

## I. The Misunderstanding of Roll Spreads Implying Convergence/Carry/Drop

Treasury Futures are different from most other forms of forwards. With a typical forward, a security with a price of 100 today (spot), may have a price of 99.75 a month forward. By inference, buying the forward at 99.75, the forward will converge to the current spot price of 100. The 'carry' on the forward is:  $100.00 - 99.75 = 0.25$ . Treasury futures do not work this way. They do not "roll up the curve" like a traditional forward, based upon a specific security and a cost-of-funds for a period from 'today' to 'forward date'. Why not?

The key is that Treasury Futures are not a forward on a single, specific security. Treasury Futures have a known basket of eligible-for-delivery securities. Determination of which security is most likely to be delivered helps define a Treasury Futures price. While virtually no one who uses Treasury Futures to hedge generic interest rate exposure will get involved with making or taking delivery, understanding that these futures typically have a DIFFERENT deliverable helps explain why a December future does not converge to a September future's price. Two different securities may converge on a yield at a maturity. That does not imply that their prices will converge. As a simple example (source: Bloomberg):

Tkr	Cpn	Mty <Key>	Price	CnvYld	ModDur	Cvx	Val01
T 2	02/15/50		114-20	1.3936	22.81	6.19	.2615
T 1	1/4 05/50		96-11	1.4007	24.57	6.92	.2375

Two securities trading at virtually identical yields (above), have decisively different convergence levels over time. In the extreme, both of the above bonds are converging to par, 100-00, as they approach maturity. Thus, the 2% security at a price of 114+ will *lose* some 14+ points on approach of maturity, while the 1.25% security will *gain* some 3+ points over a similar timeline. So, in the case of Treasury Futures, where the ultimate deliverable security is not usually the same from quarterly roll to quarterly roll, the difference in futures prices from quarter-to-quarter do not typically share the same price convergence path. We cannot infer anything about 'carry' from roll spread relationships. A bunch more information is required.

## II. Timing of Rolling Treasury Futures

Most Treasury Futures users will never make or take delivery. For any LONG in a Treasury Future that is not interested in taking delivery, these positions will roll to the more-forward Treasury future before 'First Notice Day'. Since the Delivery Option rests with the SHORT, short positions do not have to be rolled before First Notice Day—though, for liquidity reasons (and operational angst), most SHORTs that do not intend to deliver get out of the way via rolling on or before first notice. If you are a hedger or speculator, but not an arbitrage trader, the two or three days prior to first notice day are absolutely your target days to roll.

	Regular Trading	First Notice Day	First Delivery Day	Last Trade Date	Last Delivery Date
2yr TUU0	<8/31/2020	8/31/2020	9/1/2020	9/30/2020	10/5/2020
3y 3YU0	<8/31/2020	8/31/2020	9/1/2020	9/30/2020	10/5/2020
5y FVU0	<8/31/2020	8/31/2020	9/1/2020	9/30/2020	10/5/2020
7y TYU0	<8/31/2020	8/31/2020	9/1/2020	9/21/2020	9/30/2020
U10 UXYU0	<8/31/2020	8/31/2020	9/1/2020	9/21/2020	9/30/2020
20Y USU0	<8/31/2020	8/31/2020	9/1/2020	9/21/2020	9/30/2020
U30 WNU0	<8/31/2020	8/31/2020	9/1/2020	9/21/2020	9/30/2020

### III. The Deliverable Basket, Conversion Factors, and Cheapest-to-Deliver

The concept of a Treasury Future is reasonably logical. The Treasury Future behaves like the cash Treasury security that is expected to be delivered. If there are several likely possibilities, the future behaves like a hybrid: performance emulates a probability-of-being-delivered weighting.

