

# SOFR Curve Construction and Trading Ideas

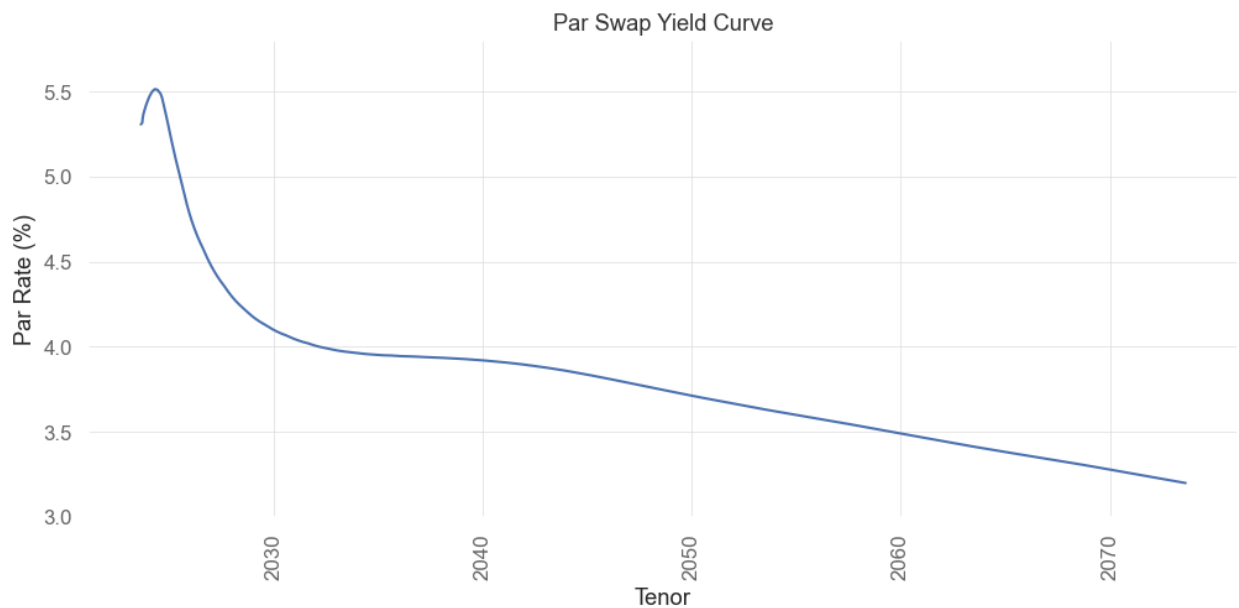
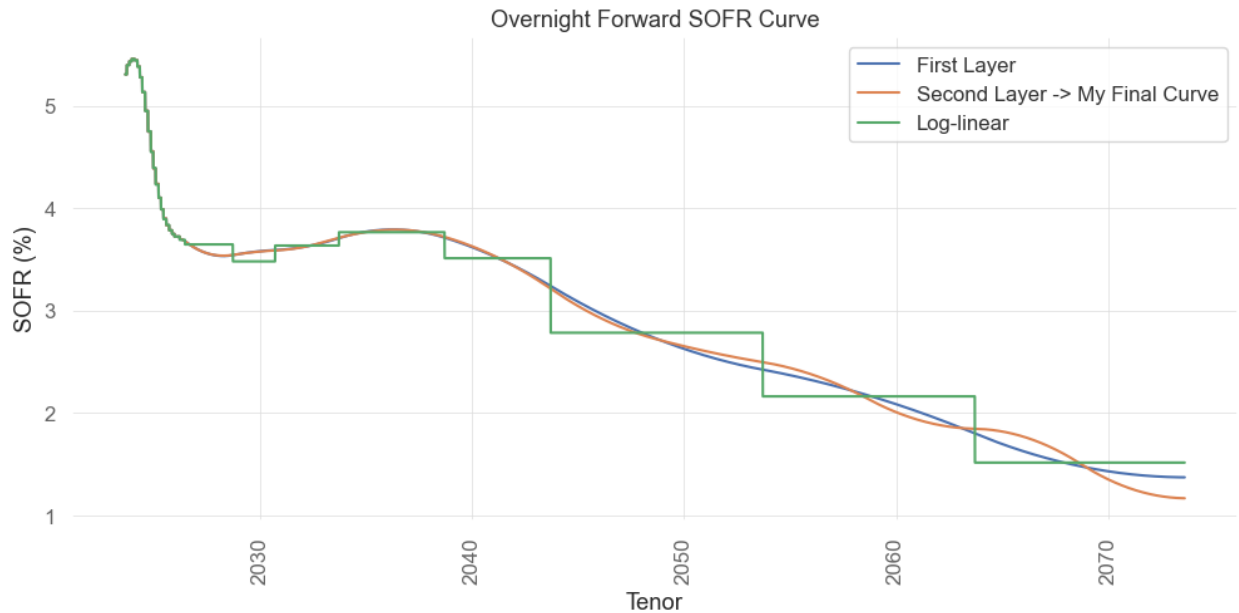
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## I. SOFR Curve Construction

