First draft: July 27, 2020

US Treasury-note futures

These notes focus on the 10-year US Treasury note futures contracts that are traded on the Chicago Mercantile Exchange. One of the sources of confusion with futures contracts in general is language. In a short-hand / sloppy way, we sometimes say "she bought a futures contract," or "I sold a futures contract." But in fact, a futures *contract* is an agreement between the buyer and the seller that pins down the terms of a future transaction. No money changes hands when the two parties enter such an agreement.

In practice, once I trade a futures contract my obligation is no longer with the counterparty to the contract – it is transferred to the clearinghouse. The role of the clearinghouse is to ensure traders in the futures markets that their contracts will indeed be honored (even if the original counterparty should default). In order to protect itself against such events, the clearinghouse requires that futures traders post collateral. In the futures markets, this collateral is called *margin*. (Which is an odd term that is potentially misleading in that it is different from the margin in equity markets, which arises when a trader borrows from her broker.) The amount of the margin is determined by the exchange and clearinghouse for each contract. The 10-year US Treasury futures contract is for $100,000 par value of a hypothetical Treasury note, with a 6% yield to maturity, and remaining term between 6.5 and 10 years. The CME currently sets the maintenance margin at $1,700 per contract. This may be posted in US Treasury Bills, with a 50 basis point haircut. So, for example, if I were to go long 100 contracts, I would have to post margin of $170,000 with the clearinghouse. So I would post $169,150 worth of US Treasury bills and $850 in cash in my margin account.

To further protect the clearinghouse contract positions are marked to market on a daily basis, using the end-of-trading-day settlement price. So let's say that on July 15, 2020 I go long 100 contracts at a price of 139-09+, and post margin of $169,150 worth of US Treasury bills and $850 in cash. On July 16, the contract's settlement price is 138-31. So I agreed to pay 139.296875% of par for $10 million par. That is $13,929,687.50. But on July 16, that is worth $13,896,875.00. So I lost $32,812.50. Since the clearinghouse is the counterparty to my position, by definition, it has gained this amount. So it transfers this amount out of my margin account (and into the margin accounts of traders with short positions in this contract). This means that I have to post this loss to my margin account–effectively zeroing out my position at the end of each day. If I fail to restore my margin account then the clearinghouse can close out my position and retain all of the funds needed to cover any losses. In this example the price dropped by $10\frac{1}{2}$ ticks. The value of a tick is $\frac{1}{32}\% \cdot 100,000 = \$31.25$. I have 100 contracts so I lost $31.25 \cdot 100 \cdot 10.5 = \$32,812.50$.

Again, the 10-year US Treasury futures contract is for $100,000 par value of a Treasury note that has a remaining term between 6.5 and 10 years. (Old 20- and 30-year bonds are not deliverable, even if their term falls within this range.) The short side must deliver an eligible note on any day (and at any time) during the contract's expiration month. Thus this contract has physical delivery. The contracts are structured on a quarterly cycle–expiring in March, June, September, and December of each year. Since multiple notes are eligible for delivery to any contract, the exchange uses a conversion factor to place them on an even basis. Like many institutional features in fixed income markets, this has an economic rationale, but is in fact just an approximation. The idea behind the conversion factor is: what would be the clean price of $1 par value of the note (with its unique coupon rate and maturity date), if it had a yield to maturity of 6% on the first day of the delivery month. The principal invoice price ("clean price") of a note to deliver against a futures contract is the price of the futures (i.e., the contract price agreed upon in advance) times the note's conversion factor.

The selling side has the options of what day to deliver the note (the timing option), what time within the day to deliver the note–including after the settlement price is set (the wildcard option), which of the deliverable notes to deliver (the quality option), and the end-of-month option. The last trading day of a contract is the eighth business day before the month end. The settlement price at the end of this last trading day is called the final settlement price. This final settlement price is used to settle all deliveries through the last settlement date, which is the last business day of the month. The end of month option derives from the fact that this price is fixed, but the note prices keep changing. So the cheapest to deliver note could change over this 7 business day period. We can identify the cheapest to deliver note as that note amongst the deliverable set with the highest implied repo rate. The implied repo rate is that overnight repo rate that would make a convergence trade of buying the note in the spot market and simultaneously entering into a futures contract to sell the note – have a zero value as of the last day of the delivery month.[1]

Even though the contract has physical settlement, most traders close their positions before physical settlement.

