Non-Convexities in the 10-Year Treasury Note Market

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Abstract

This paper examines the link between conditions in the futures market and the underlying Treasury Note. In particular, we compute the price deviations from the intrinsic value of our sample of 10-year Treasury Notes and investigate how conditions in the futures market can impact these deviations. We find that the securities that are eligible for delivery against the futures contract exhibit a positive price premium that is diminishing with the age of the bond. On the other hand, the securities that are no longer available for delivery are on average fairly priced and their premium is indistinguishable from zero. This *deliverability* factor has a stronger impact in recent years and occurs concurrently with an exponential growth in open interest and volume in the futures market. Furthermore, the securities' lending fees have a positive and statistically significant impact on the price deviation.

I. Introduction

The recent volatility in commodity markets (notably crude oil), has caused some suspicion to be directed at derivatives markets, notably futures markets and the possibility of "excessive speculation." On July 15, 2008 Senator Harry Reid introduced S 3268, the Stop Excessive Energy Speculation Act. This bill, (which has not become law), reflects concern that speculative trading (concentrated in derivatives markets) might affect market prices for underlying commodities. Of course disentangling the effect of derivatives market activities from fundamental values is complex in the commodities markets because we lack an objective fundamental valuation.

This paper looks at the market for U.S. Treasury Notes, where we have a better ability to measure intrinsic value. Specifically, we examine the interaction between the 10-year Treasury Note and futures markets noting how conditions in the futures markets relate to conditions in the spot market. Our intrinsic Note valuation is obtained through using daily STRIPS yields to discount every cash flow arising from the Note [see Carayannopoulos (1995), Jordan, Jordan, and Kuipers (1998) and Kuipers (2008)]. This methodology avoids errors that might arise through interpolation methods, or market friction effects. We then compute the price deviations from the STRIPS-Implied-Value (SIV, hereafter) and examine how conditions in the futures market affect these deviations. Following the theoretical work of Duffie (1996) and the empirical findings of Jordan and Jordan (1997), Krishnamurthy (2002) and Nashikkar (2007), we also proceed to investigate how the securities' lending fees drive this price deviation.

Our main findings are as follows: The price *premium* (market price less the SIV) is diminishing with time since issuance for all deliverable Notes. The newly issued security (On-the-Run) is the one that exhibits the highest mean price premium. However when securities are no longer part of the deliverable set, the premium is statistically indistinguishable from zero--the securities are on average fairly priced. The above results point towards plausible "*On-the-Run*" and "*Deliverability*" factors which are supported by our regression analysis. Furthermore, evidence from our univariate and multivariate analysis suggests that the On-the-Run (OTR, hereafter) premium has diminished in recent years (perhaps because liquidity has shifted from the Treasury to the mortgage-backed securities' market). The deliverability premium, on the other hand, has increased and occurred concurrently with an exponential growth in open interest in the futures markets (which now dwarfs the size of the cash market).[2] These findings provide a link between the conditions in the futures market to

[2] In June, 2007, the open interest in 10-Year T-Note futures was 2,954,456 contracts. Each contract is for $100,000 in T-Notes. Almost $3 trillion in face value compared to 10-Year issue sizes of $18 billion, on average.

conditions in the spot market. Furthermore, we find that the securities' lending fees have a positive and statistically significant impact on the SIV deviation.

The paper proceeds as follows. Section II presents the institutional background details surrounding the U.S. Treasury Note and futures markets. Section III describes the data. Section IV is the core of the paper and presents the empirical analysis undertaken: distinguishes between delivery and rollover in the futures markets, examines the determinants of delivery, presents the deviation from the SIV value, investigates the determinants of these deviations, documents a principal component analysis for various sample periods, and examines whether the securities' lending fees are an important determinant in driving the SIV deviations. Section V concludes.

II. Institutional Background

For the most part, the United States Treasury conducts an auction of 10-Year (coupon-bearing) Notes every three months: February, May, August and November. Prior to the November, 1998 auction, the format was a discriminating price auction. The Treasury switched to a uniform-price auction format starting with the November, 1998 auction, which is still used today. The Treasury announces the specific auction parameters about one week ahead of the auction.[3] At this point, when-issued trading begins on the Note.

It is well known that the most recently issued Note tends to trade rich relative to similar securities. This security is considered OTR until the next auction. The richness in price is consistent with the absence of arbitrage in the market, since the OTR security tends to trade special in the repo market. Dealers finance the purchase of Notes by selling them and agreeing to repurchase for a fixed price at a future date. Unspecified Notes (as well as Bonds and Bills) trade in this repo market at the general collateral rate. A security that is on special has a lower repo rate, which makes owning it more attractive.[4]

Trading volume tends to be concentrated in the OTR issues. Barclay, Hendershott, and Kotz (2006) document that when a Note goes off-the-run, the average trading volume drops by 90%, and trading activity switches from electronic platforms to (bilateral trading with) dealers. In early 1985, the United States Treasury introduced its STRIPS (Separate Trading of Registered Interest and Principal of Securitites) program. This allows institutions to isolate each of the separate payments promised by the note to be owned and traded.[5]

The futures market in the 10-Year Treasury Notes is very large and active. These

[3]See Garbade and Ingber (2005) for a description of the auction procedures.