I have built the SOFR curve as of closing 8/25/2023. The accuracy to Bloomberg benchmark is always within 0.02bp. The library is written in Python, using datasets from Bloomberg.

See below the overnight forward curve and the par swap yield curve.



## 1. Assumptions

My focus is on the overnight forward curve backboned upon SOFR Index, which can easily transfer to par swap rate curve. The initial date is set to be 8/25/2023, settlement is 8/27/2023.

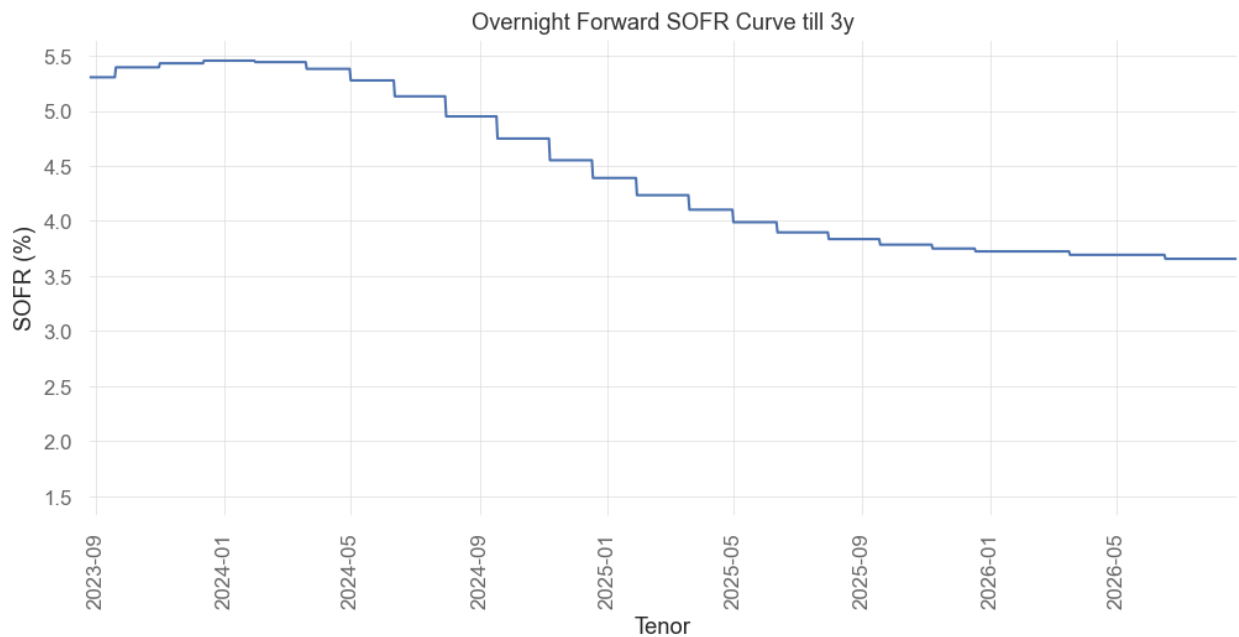
- Using the SR3 futures in the front end (<3yrs), adjusted by convexity.
- Using Swap rates for 3+ tenor, first layer is 5y, 7y, 10y, 15y, 20y, 30y, 40y and 50y. and implemented the skewness adjustment for 4y, 6y, 8y, 9y, 12y, 25y, 35y and 45y, which are the second layer. In practice, I would implement 3 layers:
  - First layer: Cash yield on (5y, 10y, 30y) + corresponding swap spreads
  - Second layer: 4y, 7y, 15y, 20y
  - Third layer: 6y, 8y, 9y, 11y, 12y, 25y, 40y, 50y
- Using Log-linear interpolation on DF for front end, and log-cubic spline interpolation for 3+ tenor.
- The curve is solved by auto-differentiation under Dual number. Levenberg-Marquardt method is used to blend both the gradient descent and Gauss-Newton method.
- No turns, no holidays and no business day convention for simplicity.
- Knots are placed at strategic points as IMM dates, rather than at the maturity of par tenor. instruments. This is to avoid large exchange basis and carry fluctuation when market advanced.