The ‘short’ decides which security to deliver. The specific security choices for the short are defined by the ‘deliverable basket’. Depending on the “which future” (say, TY vs US), the basket may have a different number of securities eligible. Eligibility of a security to be in the basket is determined by time to maturity—so, cash Treasury issuance determines ‘how many’ potentially-deliverable securities are in the basket. (source: Bloomberg):

Adjust Value	Maturity	Price Source	Coupon	Yield	Conver Factor
1) T 1 1/2	11/30/24	105-12 7/8	BGN	0.2312	0.8362
2) T 1 3/4	12/31/24	106-18 3/8	BGN	0.2367	0.8426
3) T 1 5/8	01/31/25	105-00 3/8	BGN	0.2433	0.8258
4) T 1 7/8	02/28/25	103-31 1/4	BGN	0.2423	0.8133
5) T 0 1/2	03/31/25	101-04 1/4	BGN	0.2529	0.7859
6) T 0 3/8	04/30/25	100-17+	BGN	0.2578	0.7775
7) T 0 1/4	05/31/25	99-30 3/8	BGN	0.2607	0.7689
8) T 0 1/8	06/30/25	99-29 1/4	BGN	0.2678	0.7654
9) T 0 1/4	07/31/25	99-28 3/8	BGN	0.2731	0.7618

For the September 2020 5-year future (FVU0 as shown to the left), there are nine eligible cash Treasury deliverables. Prior to last delivery date, there will be another security issued, the next cash 5-year, that will also be eligible. We can’t ‘know’ the specifics on that issue, so assumptions are made and its potential for delivery are hypothetical at this point. Securities may be added to the basket over the life of the future due to new issues. None are removed.

How would a trader decide which security to deliver? There has to be a ‘normalization’. That normalization is accomplished by re-casting each deliverable security into a 6% coupon. Obviously, the normalized coupon is well above market today, illustrating that this attribute of Treasury Futures is quite old! The “Conversion Factor” (CF) is the normalizing factor. Each cash security that is deliverable has its own CF— as shown in the right-most column of the above graphic.

Cash Treasury securities trade in ‘clean price’. The price traded in a cash Treasury is invoiced separately from the accrued interest. This separation allows for normalization of a clean price via Conversion Factor. Using the Conversion Factor, a Treasury Futures short can determine which bond is Cheapest to Deliver (CTD). The Treasury security that is CTD largely determines the performance characteristics of the Treasury Future.

To determine the CTD security in the future’s basket, the price of each eligible security is divided by its Conversion Factor. The lowest CF-adjusted price, priced forward to delivery date, is the CTD security:

TYU'20 Deliverable Basket, Current & Forward-to-Delivery Pricing					
Current (8/24/20) Pricing				Forward Price to Delivery Date (9/30/20)	
ConvFactr	Eligible Treasury	Curnt Px	Px/CF	DelivDtPx	Px_dlv/CF
0.7943	T 2 1/4 08/15/27	112.2617	141.3342	112.0961579	141.125718
0.7882	T 2 1/4 11/15/27	112.5645	142.812	112.4018457	142.605742
0.8111	T 2 3/4 02/15/28	116.5293	143.6682	116.3224026	143.413146
0.8135	T 2 7/8 05/15/28	117.8672	144.889	117.6523016	144.624833
0.8085	T 2 7/8 08/15/28	118.2949	146.3141	118.0841512	146.053372
0.8194	T 3 1/8 11/15/28	120.7129	147.3186	120.4774784	147.031338
0.7828	T 2 5/8 02/15/29	117.0723	149.5558	116.8850531	149.316624
0.7614	T 2 3/8 05/15/29	115.3105	151.4454	115.1475151	151.231304
<b>0.8072</b>	<b>T 2 3/8 05/15/27</b>	<b>112.8125</b>	<b>139.7578</b>	112.63087	<b>139.532792</b>
0.7055	T 1 5/8 08/15/29	109.0918	154.6305	108.9955821	154.499762
0.7077	T 1 3/4 11/15/29	110.3906	155.9851	110.2877623	155.839709
0.6841	T 1 1/2 02/15/30	108.1484	158.0886	108.0713427	157.975943
0.7142	T 0 5/8 03/31/27	101.2168	141.7205	101.2002902	141.69741
0.7075	T 0 1/2 04/30/27	100.3457	141.8314	100.3401698	141.823562
0.615	T 0 5/8 05/15/30	99.875	162.3984	99.87640458	162.400658
0.7075	T 0 1/2 05/31/27	100.3027	141.7706	100.2967445	141.762183
0.6984	T 0 1/2 06/30/27	100.2676	143.5676	100.265479	143.564546
0.6915	T 0 3/8 07/31/27	99.39063	143.7319	99.3986595	143.743542
0.6075	T 0 5/8 08/15/30	99.72656	164.159	99.73016948	164.164888