Let's use the September 2020 10-year US Treasury futures contract on July 15, 2020 as an example. The associated spreadsheet (SepEx.xlsm) includes the Bloomberg DLV screen for this contract. It shows that there are 13 10-year notes and 4 7-year notes that are eligible for delivery against the September contract on July 15, 2020. And the cheapest to deliver note is the $2\frac{3}{8}$ May 15 2027 note. The contract settlement price is 139-09+. I wrote a VBA function,

CONFAC(COUPON,MATYR,MATMO,CONTYR,CONTMO)

that computes the conversion factor according to the exchange's rules. Notice that this only depends on the five arguments of the function, so that it never changes. Of course a note's conversion factor for one contract will be different from its conversion factor for another contract. In particular, note that the conversion factor does not depend on any market price. Per exchange rules, it is rounded to 4 decimal places.

[1] If a note's coupon were lower than this implied repo rate, then it would be optimal to deliver on the first day of the delivery month.

Once we have the conversion factors we can compute various metrics to identify the economics of the contract, including the cheapest to deliver note (at this point in time). The 17 notes that are eligible for delivery against the September contract are arranged from cheapest- through most expensive- to deliver. Going through the Bloomberg columns: What they call the convenience yield is the note's yield-to-maturity. The gross basis is simply the difference between the note price and the futures price times the conversion factor. The implied repo rate is the financing rate that makes the following trade break-even.

1. Buy the note in the spot market and finance it in repo.
2. Simultaneously sell the same par value in the futures market.
3. Hold the position until the last day of the contract month.
4. Deliver the note against the futures contract.
5. Invest any coupons received during the holding period in repo over the remaining term.

Note that when we buy the note we pay the cash price (so we have to compute the accrued interest on the settlement date). Similarly when we deliver the note we receive the (clean) futures price, which was fixed at the time of the trade (that is the whole point of futures–the terms of trade are set in advance of the transaction) plus accrued interest on the futures settlement date. So in the absence of any coupon payments over the holding period, the implied repo rate is the r which makes the following equation hold:

$$\{P_{a,t+1} + A_{t+1}\}\left(1 + r \cdot \frac{T-t+1}{360}\right) = F_{t,T} \cdot c + A_T$$

Here, $P_{a,t+1}$ is the note's clean ask quote on day t, settling on day $t+1$ (the next business day). A_{t+1} is the accrued interest on the note on the settlement day. T is the last trading day in the futures contract expiration month. $F_{t,T}$ is the (clean) price on day t of the futures contract that matures in the month whose last trading day is day T.

If we receive a coupon during the holding period, let's say on day τ, this becomes:

$$\{P_{a,t+1} + A_{t+1}\}\left(1 + r \cdot \frac{T-t+1}{360}\right) = F_{t,T} \cdot c + A_T + C_\tau \cdot \left(1 + i \cdot \frac{T-\tau}{360}\right)$$

Here i is the prevailing repo rate.

The spreadsheet shows that Bloomberg handles this differently. First they assume reinvestment of the coupon at the implied repo rate (which is a common assumption, akin to yield to maturity or internal rate of return). They also do not correctly adjust for bad days. In the example, notes on the February / August cycle have a scheduled coupon on August 15, 2020. This is a Saturday. Note holders will not receive this coupon until the next business day, Monday, August 17. In spite of this, there are no adjustments to this payment or any other payments.

The last column from the Bloomberg screen is the Net Basis. This is the adjusted futures price minus the carrying costs of the note:

$$\text{Net Basis} = \{P_{a,t+1} + A_{t+1}\}\left(1 + i \cdot \frac{T-t+1}{360}\right) - F_{t,T} \cdot c - A_T - C_\tau \cdot \left(1 + i \cdot \frac{T-\tau}{360}\right)$$

The cheapest to deliver note is the one with the highest net basis. Using my definitions it will also be the one with the highest implied repo rate. Note that you cannot use this information to undertake a reverse trade. That is look at the most expensive to deliver, and short that, buying in the futures market. The reason for this is that the selling side in the futures market has all the options, so that note would never be delivered.