## 2. Market Instruments

Interpolation	Node Dates		Market Instruments	
Log-linear	Initial Date	8/25/2023	Partial Jun'23 Futures	SFRM3
	FOMC Meetings	9/20/2023	12 IMM Futures	SFRU3
		11/1/2023		SFRZ3
		12/13/2023		SFRH4
				SFRM4
	Provisonal FOMC Meetings	1/31/2024		SFRU4
		3/20/2024		SFRZ4
		5/1/2024		SFRH5
		6/12/2024		SFRM5
		7/31/2024		SFRU5
		9/18/2024		SFRZ5
		11/7/2024		SFRH6
		12/18/2024		SFRM6
	Estimated FOMC Meetings	1/29/2025	Par IRS	4Y
		3/20/2025		5Y
		5/1/2025		7Y
		6/12/2025		10Y
		7/31/2025		15Y
		9/18/2025		20Y
		11/7/2025		30Y
		12/18/2025		40Y
Logic-cubic	Strategic IMM Dates	3/18/2026		50Y
		6/17/2026		
	Long term IMM dates	9/15/2027		
		9/20/2028		
		9/18/2030		
		9/21/2033		
		9/15/2038		
		9/16/2043		
		9/17/2053		
		9/19/2063		
		9/20/2073		

### 3. Front End Curve

Here we zoomed in to have a better view on the front end curve. For up to 3y, we have



The nodes are placed at FOMC meeting dates.

Note that the future convexity adjustment is based on the following 2 papers.

- [Hull. 2002. Options, Future and Other Derivatives p. 566.](#)
- [Piterbarg and Renedo. 2006. Eurodollar Futures Convexity Adjustments in Stochastic Volatility Model. 2006](#)

The mean reversion speed is set to be 0.03 and rate vol is set to be 140bps. The closing for SFRM5 is 96.075, so if you look at *SFRM5C 96.0000 COMB Comdty*, this serial option has implied volatility at 37.188% which at current rates (3.925%) is around 140bps.