To calculate the forward clean price of a Treasury, the =PRICE() function on Excel may be used.

Once the price of each eligible Treasury security is calculated to find its 'forward price on delivery date' (in blue, DelivDtPx), those forward Treasury prices are divided by each of their respective Conversion Factors to determine which security is CTD—cheapest. For TYU0, the price is highlighted in orange. The short delivers the cheapest available.

“Isn't this piece about ROLL SPREADS?”—Yes, and the complexity of the CTD logic must be sorted first. When attempting to value the spread, the CTD for the more-forward Treasury Futures contract (currently, Dec'20) must also be calculated.

The same calculations are deployed for the more-deferred future, TYZ'20.

The key variable that changes is the Delivery Date (12/31/20 here). The forward price to 12/31/20 is calculated for each cash security eligible for delivery.

Again, the security with the lowest Conversion Factor-adjusted forward price is CTD (green)

TYZ'20 Deliverable Basket, Current & Forward-to-Delivery Pricing					
Current (8/24/20) Pricing				Forward Price to Delivery Date (12/31/20)	
ConvFactr	Eligible Treasury	Curnt Px	Px/CF	DelivDtPx	Px_dlv/CF
0.8006	T 2 1/4 08/15/27	112.293	140.261	111.6823953	<b>139.49837</b>
0.7943	T 2 1/4 11/15/27	112.5977	141.7571	111.9941908	140.997345
0.8164	T 2 3/4 02/15/28	116.5664	142.781	115.7992694	141.841339
0.8184	T 2 7/8 05/15/28	117.9063	144.0692	117.1096208	143.095822
0.8135	T 2 7/8 08/15/28	118.3379	145.4676	117.5479186	144.496519
0.8238	T 3 1/8 11/15/28	120.7578	146.5863	119.8922818	145.535666
0.788	T 2 5/8 02/15/29	117.1152	148.6234	116.4257172	147.748372
0.7668	T 2 3/8 05/15/29	115.3691	150.4553	114.7669795	149.670031
0.712	T 1 5/8 08/15/29	109.1387	153.2847	108.7892073	152.79383
0.7139	T 1 3/4 11/15/29	110.4414	154.7015	110.0533666	154.157959
0.6905	T 1 1/2 02/15/30	108.1992	156.6969	107.9012872	156.265441
0.6226	T 0 5/8 05/15/30	99.91797	160.485	99.9226796	160.492579
0.7075	T 0 1/2 06/30/27	100.291	141.7541	100.2766817	141.733826
0.7009	T 0 3/8 07/31/27	99.41406	141.8377	99.44294047	141.878928
0.615	T 0 5/8 08/15/30	99.77344	162.2332	99.78103857	162.245591

These two calculation grids yield the CTDs for each of the TYU20 and TYZ20 futures:

- T 2 3/8s of 5/15/27 is CTD for TYU20
- T 2 1/4s of 8/15/27 is CTD for TYZ20

#### IV. Calculating the Fair Value of the Roll Spread from the CTD's

Using the =PRICE() function on Excel, calculate the forward cash CTD prices to 9/30/2020 (Sep Deliv Dt)

