Prime Trading

Project Lab - The University of Chicago
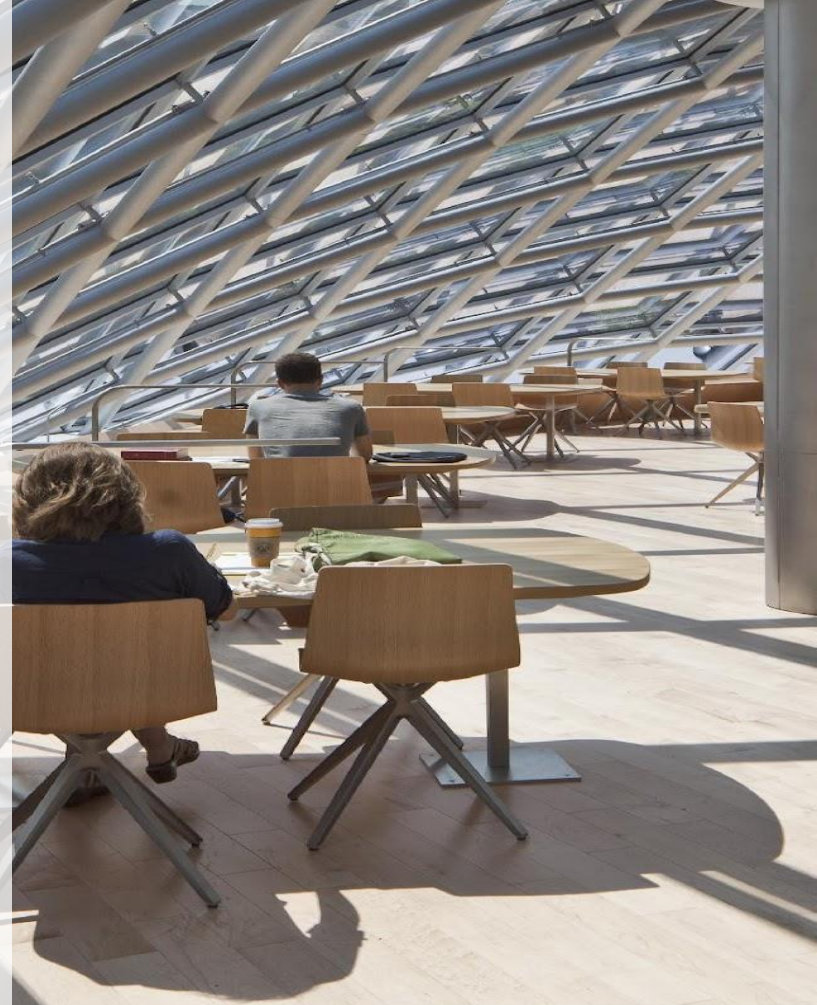**April 25th meeting**

Futures Basis Model

Presented by

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1. **Theoretical value for basis**
   - **Interest rate**
   - **Dividend yield / Points**
   - **Market Implied Pricing**

2. **Milestone**

1. Theoretical value for basis

Cost Carrying Model: Equations

(1) Definition of Basis

$$B_t = F_t^{\text{mkt}} - S_t$$

(2) Cost-of-Carry Model (Fair-Value Futures Price)

$$F_t^{\text{fair}} = S_t \, e^{(r-q)(T-t)}$$

(3) Definition of Fair-Value Basis

$$(S_t - D_t) \, e^{r(T-t)}$$

where D_t is expected dividend points from t to expiration.

Interest rate

- **What interest rate curve should we use?**
- SOFR - standard risk free rate used for risk free, one day overnight collateralized rate
- However, SOFR is 1day interest rate thus introduced term SOFR (1M, 3M, 6M, 12M)
- CME is calculating Term SOFR
  https://www.cmegroup.com/market-data/cme-group-benchmark-administration/term-sofr.html

Interest rate

- **How should we interpolate the curve**
- Linear interpolation : simple but inaccurate
- Piecewise CubicSpline : smoother curve fitting cubic spline for each data points
- Nelson Siegel