[4]Krishnamurthy (2002) confirms the absence of arbitrage opportunities despite the consistent price differentials.

[5]See Bennett, Garbade, and Kambhu (2000) for a complete description of STRIPS.

contracts trade on the (old Chicago Board of Trade, now part of the) CME Group. Contracts expire on a quarterly cycle: March, June, September, and December. The contracts embody several options for the short side: delivery (or quality), timing, end-of-month, and wild-card options. The quality option means that any original issue 10-Year Note with a remaining term of at least 6.5 years may be delivered against the contract. The timing option means that the short may deliver on any day in the delivery month. The end-of-month option refers to the fact that the last trading day of the futures contract is one (trading) week before month end. The wildcard option is an intra-day version of the end-of-month option. The CME Group uses a standardization procedure to attempt to place all of the Notes on a common footing. This is done with a conversion factor that, roughly speaking, equals the price that the Note would have on the first day of the delivery month, were its yield to maturity equal to the specified notional yield, on a $1 par.[6] Prior to 2000, the notional yield was 8%. In February, 1999, the CBOT changed the notional yield to 6%. The relationship between market yields and the notional yield affects the cheapest-to-deliver (CTD, hereafter). The CBOT lowered the nominal yield because the fact that eligible Notes have lower coupons than the notional rate meant that the shortest-term Note was entrenched as the CTD. By contrast, in the early 1990's, when Note coupons tended to exceed the notional yield, the CTD was typically the longest-term Note.[7]

Volume and open interest have grown exponentially since 2003, when electronic trading in this futures contract was introduced. To put the markets in comparison, the maximum open interest in the June 2005 contract was $250 billion (each contract has a face value of $100,000 par units of Notes). As was discussed during the summer of 2005 in the media, the February 2012 (4 7/8 coupon) Note was firmly entrenched as the CTD against this contract. The Treasury auctioned $13.7 billion of the February 2012 Note on February 6, 2002, and reopened this issue with an additional $11.3 billion in its May 8, 2002 auction.

III. Data

We employ multiple sources to obtain our data for this study. In terms of Treasury Notes, we obtain daily yields and prices on the 10-year and 7-year Notes from Bloomberg Services as these are the Notes that can be eligible for delivery into the 10-year U.S. Treasury futures contracts.[8] Bloomberg provides bid/mid/ask yields, as well as bid/mid/ask/low/high/

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[6] This is not exact, but captures the economic consequence of the conversion factor. See e.g., Burghardt, Belton, Lane and Papa (2005) for the exact approach, and Tuckman, p. 430 for the accuracy of this approximation.

[7] See Nordstrom (1999) and Burghardt, Belton, Lane and Papa (2005).

[8] The auction of the 7-year U.S. Treasury Note was discontinued in 1993 thus our analysis employs only a small number of eligible 7-year issues.

open/last prices. We use the last price for our analysis. This sample starts on June 3, 1991 and ends on June 30, 2008. As noted earlier, a key to our analysis of the 10-year Treasury Note is our ability to compare its market price to a measure of its intrinsic value. To this end, we employ daily coupon STRIPS yields and prices obtained again from Bloomberg Services.[9] Available data on STRIPS constrains our time frame and thus our pricing analysis is restricted between May 15, 1997 and June 30, 2008. In cases of missing STRIPS prices from Bloomberg (usually a few days prior to the maturity of the STRIPS), we search for the data using the *Wall Street Journal* archives. For our pricing analysis, we use the mid-point of the bid-ask spread.

Daily data on the 10-year U.S. Treasury futures contracts is obtained from the CBOT (now part of the CME Group) until the September 2005 contract, and for the remainder of the sample through Bloomberg Services. The sample spans from June 3, 1991 until June 30, 2008 and covers 68 contracts. The data from CBOT consists of the low, high, open, close, and settlement prices, as well as the volume and open interest. Prior to 2003 the data provided comes solely from the auction platform. From January 2, 2003, we have data however from both the auction and electronic trading platform (where the majority of the volume comes) and thus the total volume is the sum of the volume from both platforms. Data from Bloomberg consists of the bid/mid/ask/low/high/open/last prices, as well as the volume and open interest.[10]

Table I presents summary statistics for the 10-year U.S. Treasury futures contracts and deliverable Notes covering the period from June 3, 1991 until June 30, 2008. Our time-series sample covers each futures contract for the three months prior to delivery and rolls-over into the new contract on the first day of the delivery month. Panel A presents summary statistics for the deliverable Notes. Any Note maturing at least 6 1/2 years, but not more than 10 years, from the first day of the delivery month is eligible for delivery.[11] As shown, there are 68 original 10-year Notes that are eligible throughout our sample issued from May, 1988 until May, 2008. There are also eight original 7-year Notes issued between July, 1991 until April, 1993. As noted earlier, for the most part these Notes are issued every quarter although in some cases new issuance occurs every six months (in case of a reopening at the next quarter). There were 36 reopenings for the 10-year Note in our sample period, usually one-month or three-months from issuance, and in a rare case (October 2001) two-months from issuance (an emergency reopening of $6 billion of the 5% 10-year Note issued on August, 2001). The average annual coupon rates are 6.03% and 6.63% for the 10- and 7-year Notes, respectively. Panel B presents summary

[9] See Jordan, Jorgensen, and Kuipers (2000) for a detailed analysis of the U.S. Treasury STRIPS market.