Why is the contract structured so that there are such delivery options? The answer is linked to fears of market manipulation. In 2020 a contract may have open interest of 4 million contracts. Since each contract is for \$100,000 par of notes, this represents \$400 billion par value. So this is a very large and liquid market. By contrast, even now when each 10-year note is reopened twice, a single note's float is less than \$60 billion. (Although since the Fed lends securities from it's SOMA the available notes could be closer to \$75 billion.) So the futures market dwarfs the spot market. If only one contract were eligible for delivery, then it could conceivable be "cornered," leading to a *short squeeze*.

In fact, as the accompanying documents detail, Pimco settled a class action lawsuit in January 2011 for \$118,750,000–while denying culpability–which claimed that Pimco has manipulated the 10-year Treasury note market in connection with the June 2005 futures contract. This was an ususual situation in which the cheapest-to-deliver note was much cheaper than the second cheapest-to-deliver, and this created a unique opportunity. Interestingly, much of the evidence assembled by the plaintiffs in this PIMCO case concerns the conditions in the repo market for the cheapest to deliver note.

In earlier research, George Theocharides looked at this event, and I take the following from one of our papers:

Figure 12 shows the behavior of the $4\frac{7}{8}$ February 15, 2012 note in the spring and summer of 2005. This note was cheapest to deliver against the June, 2005 futures contract. For this contract, the cost of delivering the second cheapest to deliver was much higher than this note. The Treasury issued \$13.8 billion of this note on February 15, 2002, and re-issued another \$11.4 billion three months later, so the outstanding supply was \$25.2 billion. Open interest in the June 2005 futures contract peaked in May at over \$200 billion. There was much speculation in the media about a squeeze in this market. For example, the following facts are taken from the *Wall Street Journal*.[2]

[2] "Hedge Funds Role Dents Market Theory," by Mark Whitehouse and Gregory Zuckerman, August 18, 2005. This episode is also documented in academic analysis of idiosyncratic movements in interest rates. Gürkaynak, Sack and Wright (2007) show how the actual yields on the CTD and related securities differ from what is predicted by a smoothed prediction on May 24, 2005 in their Figure 4 (p. 2301).