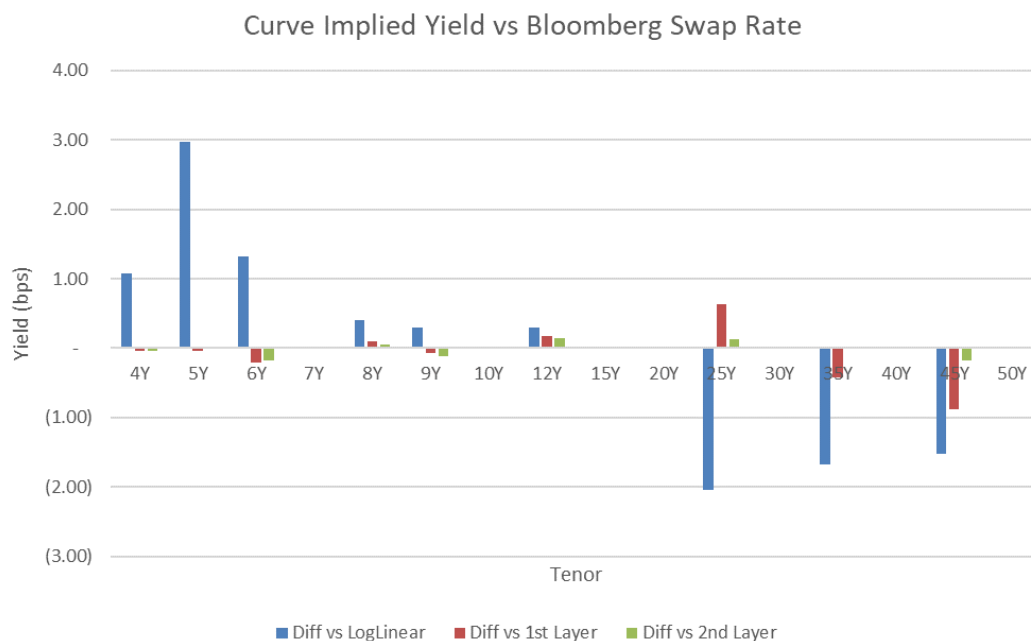
Start Date	Days	Ticker	Last	Implied Forward
08/30/2023	21	SFRM3	94.6847	5.3153
09/20/2023	91	SFRU3	94.545	5.4543
12/20/2023	91	SFRZ3	94.51	5.4868
03/20/2024	91	SFRH4	94.645	5.3482
06/19/2024	91	SFRM4	94.925	5.0634
09/18/2024	91	SFRU4	95.295	4.6874
12/18/2024	91	SFRZ4	95.645	4.3304
03/19/2025	91	SFRH5	95.91	4.0572
06/18/2025	91	SFRM5	96.075	3.883
09/17/2025	91	SFRU5	96.16	3.7877
12/17/2025	91	SFRZ5	96.195	3.7414
03/18/2026	91	SFRH6	96.215	3.7092
06/17/2026	91	SFRM6	96.235	3.6759

#### 4. 3y+ Curve Residual control

In the daily trading activities, we need to mark level 2 and level 3 residuals according to broker's screen. I have also implemented this in my curve, which gives me control to skew the curve on 4y, 6y, 8y, 9y, 12y, 25y, 35y and 45y. this is implemented by having a layered curve set.

Input Instruments	First Layer Rate (bps)	Second Layer Skew (bps)
4y		0
5y	421.5	
6y		0
7y	406.3	
8y		-0.05
9y		-0.05
10y	396.75	
12y		-0.02
15y	393.125	
20y	386.525	
25y		-0.5
30y	362.7	
35y		0.4
40y	340.845	
45y		0.7
50y	319.735	

By implement the skew, our final curve (i.e., the 2<sup>nd</sup> layer below) have less than 0.02bps difference to Bloomberg's closing yield.



## II. Trading Ideas

### 1. 5s10s30s Swap Fly

- Expected to make 5 million by trading this in a relative value set up.
- Average holding time: daily / weekly
- Current level: 9.31
- Target mean: 9