[10] Note that Bloomberg does not provide a settlement price, and thus the last price serves as the settlement price.

[11] See the CBOT website for more details about the specifications of the contract.

statistics for the 10-year futures contracts. These are quarterly contracts and our sample covers 68 contracts from September 1991 to June 2008 with mean/median daily futures returns close to zero. The mean daily open interest is around 764,000 contracts, the mean daily change in open interest is 505 contracts, while the mean daily volume is around 332,000 contracts. These figures refer to the nearby contract. To highlight the explosion in this market, we divide our sample into a pre-2003 and a post-2003 period (in terms of contracts). This break point is motivated by the introduction of the electronic platform in January, 2003. As shown, the numbers for the open interest and volume for the post-2003 period are substantially and significantly larger compared to the pre-2003 period. Panel C shows that the number of deliverables per contract fluctucates with a median, minimum, and maximum numbers of 12, 7, and 16, respectively.

Our data on repo and lending rates come from various sources. Daily general collateral rates are obtained from Bloomberg Services (ask/low/high/open/last rates). These are repo and reverse repo rates for overnight, 1/2/3-week, and 1/2/3-month time frame. The sample spans from May 15, 1997 until June 30, 2008. For our analysis we employ the last rate. Wells-Fargo, Inc. has also provided us with daily special financing rates on the OTR 10-year Treasury Notes for the period January 2, 2004 to August 27, 2007 (low/high/open/close/avg rates). We use the average rate. Furthermore, we utilize data on overnight lending rates for specific Treasury bonds obtained from the Federal Reserve's Securities Lending program.[12] This is a program that began originally in 1969 with the Fed lending Treasury securities from its System Open Market Account (SOMA). Daily auctions were then introduced in 1999 where the Fed acts as a lender of last resort for securities that are high in demand to short (usually OTR and CTD securities in the Treasury futures contracts). When a security trades in this market it can be considered to trade on special. Note that this is a bond vs. bond lending, unlike the private market where we have cash vs. bond lending. There is also a minimum loan fee that has fluctuated over the years and now stands at only 1 basis point (since December 18, 2008). Our sample spans from April 29, 1999 until June 30, 2008.

Table II presents summary statistics for our repurchase and lending rates' sample. Panel A presents the mean/median/minimum/maximum repo and reverse repo rates (general collateral) for the overnight, 1/2/3-week, and 1/2/3-month time frame. One thing to note is that the reverse repo are bigger than the repo rates and this difference can serve as the compensation to a dealer for creating a matched book (borrowing a security in a reverse repo transaction and

[12]Data can be obtained from the following website: (*http://www.newyorkfed.org/markets/securitieslending.html*). See Fleming and Garbade (2007) for a detailed explanation of this program.

lending it out using a repo transaction). Panel B presents summary statistics for the sample on the OTR securities provided by Wells-Fargo. The sample covers 16 10-year Treasury Notes. In this sample the special rate never exceeds the overnight general collateral rate thus the minimum specialness (difference between the general collateral rate and the special rate) is positive. At the same time, the special rate never drops below zero and thus the minimum special rate is positive. Panel C presents summary statistics on the data obtained from the Fed's Securities Lending program. The sample covers 62 deliverable 10-year Treasury Notes. As expected, the mean/median difference between the overnight general collateral rate and the Fed lending rate is positive. However, there are cases when the costs of the settlement fails in a short position are so high that market participants are willing to lend out money with a *negative* interest rate. When this occurs the implied special repo rate turns negative (shown as the difference between the general collateral rate and the Fed lending rate).[13] We also examine the difference in the Fed lending rate and the Wells-Fargo specialness. On average the Fed lending rate is higher. Perhaps market participants are willing to pay more to borrow from the Fed than the private market, either because of borrowing demands later in the day or the certainty of delivery, as argued by Fleming and Garbade (2007).

IV. Empirical Analysis

A. Delivery and Rollover

The usual practice in these markets is that delivery does not occur, but rather that traders rollover their position to the nearby contract before the start of the delivery month. However, that is not always the case. In some cases, the long will demand delivery and the short will have to deliver, with the options explained earlier - delivery (or quality), timing, end-of-month, and wild-card options. This demand for delivery might create a price pressure on the deliverable securities.

Table III presents summary statistics for the actual deliveries and rollover in the 10-year Treasury futures contract. The delivery data are obtained from the CME website (*http://www.cmegroup.com/market-data/ datamine-historical-data/registrar-reports.html*) and includes the specific issue delivered, the exact delivery date, as well as the number of contracts delivered. Note again that each contract is for $100,000 face value of the Treasury Note. Panel A presents the mean/median value of all deliveries as a percentage of the peak open interest, the open interest at the first day of the delivery month, and the total size of all deliverables (contract equivalent). We again highlight any differences between the pre- and post-2003 period. The mean value of all deliveries as a percentage of peak open interest is at 4.1%, with no statistical differences between the pre- and post-2003 period. Any increase in the contracts delivered in

[13] See Fleming and Garbade (2004) for a description of such a case.

recent years is offset by the exponential increase in the peak open interest. However, statistical differences exist for deliveries as a percentage of open interest at the beginning of the delivery month between the pre- and post-2003 period. Specifically, this percentage increases from 11.5% to 19.5% with a maximum value of 83.3% for the December 2006 contract (unreported result). The same result is obtained when we examine the percentage of all deliveries as a function of the total size of all deliverable Notes in the contract. There are statistical differences between the pre- and post-2003 period, increasing from 0.9% to 2.2%, with a maximum value of 6.1% occurring again for the December 2006 contract.