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Nelson Siegel Approach

1. SOFR data (different tenors)
2. Calibrate inputs to Nelson Siegel using OLS (fixed decay)
3. Use Nelson-Siegel to build continuous curve

$$y(\tau) = \beta_1 + \beta_2 \left[\frac{1 - \exp(-\tau/\lambda)}{\tau/\lambda} \right] + \beta_3 \left[\frac{1 - \exp(-\tau/\lambda)}{\tau/\lambda} - \exp(-\tau/\lambda) \right].$$
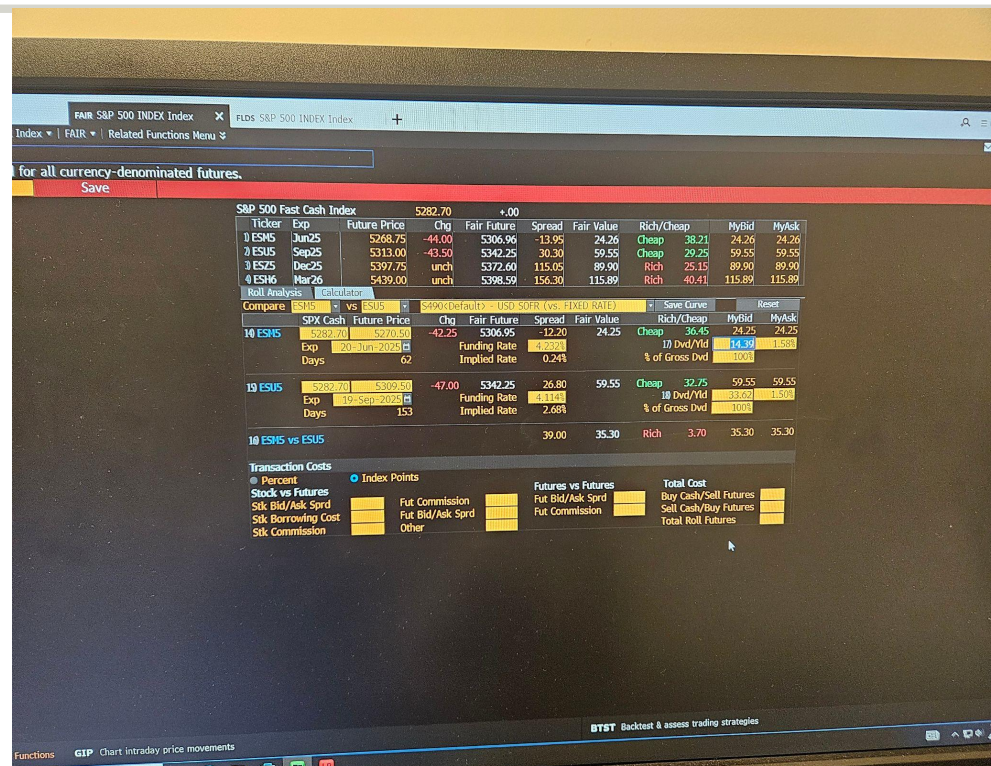
Dividend points/ yield

- **What is the potential candidate method for dividend yield points?**
- Using Bloomberg analyst estimates
- Using Dividend index and futures
- Implied Q from futures contract or index option