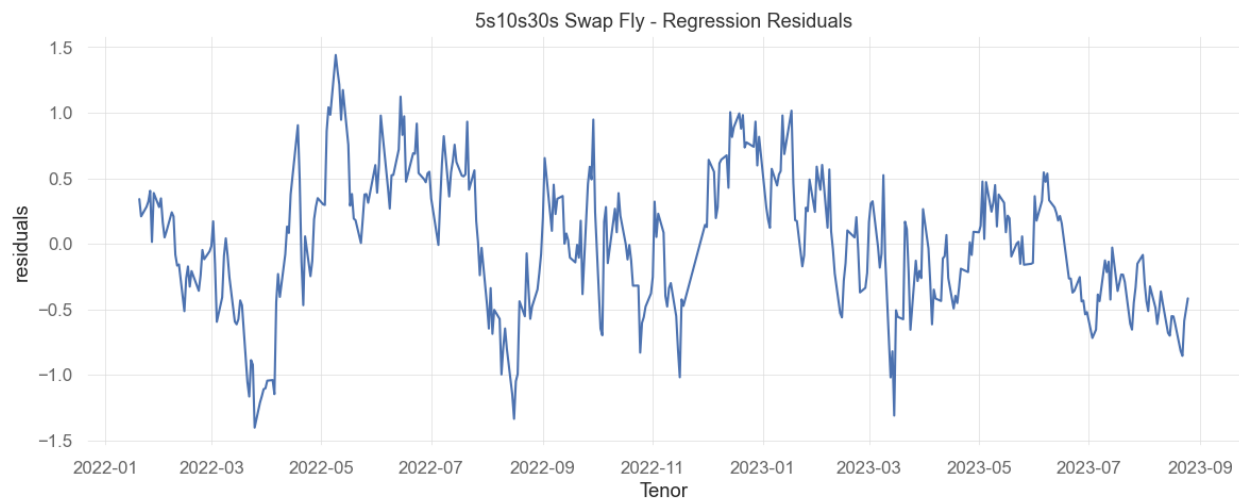
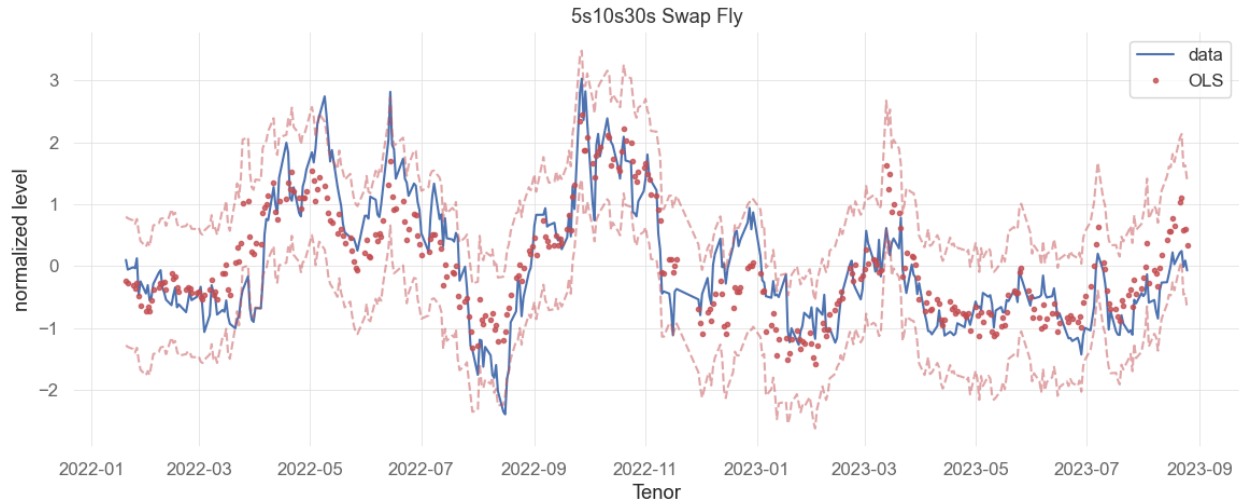
This is a macro theme trade that expresses view on the curvature of the yield curve. It shows a strong mean reverting behavior since 2022 January. By ADF test, we can reject the null hypothesis (time series is non-stationary) at 1% significance level. So it is highly likely that we are able to trade the RV of this structure.