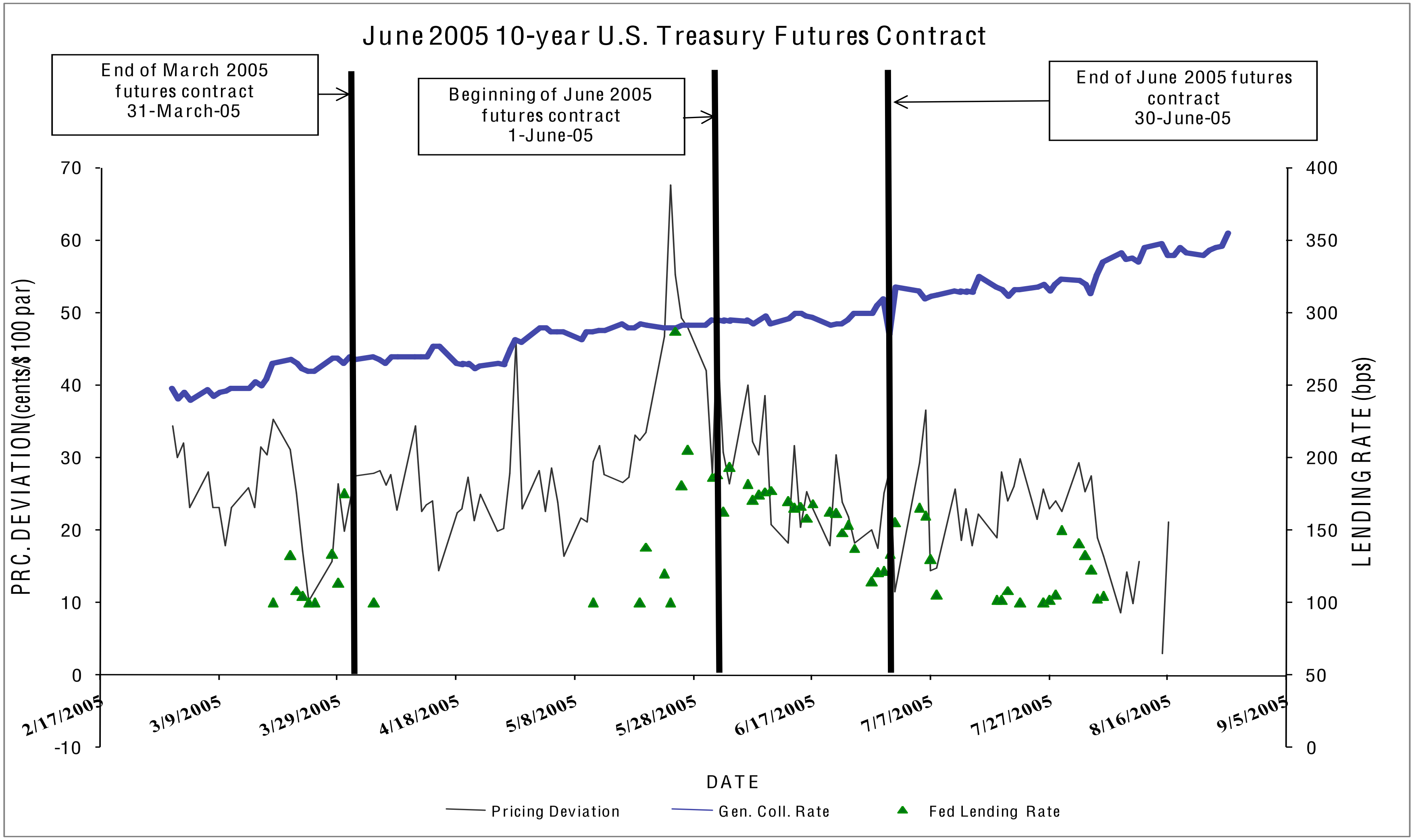

Figure 12 – This graph depicts the average deviation between the bid quote of the February 2012 4 7/8 note issued on February 15, 2002 and its replicated value from bid quotes on fungible coupon STRIPS (shown on the left vertical axis), along with the Fed lending rate for this note (its specialness), and the general collateral rate from March 1, 2005 to August 31, 2005.

1. "In late May, the price of the June futures contract was effectively higher than that of the 10-year Treasury note maturing in February 2012. Any investor who bought $8 billion in the notes and sold the same amount in futures contracts, traders say, could have made $5 million, based on the price difference between the two."

2. The repo market was going crazy: "At one point, investors seeking to borrow the February 2012 notes were offering to pay 30% annual interest on the bonds' market value."

3. Delivery fails on this bond were unusually high.

4. According to Morningstar, PIMCO held $2.8 million of February 2012 notes on March 31, and $11.4 **b**illion on June 30.

5. CBOT records show that one account delivered $8.2 billion of Feb 2012 notes.

In fact, a squeeze did not occur since the only note that was delivered against this futures contract was the February 2012 note. Nevertheless, the fear of a squeeze affected this market. The cost of delivering the second cheapest note of 127 basis points is eight standard deviations above the mean (21 basis points). The lack of low cost substitutes for delivery is necessary for a squeeze to develop, and this was a predictable and well-known feature of this contract. The repo rates in Figure 11 suggest a lack of availability (liquidity) of the February 15, 2012 note. The average specialness over the 132 day period (March 1, 2005 - August 31, 2005) is 63 basis points. The average price deviation over this period is 21.8¢. In the months of May and June, the average specialness is 112 basis points, and the average pricing error over these 44 days is 27¢. This level of specialness is almost twice that of the average for on-the-run notes, post-January 2003. By contrast, the pricing deviation is less than half the average for on-the-run securities in this period. The maximum price deviation during this period is 65¢ on May 24. The maximum specialness of 288 basis points occurs on May 25. In the months of July and August, after the contract expired and this note is no longer deliverable (against any futures contracts), the average price deviation is 16¢ and the average specialness is 50 basis points.

The significant amount of specialness on July 1 - August 5–the lending rate exceeds the minimum (100 basis points) on 18 of those 25 business days–is consistent with settlement difficulties in the spot market that arise because of the large costs of failing to deliver against a short futures position, coupled with the unusually high requests for delivery by the long futures positions.

Figure 12 and Table 7 show the total deliveries against futures contracts for each of the 10-year note contracts in our sample. By historical standards, June 2005 was a record (59%)– $14.2 billion in deliveries. Prior to that the highest ratio was the previous contract, March 2005 when 48% of the outstanding CTD note (also approximately $24 billion) were delivered. However the proportional deliveries in June (59%), September (87%), and December (65%), 2006 all exceeded the June 2005 level. After the June 2005 episode, the Chicago Board of Trade imposed a limit that long positions cannot request delivery of more than 10% of the outstanding note.[3]

[3]The current CME rules place a position limit of $6 billion par value (60,000 contracts) in the last 10 days of the expiration month.