Dividend points/ yield

- Using Bloomberg analyst estimates
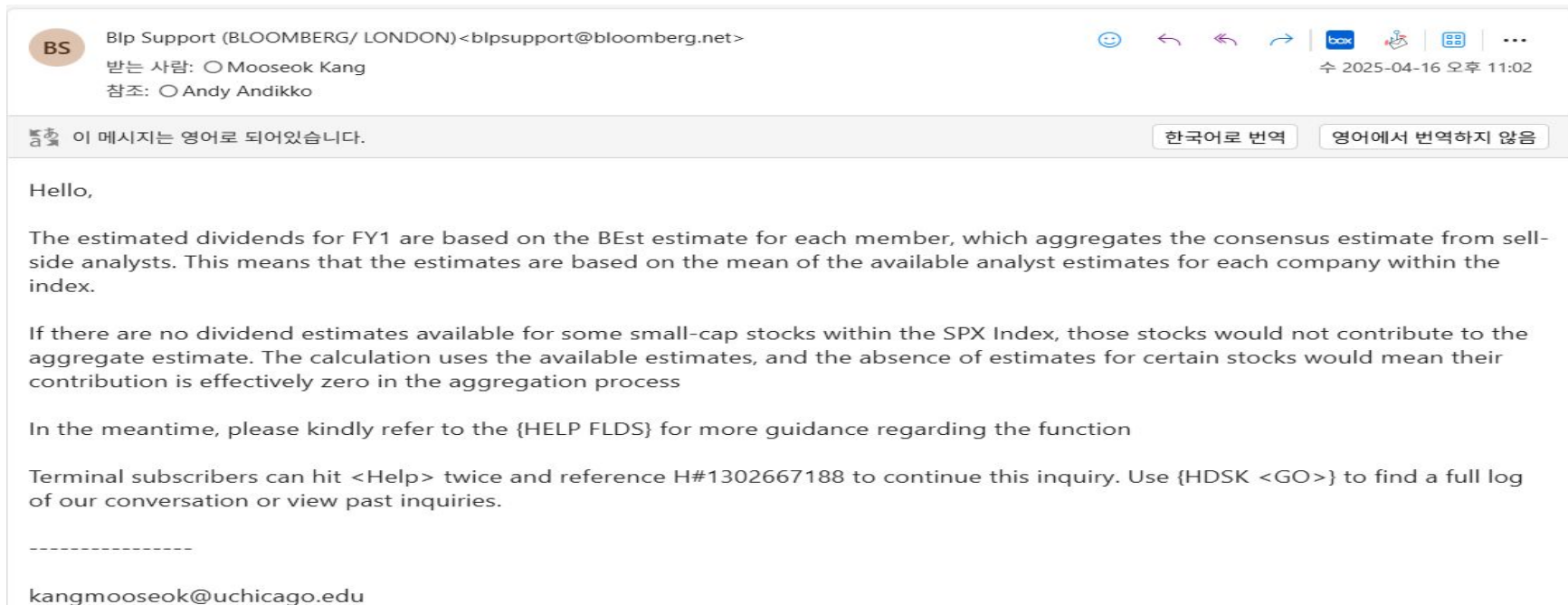- Ideal: fetching dividend points on bbg

Dividend points/ yield

- Using Bloomberg analyst estimates
- IDX_EST_DVD_YLD is not a good proxy for q(index dividend yield)
- It is calculated as Estimated Dividends FY1 / Last Price of Index
- It is not reflecting estimated dividends until expiration date we are targeting
- Even worse, if there is no analyst coverage then it leaves as 0

Dividend points/ yield

- **Bloomberg Help desk email**

Blp Support (BLOOMBERG/ LONDON)<blpsupport@bloomberg.net>
받는 사람: ○ Mooseok Kang
참조: ○ Andy Andikko

수 2025-04-16 오후 11:02

이 메시지는 영어로 되어있습니다.   한국어로 번역   영어에서 번역하지 않음

Hello,

The estimated dividends for FY1 are based on the BEst estimate for each member, which aggregates the consensus estimate from sell-side analysts. This means that the estimates are based on the mean of the available analyst estimates for each company within the index.

If there are no dividend estimates available for some small-cap stocks within the SPX Index, those stocks would not contribute to the aggregate estimate. The calculation uses the available estimates, and the absence of estimates for certain stocks would mean their contribution is effectively zero in the aggregation process

In the meantime, please kindly refer to the {HELP FLDS} for more guidance regarding the function

Terminal subscribers can hit <Help> twice and reference H#1302667188 to continue this inquiry. Use {HDSK <GO>} to find a full log of our conversation or view past inquiries.

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Dividend points/ yield

- **-** Using Dividend index and futures
- - What is Dividend Index and futures?
- - Dividend index is a index that accumulates dividend in points on ex-dates
- - Dividend futures is a futures traded as a expectation in dividend points level
- - Dividend futures has both quarterly and annual contracts

Dividend points/ yield

- Using Dividend index and futures
- https://www.spglobal.com/spdji/en/indices/equity/sp-500-dividend-points-index-quarterly/#overview
- https://www.cmegroup.com/markets/equities/sp/sp-500-quarterly-dividend-index.quotes.html?videoId=6370489182112
- Dividend futures - Dividend index will be market expectation of the dividend points until the end of the expiration date
- However, quarterly contracts are very illiquid thus, don't think this can be used
- https://www.cmegroup.com/markets/equities/sp/sp-500-quarterly-dividend-index.volume.html?videoId=6370489182112

Dividend points/ yield

- **-** Implied Q
- - We can pull out implied q from the futures contract but that is no different from using the market price
- - Pros would be that if there is a information leak, they can reflect the dividends better than the analyst forecast

Dividend points/ yield

- Implied Q
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Theoretical value for basis

- Viable methods and data necessary
1. Interest rate
- Use Term SOFR, interpolate with either cubic spline or Nelson Siegel
2. Dividend points / yield
- Use forward looking dividend points in FAIR monitor
- If don't have such, use dividend futures - dividend index (although its illiquid)...?