Regression formula (value normalized):

$$5s10s30s = 1.04 * 2s5s10s + 0.754 * 10y + 0.367 * 1m10y + residuals$$

By statistical model, we can see 5s10s30s can be expressed by a combination of 2s5s10s, 10y (market beta) and 1m10y norm vol (market scarcity). By the following regression results, we can see a high R-square and each independent variable is significant enough to explain the dependent variable.

OLS Regression Results						
=====						
Dep. Variable:	5s10s30s		R-squared:	0.729		
Model:	OLS		Adj. R-squared:	0.727		
Method:	Least Squares		F-statistic:	351.6		
Date:	Sun, 27 Aug 2023		Prob (F-statistic):	9.57e-111		
Time:	22:18:00		Log-Likelihood:	-302.85		
No. Observations:	396		AIC:	613.7		
Df Residuals:	392		BIC:	629.6		
Df Model:	3					
Covariance Type:	nonrobust					
=====						
	coef	std err	t	P> t	[0.025	0.975]
-----						
const	1.093e-15	0.026	4.16e-14	1.000	-0.052	0.052
1m10y	0.3672	0.031	11.797	0.000	0.306	0.428
2s5s10s	1.0445	0.042	24.899	0.000	0.962	1.127
10y	0.7540	0.047	16.169	0.000	0.662	0.846
=====						
Omnibus:	1.052		Durbin-Watson:	0.275		
Prob(Omnibus):	0.591		Jarque-Bera (JB):	1.093		
Skew:	-0.048		Prob(JB):	0.579		
Kurtosis:	2.761		Cond. No.	3.26		



Note the regression has 1m10y norm vol as a factor that represents the short-term driver of interest rate under the scenario “flight to quality”. As funds flee from riskier assets, the sectors at the front end receive the greatest amount of flows, given their easy access for liquidity purpose. When market is negatively shocked by credit shortage, investor tends to buy short-term cash and pushes the yield lower. As a result, 5s10s30s will cheapen when market turns risk-off and we can see the positive correlation vs 1m10y.

Currently, the 3m roll down of 5s10s30s swap fly is 2.2bps, and carry is 0.7bps. But by the above plots, we can see the current residual is -0.41, which means 5s10s30s is rich in a relative value framework. Another consideration is the possible tightening of the belly spread in the future when credit getting better, which will enrich the swap fly more. As a result, I am neutral to this structure at this moment, and will not build any positions.

2. Short 10y Spread.

- Short belly spreads, i.e., 10y
- Average holding time: monthly
- Can express this view by selling 5s10s30s spread fly, currently at 34

	Spread Drivers	My Current View	Prediction
Long Term Trends	Banking System Credit	Much relieved after SVB, FRB and CS failure. The Banking aggregated CDS index has dropped 50% from the peak at 2023 March.	Tighten
	Expected Future Budget Deficits	Currently Deficits % of GDP is 8.432% and see a declining trend till 2024 by CBO. The US Treasury ramped up debt issuance, heralding a supply deluge that's likely to last several quarters	Tighten
	Availability of Money/Liquidity	Expected the Fed loosen monetary policy in 2024 and adding money supply. The real funds rates has increased to 2.15%, which is highest since the Credit Crunch in 2008. Believe the rate will go lower, which indicating an easier monetary policy	Tighten
	Pension Funds Matching Liability	High interest rates environment will last for years and Pension funds have to match the decreasing value of long-term liabilities. They tend to pay swaps due to simple and relatively liquid way to reduce exposure. This action will take years to fully manifest themselves.	Widen 30y spread
Short Term Trends	Mortgage Hedging	The 30-year fixed-rate mortgage averaged 7.23% in the week ending August 24, rising to their highest level since 2001. The ongoing economic strength and persistent high inflation may push mortgage rates higher.	Widen belly spread
	Corporate Issuance	September usually has larger than usual corporate issuance.	Tighten

The impact of the aggregated factors above on belly spreads will be a strong tightening force. As a result, I would short 10y spread with continuous evaluations on the factors listed above.