Panel B presents similar results for the most-delivered bond. As shown, the deliveries as a percentage of the peak open interest is at 3.8%, with again no statistical differences between the pre- and post-2003 period. However, statistical differences exist between the two periods for deliveries as a percentage of the open interest at the beginning of the month, or of the security's issue size. Specifically, these percentages increase from 10.4% to 19.5% and from 8.1% to 30%, respectively. Furthermore, the December 2006 contract has the maximum percentage as a function of the open interest at the beginning of the month (at 82.9%), while the September 2006 contract has the maximum percentage as a function of the security's issue size (at 86.6%).

The norm in these markets is that the security that is considered the CTD is the one that is being delivered. However as Panel C shows this is again not always the case. The short has the delivery (or quality) option to deliver any original issue 10-year Note with at least 6 1/2 years remaining to maturity. In 29 cases (out of 68 contracts) more than one security has been delivered, with June 1994 being the contract with the highest number of securities delivered (five securities).

We also investigate the rolling over to the next contract. To this end, we employ the methodology of Holmes and Rougier (2005) to construct an upper bound for the rollover. Using the relationship between four ***observed*** variables (trading volume and change in open interest in the near and next contract) and five ***unobserved*** variables (number of contracts opened and closed in the nearby and next contract, as well as the rollover between the near and next contract), Holmes and Rougier derive an upper bound for this rollover given as follows:

$$0 \le r \le min\{\frac{1}{2}(n' - \Delta'), \frac{1}{2}(n'' - \Delta'')\} \qquad (1)$$

where n' (n'') and Δ' (Δ'') denote the trading volume and daily change in the open interest for the nearby (next) contract, respectively, and r denotes the number of contracts rolled over from the near to the next contract.

Panel D presents the mean peak rollover to the next contract as a percentage of the peak open interest as well as the mean value of the cumulative rollover per contract as a percentage of the peak open interest, distinguishing between the pre- and post-2003 period. Similar to deliveries the above percentages have statistically increased for the post-2003 period, a consequence of the exponential increase in this market. Specifically, the peak rollover as a percentage of the peak open interest has increased from 16.8% to 28.9% between the pre- and post-2003 period. The maximum percentage (38.4%) has occurred between the March and June 2007 contracts. The cumulative rollover per contract as a percentage of the peak open interest has increased from 148.8% to 168.5%, with the maximum percentage occurring at the beginning of 2003 (between the March and June 2003 contracts) coinciding with the introduction of the electronic platform.

B. Determinants of Delivery

In this section, we investigate the determinants of deliveries in a similar manner to Peck and Williams (1992).[14] To this end, we construct the *calendar spread* and the *gross basis* on the first business day of the delivery month. Calendar spread is measured as the difference between the closing price of the nearby contract and the expiring one, in percentage points. Calendar spread defined in this manner is usually negative (the nearby contract being less expensive than the expiring one), allowing the long to rollover her position. However, in certain cases the spread can turn positive thus the convenience yield decreases, resulting in greater deliveries. Because of a previously documented non-linear relationship between this variable and delivery in commodities markets, we also include the calendar spread squared. We also compute and include in our regression the gross basis of the CTD security among the available deliverables on the first business day of the delivery month. This is defined as the difference between the quoted bond price (last price available from Bloomberg) and the futures settlement price adjusted by the conversion factor. If the gross basis is large, we would expect a small amount of deliveries. We also include a dummy variable that captures the post-2003 period as well as quarterly dummies to control for seasonality.

Table IV reports results from ordinary least squares regressions on these determinants of deliveries. Our dependent variables are the proportion of total deliverable Notes delivered, as well as the proportion of the delivery of the most delivered bond as a function of its original issue size. The independent variables are the ones described above. Note that although our sample of contracts is 68, the number of observations is 67 since to construct the last data point for the calendar spread we require information for the September 2008 contract (not available). Both the calendar spread and the calendar spread squared have a positive and statistically significant coefficient, implying that the more positive this spread, the greater the deliveries.

[14] Peck and Williams (1992) investigate the deliveries on commodity futures contracts and find them to be significant and in the order of approximately 10 percent of the maximum open interest in the delivery month.

The post-2003 dummy coefficient is also positive and significant, indicating the greater amount of deliveries in recent years. The gross basis coefficient is not significant.[15]

C. STRIPS-Implied-Value

Kuipers (2008) examines the value related to the delivery eligibility in the Treasury bond futures market. He finds that indeed deliverability enhances value. Deliverable securities are on average 6.4 cents (per $100 par) more valuable than, otherwise comparable, bonds not eligible for delivery. Based on the above finding, our goal is to explore the value enhancement from the delivery eligibility especially in recent years.