TY	8/24/2020				9/30/2020							
Fut Px	fut dlv dt	last SETTLE_DT	Future	FUT_CTD	cnvs factor	ISSUE_DT	MATURITY	CPN	CPN_FREQ	CashPx	CashYLD	FwdCashPx
139.4922	9/30/2020	8/25/2020	TYU0 Comdty	T 2.375 05/15/27	0.8072	5/15/2017	5/15/2027	2.375	2	112.8125	0.4385	112.63087
139.3672	12/31/2020	8/25/2020	TYZ0 Comdty	T 2.25 08/15/27	0.8006	8/15/2017	8/15/2027	2.25	2	112.293	0.457	112.12137

Using the FwdCashPx on 9/30, calculate the futures prices for each CTD by:  $FwdCashPx/ConvFactor$ . The result (**FutPxDlvDt**, below) is the unadjusted futures price on 9/30/20 for each of the TYU0 and TYZ0 contracts. In the case of TYU0, 139.53279 IS the futures equivalent delivery price. This value is not adjusted further. The Dec'20 value, however, presents a problem. The conversion factor for DEC'20 is calculated based upon a last delivery date of 12/31/20, not 9/30/20. To rectify the problem, the gross 'basis' is calculated for each Treasury Future. The basis defines 'curve roll up' for the futures contract between 'today' and 'forward price date'. The basis is the difference between spot futures price and the futures price on delivery date,  $FutPxDlvDt$ . (Final Future Price) – (Spot Futures Price) = Basis

	9/30/2020		9/30/2020	
	FwdCashPx	FutPxSpot	FutPxDlvDt	\$basis
TYU0 CTD=>	112.63087	139.49219	139.53279	0.040603
TYZ0 CTD=>	112.12137	139.36719	140.04668	0.679492

In the case of TYU0, with a basis of 0.040603 points, or 1.2993 ticks, all things held steady, the TYU0 future will appreciate by 1.2993 ticks between now and delivery (9/30/20). At delivery, the basis will be zero because the invoice price for the CTD will be the same as the futures settlement price, adjusted for the conversion factor. Bottom line: TYU0 will roll up the curve by 0.040603 points.

As mentioned earlier, each eligible-to-deliver security for each Treasury future has a unique conversion factor. The CF translates the cash Treasury clean price into the equivalent price for a 6% coupon. This equalization translates to: "The change in clean price of all 6% Treasury securities from today to some forward date must be the same by 'no arbitrage'." Or, same credit, same partial term, same discount rate = same  $\Delta PV$ .

To correct the forward futures price for TYZ0 (Dec20):

$$TYZ0\_FutPxDlvDt (140.04668) - TYZ0\_\$basis (0.679492) + TYU0\_\$basis (0.040603) = TYZ0 \text{ on } 9/30/20$$

	9/30/2020		9/30/2020		
	FwdCashPx	FutPxSpot	FutPxDlvDt	\$basis	Adj FutPx
	112.63087	139.49219	139.53279	0.040603	139.53279
	112.12137	139.36719	140.04668	0.679492	139.40779

From here, the fair value of the TYU0/TYZ0 spread is simply the difference of the Adjusted Futures Prices: TYU0 (139.53279) – TYZ0 (139.40779) = 0.125 points or 4/32.

The open market bid/ask of the roll spread? Real time source: Bloomberg

The screenshot shows a Bloomberg terminal window with the following data for TYU0 and TYZ0:

Contract	Price	Change	Vol	Op	Hi	Lo	OpenInt
RTYU0Z0	139.53279	+0-03 <sup>3</sup> / <sub>4</sub>	43438	0-04	0-04	0-03 <sup>3</sup> / <sub>4</sub>	251202
RTYZ0Z0	139.40779	-00 <sup>1</sup> / <sub>4</sub>		0-04	0-04	0-03 <sup>3</sup> / <sub>4</sub>	

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