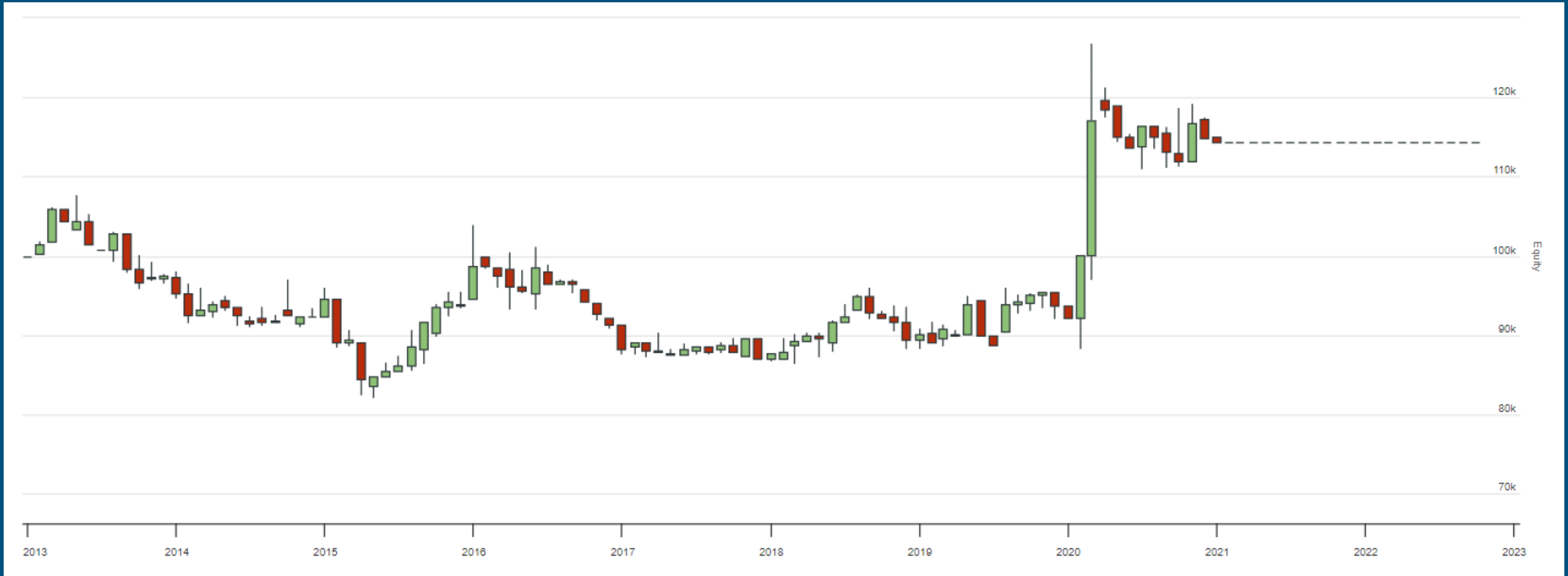
```
long_count = len(long)
        short_count = len(short)

        for symbol in long:
                self.SetHoldings(symbol, 1/long_count)
        for symbol in short:
                self.SetHoldings(symbol, -1/short_count)
```

Statistics

Overall Statistics

Total Trades	744	Average Win	0.79%
Average Loss	-0.76%	Compounding Annual Return	1.385%
Drawdown	23.800%	Expectancy	0.057
Net Profit	14.387%	Sharpe Ratio	0.149
Probabilistic Sharpe Ratio	0.059%	Loss Rate	48%
Win Rate	52%	Profit-Loss Ratio	1.03
Alpha	0.043	Beta	-0.31
Annual Standard Deviation	0.094	Annual Variance	0.009
Information Ratio	-0.387	Tracking Error	0.205
Treynor Ratio	-0.045	Total Fees	$964.38
Estimated Strategy Capacity	$0	Lowest Capacity Asset	EUREX_FGBL1.QuantpediaFutures 2S

QuantConnect result graph



Improvements to Strategy

- **Change weightings between factor styles**
  Improve from equal weight (50% momentum, 50% value). Perhaps performance-adjusted weight. Also, change weightings within momentum.

- **Add more factor styles**
  More factors usually lead to better performances (see previous slides)

Questions & Answers