As noted earlier, to perform our analysis we need to compute the fundamental value of each security in order to observe any market price deviations. To this end, we employ a similar methodology as applied by Carayannopoulos (1995), Jordan, Jordan, and Kuipers (1998), and Kuipers (2008). Specifically, using our STRIPS sample we construct a daily STRIPS-Implied-Value for all bonds (deliverables and non-deliverables). Our sample runs from May 15, 1997 until June 30, 2008. We believe this methodology has several advantages as compared to alternative approaches - linear interpolation of the term structure, the cubic spline functional form, or the Nelson and Siegel (1987) specification. The methodology we employ avoids any errors resulting from interpolation. Furthermore, as argued by Jordan, Jordan, and Kuipers (1998), generic and fungible coupon Treasury STRIPS are probably not affected by market friction effects. Since the payment dates from the STRIPS and Treasury Notes coincide (August 15th, November 15th, February 15th, and May 15th), we can easily produce the SIV value by using the daily STRIPS yield to discount every cash flow arising from the Note. Then we proceed to calculate the deviation of the market value from this intrinsic calculation. Specifically, the deviation in price is given by:

$$d_{i,t} = P_{i,t} + AI_{i,t} - SIV_{i,t} \tag{2}$$

where $P_{i,t}$ is the flat price for the *i*th bond on day *t*, $AI_{i,t}$ is the calculated accrued interest, and $SIV_{i,t}$ is the STRIPS-Implied-Value.[16]

Table V presents summary statistics for these deviations using various sub-samples,

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[15] Peck and Williams (1992) also find that the gross basis is not significant in explaining the delivery in commodity futures contracts.

[16] There are two 10-year Treasury Notes that we are unable to price using our approach due to the lack of availability of the necessary STRIPS data. These are the 7% 10-year Note issued on July 15, 1996, and the 6 1/2% 10-year Note issued on October 15, 1996.

distinguishing once more between the pre- and post-2003 period. Panel A includes all Notes, Panel B, C, D, and E present the results for the OTR, first Off-the-Run, second Off-the-Run, and third Off-the-Run Notes, respectively. Panels F and G present the results for the sub-sample of All Deliverables, and All Deliverables excluding the On-the-Run, first, second, and third Off-the-Run Notes, respectively. Panels H and I present the results for the CTD Note and All Non-Deliverables, respectively. Panel A shows that there are on average 29 original 10-year issuance Treasury Notes traded on each day with a mean deviation from the intrinsic value of 22 cents (4 cents for the median). This result is not far off from the findings of Jordan, Jordan, and Kuipers (1998). They find that for a portfolio of long-term, noncallable strippable bonds, the cash price overvalues the STRIPS portfolio by 17 cents, on average. The mispricing is more pronounced for discount bonds. Their sample includes daily prices for the period 1990-1994. The explanation for the mispricing is due to the STRIPS tax disadvantage argument put forth by Jordan, Jordan, and Jorgensen (1995). Comparing the pre- and post-2003 periods, this mispricing has increased significantly (both for the mean and the median). Panel B confirms the widely recognized “On-the-Run” premium, and it shows that this premium has diminished significantly in the post-2003 period. The average premium for the whole time period is 145 basis points: dropping from 176 to 113 basis points from the pre-2003 to the post-2003 period. This drop is statistically significant at the 1% level. Panel C shows that this premium persists even when the security is no longer “On-the-Run” although the premium is now smaller. The average premium is now at 105 basis points. Furthermore, there is again a drop in the premium in the post-2003 period, falling to 94 basis points from 115. As the security ages, the premium drops even more down to 85 and 68 basis points for the second and third Off-the-Run Notes, respectively, with these differences between the pre- and post-2003 period being statistically insignificant.

Panel F shows that in the case for all Notes eligible for deliverability the average premium is 64 cents, falling from 69 to 60 cents from the pre- to the post-2003 period. However, the median premium values remain constant. The average number of deliverables that are observed on each day is 10.[17] Panel G indicates that if we exclude from the deliverable sample the newly issued securities (OTR, first, second, and third Off-the-Run), we experience a rise in the average premium between the two periods, up from 33 to 45 cents. The above results suggest a fall in the “On-the-Run” premium in the post-2003 period and a rise in the “deliverability" premium. Panel H shows the results for a sample that includes the CTD security

[17]Note that to construct this sample, we include the pricing on deliverable securities for a period of three months prior to the delivery month and we rollover the series to the next contract on the first day of the delivery month.

on each date.[18] The average premium on this security has been 31 cents, slightly decreasing from 33 to 30 cents between the two periods. Panel I presents the results for all securities that are *not* eligible for delivery. Here the premium is statistically indistinguishable from zero--the securities are on average fairly priced. The mean premium is 1 cent and has increased slightly from -1 to 3 in the post-2003 period.

Our next step is to determine the causes of the above premiums, or deviations from the intrinsic value. To this end, we run Generalized Method of Moments (GMM) regressions having these deviations as our dependent variable. We group our data into five panels as follows: All Notes, All Notes eligible for Delivery, All Notes that are not eligible for Delivery, the On-the-Run Notes, and the Cheapest-to-Deliver Notes. We then construct several variables that can help to clarify the reasons for these deviations. These are the following:

- *Issue Size*: The issue size enters into our regression analysis as a de-trended variable (using a linear analysis). We expect that this variable will have a *negative* effect, as the larger the size of the issue the less likely to experience a price pressure because of deliverability.