### 3. SR3 vs SR1 Futures

- Expected to make 3mil on trading the discrepancy between SR1 and SR3
- Example: short SFRU3, long delta hedged SERU3, SERV3, SERX3 and SERZ3
- Average holding time: months

Front end curves can be calibrated using either SR1 or SR3, or a mixture of both adjusted by convexities and weights. However, the implied forward rate can be different from choosing which curvesets to calibrate. The discrepancy between SR3 and the overlapped SR1 may come from liquidity, volatility or simply market mispricing.

Example: SFRU3 vs (SERU3, SERV3, SERX3, SERZ3)

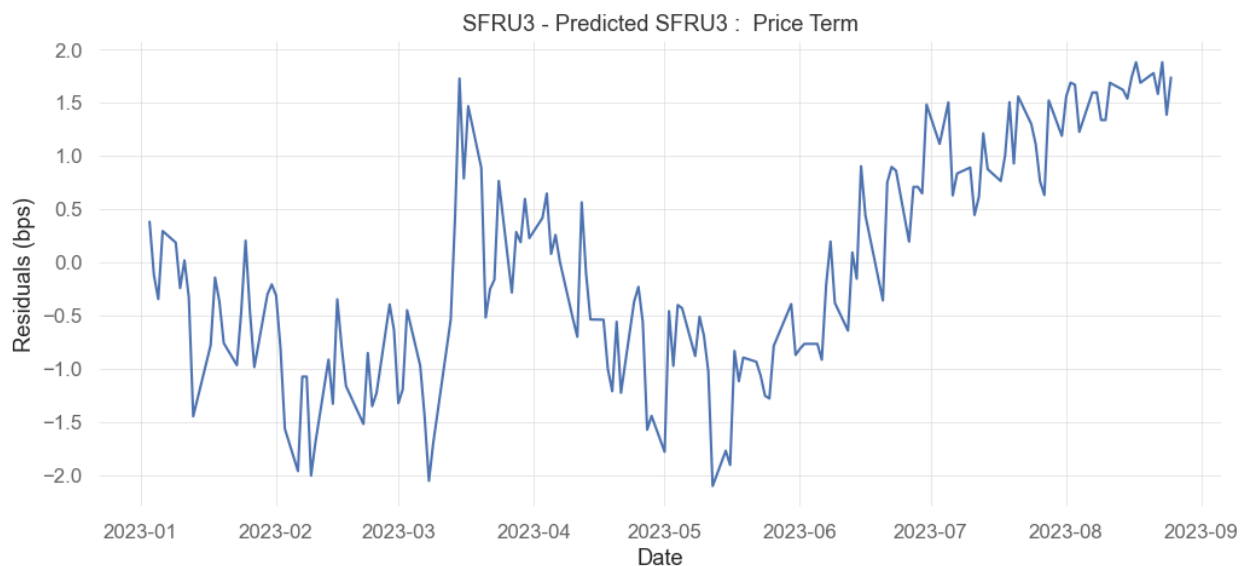
Instead of the traditional regression model, we are using neural network here to overcome:

- Multi-collinearity between exogenous variables
- Non-linear relationship between the prices of SR1 and SR3 because of stepwise forward

I have used the following hyperparameters in my MLP regressor:

*MLPRegressor(hidden\_layer\_sizes = (10,), random\_state = 1, alpha = 0.0001, activation = 'relu', max\_iter = 10000)*

The neural network shows a prediction score at 0.999, which is high enough to trust.