Data Necessary
- Term SOFR daily (1M,3M,6M,12M)
- FAIR dividend points daily estimates
- Dividend futures 1min / Dividend index daily

Market Implied Pricing through Trade data

1. Data Download & Load:
   - Downloads trade data from Google Drive using gdown and read it using Polars.
2. Rolling VWAP Model:
   - Defines a class to compute rolling VWAP based on traded price and volume over a given window size.
   - Default window size = 5
3. Hampel Filter:
   - Applies a median-based outlier detection filter on the VWAP time series.
   - Replaces values that deviate significantly from the local median based on MAD (Median Absolute Deviation).
   - Default window size = 10, threshold = 3

MAD (Median Absolute Deviation) is computed as:

$$\text{MAD} = \text{median}(|x_i - \text{median}(x)|)$$

A point is considered an outlier if:

$$|x_i - \text{median}| > \text{threshold} \times \text{MAD}$$

Market Implied Pricing through Trade data

Evaluation of the results:

1. Error Metric Evaluation:
   - Computes log return errors for both original and filtered VWAP series.
   - Evaluates error mean and mean absolute error (MAE) across the entire time series.
2. Visualization:
   - Uses Plotly to plot original vs filtered VWAP values over time.

```
Hampel filter replaced 89 outliers.

Overall Log Return Error Comparison:
Original Error Mean: -0.0000027909
Filtered Error Mean: -0.0000027909
Original MAE: 0.0001278832
Filtered MAE: 0.0001273319
```


Example Plot on 1 min trade data

Market Implied Pricing through Quote Data

Since only have top of the book (nbbo) quote data, vwap through depth of the book is unavailable.

If only current setup, potential models:

- TopOfBookTheoWeighted: Computes size-weighted average of bid and ask prices.
- TopOfBookTheoMid: Computes the midpoint between bid and ask.

Market Implied Pricing through Quote Data

Comparison of the example plots

Example Plot with size weighted
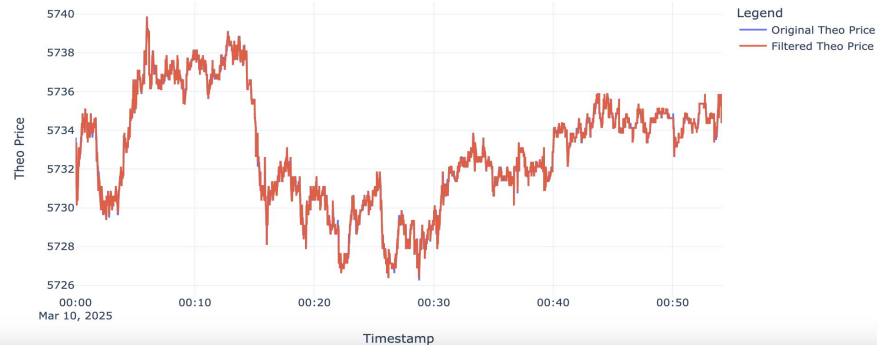
Example Plot with mid price

2. Milestone

Milestones

- **Week April 28th:** Finalize theoretical pricing model and identify patterns between market price

- **Week May 5th:** Design trading strategy framework.

  - strategy:
    - Define entry/exit signals based on patterns (e.g., arbitrage when theoretical vs. market spread exceeds 2σ).
    - Incorporate Rolling VWAP (window=5) as a baseline for fair value.
  - risk management:
    - Set position sizing, stop-loss thresholds, and maximum exposure.
    - Consider transaction costs, volume limitation etc..

- **Week May 12th:** Backtest strategy and analyze performance.

  - Simulate trades using provided ES data from 03-05 to 03- 21

  - Validate signals against Hampel-filtered VWAP and term SOFR-driven theoretical prices(not sure about whether the frequency would match)
  - Calculate sharpe ratio, max drawdown, win rate, return, extra.
  - Identify any potential edge cases
- **Week May 19th:**
  - Optimize hyperparameters such as VWAP window, Hampel filter parameters, etcs using grid-search , check on overfitting
  - Adjust thresholds based on backtesting results

Thank you!