- *Calendar Spread*: The construction of this variable is explained above. As it was shown in Table IV, the larger the calendar spread will have a positive impact on delivery, and in turn can create more price pressure on the deliverable securities. This in turn implies an expected *positive* effect on the price deviation.

- *Gross Basis Difference between the CTD and 2nd CTD Note*: Gross basis is explained above and helps to identify the CTD for each date. If the difference in gross basis between the CTD and second CTD Note is large, i.e. the CTD Note is a lot less expensive than the rest of the securities, this can create a price pressure on the CTD issue. Thus this variable is expected to *positively* affect the price deviation.

- *Post-2003 Period Dummy*: This variable captures the institutional changes in the futures market that occurred in 2003, and as seen in Table V, is expected to have a positive impact on the price premium, apart from the OTR sample.

- *Deliverable, OTR, First/Second/Third-Off-the-Run Dummies*: All of these variables are expected to have a *positive* effect on the price deviations. Newly-issued securities, as well as securities eligible for delivery tend to trade at a price premium.

- *CTD Dummy*: We expect this variable to have a *positive* coefficient since if a Note is the CTD, it is more valuable to investors.

- *Ratio of Open Interest to Issue Size*: If the open interest is substantially greater than the available supply of an issue this might enhance the value of the security especially if this is

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[18] The CTD Note is identified using the gross basis, and the series rolls over into the next contract on the first day of the delivery month.

the CTD Note. Thus this is expected to have a *positive* impact on the price premium.

- *Ratio of Open Interest to Size of All Deliverable Issues*: Similar to the above variable, if the combined available supply of all deliverable Notes is small compared to the open interest in the futures contract, then this might add value to the deliverable securities. Thus its coefficient is expected to have a *positive* sign.

- *Interaction Dummy between the Deliverables/On-the-Run/Cheapest-to-Deliver and the Post-2003 Period*: The above interaction variables serve to highlight differences in the Deliverability/OTR/CTD effect between the pre- and post-2003 periods. The deliverability and CTD interaction variables should have *positive* coefficients as the explosion in the futures markets in recent years should enhance the value of these securities. However, we expect that the coefficient on the OTR interaction variable will have a negative sign as the OTR premium has diminished recently (as shown in Table V).

Table VI present the results from the GMM regressions. Note that our sample stops on May 30, 2008 (and not on June 30, 2008) due to our sample construction. Specifically, we roll over into the next contract at the beginning of the delivery month. Because of plausible correlation in the error terms over time, we use heteroskedasticity and autocorrelation-consistent (HAC) standard errors. Specifically, we obtain Newey-West (1987) standard errors with thirty lags. We have experimented with different lags and the results are qualitatively similar. We have also experimented with different specifications, such as running our regressions using clustered standard errors in one dimension (Note), or cluster in two dimensions (Note and year). Any differences in the significance based on these standard errors are presented in the table.

As shown in our regression using All Notes, the Deliverability, OTR, and First/Second/Third-Off-the-Run dummies turn out positive and highly significant, consistent with our expectations. These results are robust to whatever method we choose to estimate the standard errors. The interaction dummy between the OTR and the post-2003 period turns out significant and negative, consistent with our priors. The issue size and post-2003 dummy turn out negative and positive, respectively, consistent with our expectations. However, when we use clustered standard errors the significance disappears. Furthermore, the interaction dummy between the Deliverables and the post-2003 period turns out insignificant. Contrary to our expectations, the coefficients on the CTD dummy as well as the interaction dummies between the Deliverables/CTD and the post-2003 period are negative.

Similar results are obtained in our second regression that includes All Deliverables. That is, the coefficients on the On-the-Run, First/Second/Third-Off-the-Run dummies turn out positive and highly significant, while the issue size and post-2003 dummy turn out negative and positive, respectively. The interaction dummy between the OTR and the post-2003 period turns out negative and significant. However, the CTD dummy turns out again negative as well as the interaction dummy of the CTD with the post-2003 period, contrary to our expectations. Furthermore, the ratio of open interest to the size of all deliverables issues turns out negative and significant--inconsistent with our prior.

In the third regression specification that includes All Non-Deliverables, the important result is that the post-2003 dummy turns out positive and significant. In the fourth regression, we include only the On-the-Run securities and find that the coefficient on the post-2003 dummy is positive, as suggested by our earlier results. However the coefficient on the ratio of issue size to open interest is negative and significant. In the last specification, we model the determinants of the deviation from the intrinsic value for the CTD Note. The main results show that, contrary to our expectations, the coefficient on the calendar spread is negative and significant while the gross basis difference between the CTD and the second CTD Note and the post-2003 dummy are not significant.

The above results provide evidence and support for the OTR premium that extends to the First/Second/Third-Off-the-Run Notes. There is also evidence however of a Deliverability premium as indicated by our first regression specification. In terms of differences in the post-2003 period, the results are mixed. There is evidence that the premium for all Notes increases after 2003, however that is not the case for the OTR premium. This is materially smaller in the post-2003 era. It will be interesting to discover the exact causes for the decrease in this premium, however such an analysis is beyond the scope of this project.