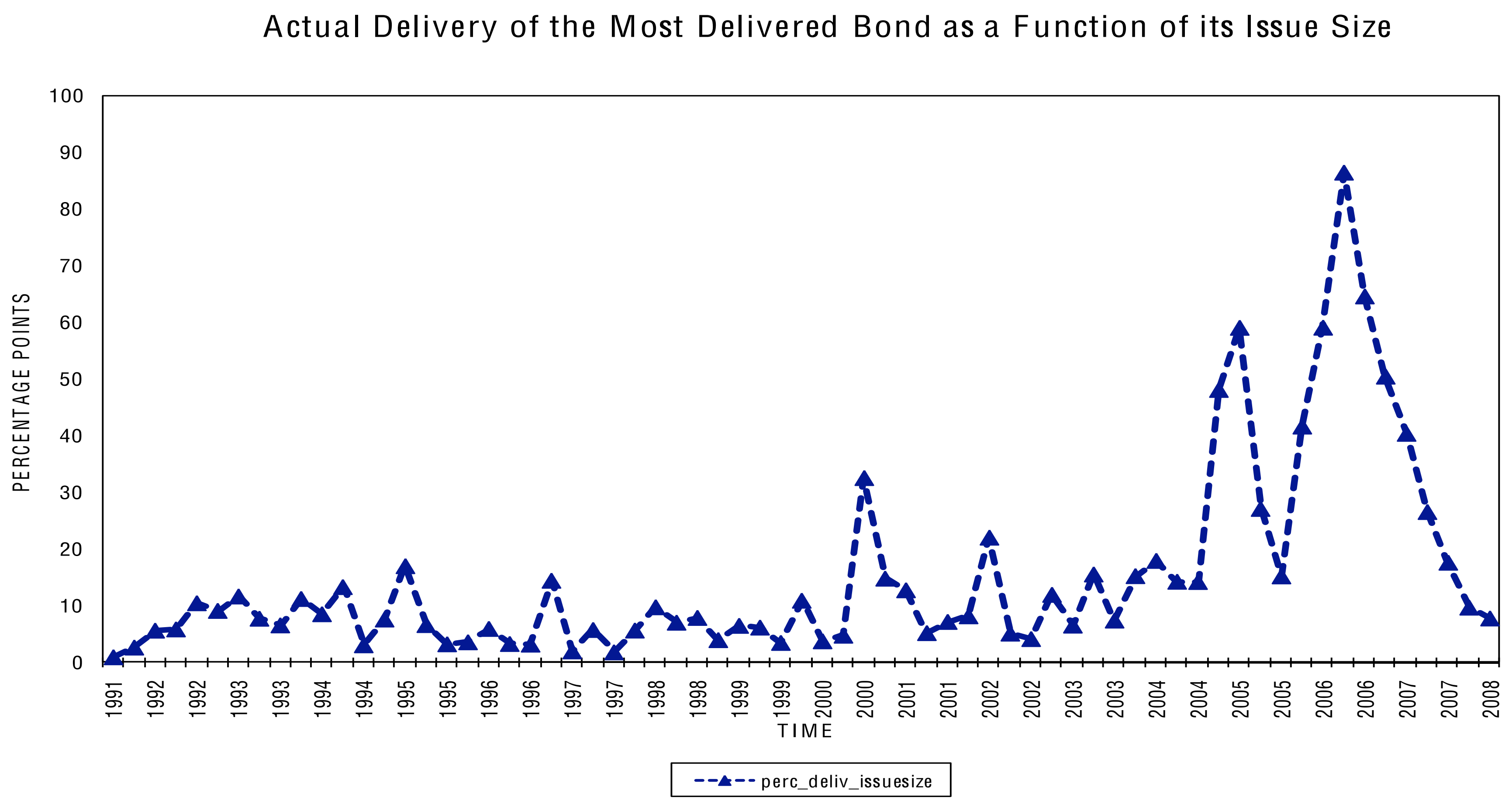

Figure 13 – This graph depicts the delivery of the most delivered bond as a function of its original issue size (offered to the public). Our sample contains 68 contracts. The first contract expires in September, 1991 and the last contract expires in June, 2008. The delivery data can be found on the CME website (*http://www.cmegroup.com/market-data/datamine-historical-data/registrar-reports.html).*