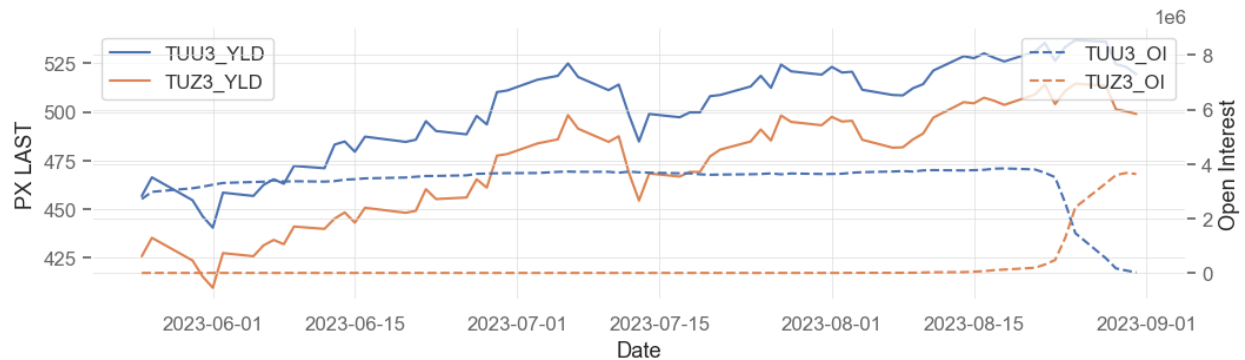
By the above plots of the prediction residuals, we can see SFRU3 is rich compared to the SR1 futures for the past 2 months and also reached the YTD highest.

Assuming 0.5bps for transaction cost, the capacity of this arbitrage can be 1.5bps and 100k DV01. Ignoring the possible curve risk because of imperfect hedging, I am expecting to make 150k on this spread trade.

#### 4. TU Futures Rolling

- Example: sell BSFRH5U5
- Average holding time: several days
- Current level: -9 / -8.5

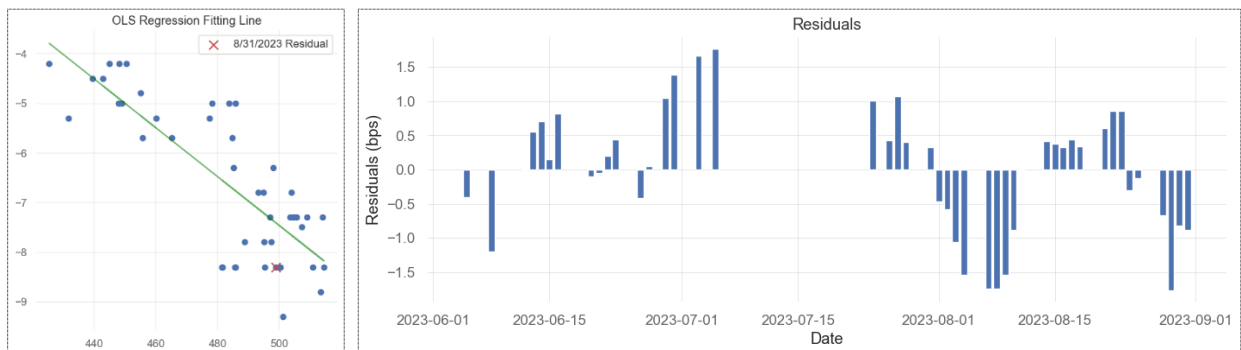
When it comes to the first delivery date (i.e., 9/1/2023) for TUU3, people tend to roll the futures into TUZ3, which will result in the hedging need to buy SFRM5. As a result, SFRM5 will likely get richer, which creates an opportunity to short SFRM5. For tradable asset, I believe the SFR Butterfly can be a good structure to express this view which is delta neutral.



Regression:  $BSFRH5U5_t = const + \beta \times TUZ3_t + residual_t$

All the inputs are in yield terms for simplicity. The R square of this regression is 0.65 and the coefficients are all significant in 1%.

By the below regression fitting line and residuals plot, we can see that BSFRH5U5 is consistently rich since 8/23/2023, where pressure coming from the hedging needs by my guess.



I am happy to short BSFRH5U5 passively because it is not worthy to cross the spreads when it is not the richest right now.