D. Principal Component Analysis

Motivated by our previous analysis documenting a possible OTR and Deliverability factor, we perform a principal components analysis for the whole sample period as well as various sub-samples. Table VII presents the results. It shows the cumulative proportion explained by the first six principal components.

The first factor explains 52% of the variation in the full sample, 43% for the pre-2005 period, 65% for the post-2003 period, and 79% for the post-2005 period. Observing the eigenvectors for this principal component (not reported for brevity), we note that in all cases it is monotonically decreasing in the age of the issue with a positive loading for almost all Notes. A plausible interpretation of this factor is that it picks up the aggregating nature of the construction of the deviations, as documented in Table V. Since it monotonically decreases in age, it can be related to the OTR and Deliverability effect, however there is no break in the loadings near the OTR Note, or the transition from the Deliverable to the Non-Deliverable Notes. The fact that this factor is much more important in recent years may reflect a more efficient market causing less idiosyncratic variation in these deviations.

The second factor appears to be an OTR phenomenon which has diminished in recent years. For example, for the pre-2005 period explains about 17% of the deviations, while for the post-2003 and post-2005 periods explains 12% and 6%, respectively. The fact that this factor has changed in recent years can be seen also from the eigenvectors (not reported for brevity). For the pre-2005 period, the loadings are positive on the first four issues, close to zero on the fifth, and then become negative for all older Notes. For the post-2003 and post-2005 periods, this factor seems to differentiate older, but still deliverable Notes, from the first factor. The third factor seems to differentiate the other deliverables from the OTR Note in the pre-2005 period.

E. Can the pricing deviations be explained by the securities' lending fees?

Duffie's (1996) seminal paper concludes that an issue trading on special will command a premium. That is, ex-ante this security should provide a price premium by an amount that exactly offsets the fee that has to be paid to borrow the security. Jordan and Jordan (1997) provide empirical support for this argument. Using a sample of general collateral and special financing rates for the period September, 1991 to December, 1992, they compare the actual vs. a reference price for issues trading on special and on securities that are not. They show that issues on special exhibit a large positive price differential from their reference value. Krishnamurthy (2002) examines a strategy of longing the old (first Off-the-Run) 30-year Treasury bond and shorting the OTR issue, and then rolling this strategy at the next auction date. This strategy in certain times looks profitable. However, if one considers the repo financing expenses in order to short the OTR issue, any arbitrage profits disappear. Nashikkar (2007) makes the argument that in the presence of search frictions, the proportion of the lending fees incorporated into the price will depend on the reason for shorting - if shorting is initiated by hedging needs then this proportion is *less* than one, while if it is initiated by arbitrage is *more* than one. He also provides empirical evidence in support of this argument.

The above papers have mainly examined the OTR securities. Our aim in this section is to re-examine the above hypothesis for the OTR securities, but more importantly for all deliverable issues. Using our sample from the Federal Reserve's Securities Lending program as well as the sample on the OTR issues provided by Wells-Fargo, we explore how specialness can impact the price of the deliverable issues.

As was noted earlier, our original sample from the Fed's program runs from April 29, 1999 through to June 30, 2008 and includes 62 deliverable 10-year Treasury Notes. After merging with the our daily price deviation file (that rolls over into the new contract at the beginning of the delivery month) we are left with 4,508 observations where 57% are on deliverable securities. Only 23% of the 4,508 observations are for OTR securities. Also, there are 152 observations (3.4% of the sample) on securities that are the CTD in the 10-year Treasury futures contract.[19] The average days on special for every issue is 76.4 days. The

[19] Due to the rolling over of our daily pricing sample at the beginning of the delivery month, we exclude

sample from Wells-Fargo runs from January 2, 2004 through to August 28, 2007 and includes 16 On-the-Run Notes. After merging with our daily price deviation file we are left with 885 daily observations.

Table VIII presents our main results in this section which are derived from Generalized Method of Moments (GMM) regressions examining the impact of repo specialness on the SIV deviation.[20] Following a similar approach to Jordan and Jordan (1997), we run three different types of regression specifications aimed at examining the impact of repo specialness on our price deviations. Our prior is that specialness will have a positive impact on the price deviation. Thus in addition to some other variables that we have used in our previous analysis, we add the following variables:

- *Specialness Dummy*: This variable will take the value of 1 if issue ***i*** is on special and trades on the Fed Lending Program on day *t* and 0 otherwise.

- *Interaction Dummy between Specialness & the Post-2003 Period*: To capture any changes on the impact of specialness in the post-2003 period, we use this interaction dummy variable.

- *Degree of Repo Specialness*: This variable captures the interest savings that arise due to specialness for issue *i* on day *t*. It is computed by multiplying the intrinsic value of each security with the one-day general collateral rate on that date, and then subtracting the market price multiplied by the implied special rate. The implied special rate is simply the difference between the general collateral rate and the Fed lending rate.

- *Total Future Specialness*: This variable captures *all* future savings that can arise due to specialness for each issue *i* on day *t*. It sums the degree of repo specialness on the current and all future days, until the last trade day for the issue or the end of our sample period.

The second column of Table VIII shows that the coefficient on the specialness dummy variable is positive and highly significant, confirming our prior. Furthermore, the interaction dummy between specialness and the post-2003 period turns out negative and significant. As before, we use Newey-West standard errors with thirty lags. Furthermore, we check the robustness of our results by also estimating clustered standard errors in one dimension (Note), or cluster in two dimensions (Note and year). Again, all cases where there is a qualitative difference in statistical significance from the alternative procedures are presented in the table. The impact of specialness on the pricing deviation is confirmed in the second and third regression specifications. The coefficients on the degree of specialness dummy as well as on the

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any specialness during the delivery month.

[20] In unreported results, we find that the deviations on observations for Notes that are on special are on average 70 cents compared to only 18 cents for Notes that are not on special.

total future specialness turn out to be also positive and significant.

V. Conclusions

What is the link between the futures and spot markets? Is “excessive speculation" in the futures market creating price volatility in the underlying securities? We address these fundamental questions by investigating the interaction between the markets for U.S. 10-year Treasury Note and futures. We choose to use this market as we are able to get a reliable estimate of the intrinsic value for the underlying security. Specifically, we compute the price deviation from the SIV for each Note in our sample and examine how conditions in the futures markets affect these deviations. We also examine the impact of the securities' lending fees on these deviations.

We find a positive price premium that is diminishing with time since issuance. Interestingly, when securities fall out of the deliverable set, this premium falls to zero. Our regression analysis then points to “On-the-Run" and “Deliverability" phenomenons. The first one, a widely documented result, seems to have diminished in recent years while the second one seems to link the conditions in the futures market with the spot market. That is, the increase in the deliverability premium has occurred concurrently with an exponential growth in the open interest and volume in the futures market. Furthermore, it seems that there is a positive and statistically significant effect of the specialness of the security on its price premium.

In conclusion, our results suggest that conditions in the futures market have an important impact on the spot market. As Merrick, Naik, and Yadav (2005) pointed out this can sometimes lead to squeeze conditions in the spot market. This was indeed what PIMCO and Citadel were accused in the June 2005 contract episode. However, the interaction between the two markets seems to be more dynamic than static. It would be interesting to observe through our sample of contracts how this dynamic interaction can lead to squeezes and price manipulations. We leave this research avenue for the future.

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Table I

Summary Statistics for U.S. 10-Year Treasury Futures Contracts and Deliverable Notes

We report summary statistics for our sample of 10-year U.S. Treasury futures contracts and deliverable Notes. The time span covers the period from June 3, 1991 until June 30, 2008. Our sample covers each futures contract for the three months prior to delivery, and then rolls-over into the next contract. Panel A presents summary statistics for the U.S. Treasury Notes that are eligible for delivery in the 10-year U.S. Treasury futures contract, the number of reopenings (either one-month, three-months, and in a special case (Oct. 2001) two-months from issuance), the first and last issuance date, as well as the mean coupon rate. Panel B presents summary statistics for the 10-year U.S. Treasury futures contracts; the number of contracts, the mean daily futures return, the mean daily open interest, the mean daily change in open interest, as well as the mean daily volume. The numbers in parentheses present the corresponding median values and the numbers in square brackets are t-statistics for differences in sub-samples. The superscript *** indicates significance at the 1% level. Panel C presents the number of deliverable notes per contract: the median, minimum and maximum values.

Panel A: U.S. Treasury Notes Eligible for Delivery

	10-yr T-Notes	7-yr T-Notes
No. of Notes	68	8
No. of Reopenings	36	0
Offer. Amt (Includ. Reopenings)	17.47	9.56
First Issuance Date	5/16/1988	7/15/1991
Last Issuance Date	5/15/2008	4/15/1993
Ave. Coupon Rate	6.03	6.63

Panel B: 10-year U.S. Treasury Futures Contracts

	06/1991 - 05/2008	Pre-2003 Period	Post-2003 Period
No. of Contracts	68	46	22
Futures Return	0.0001	0.0000	0.0001
	(0.0003)	(0.0003)	(0.0001)
			[0.48]
Open Interest	763,690	351,768	1,630,156
	(491,737)	(292,453)	(1,641,195)
			[102.77]***
Δ in Open Int.	505	313	910
	(478)	(479)	(477)
			[0.19]
Volume	331,675	87,815	844,257
	(110,945)	(81,305)	(763,007)
			[95.44]***

Panel C: No. of Deliverables/Contract

	Median	Min.	Max.
No. of Deliverables/Contract	12	7	16

Table II

Summary Statistics for Repo & Lending Rates

We report summary statistics for our sample of repo (lending) rates. Panel A presents summary statistics for our daily sample of general collateral rates. The time span covers the period from May 15, 1997 until June 30, 2008. Panel B presents summary statistics for a daily sample of special rates on the 0n-the-Run (OTR) 10-year Treasury notes provided by Wells-Fargo, Inc., as well as differences from the one-day general collateral rates. The time span covers the period from January 2, 2004 to August 27, 2007. Panel C presents summary statistics for data obtained from the Federal Reserve Bank of New York's Securities Lending program (http://www.newyorkfed.org/markets/securitieslending.html). The time span covers the period from April 29, 1999 to June 30, 2008 and includes 62 deliverable 10-year Treasury Notes. This sample is merged with the one-day general collateral rates as well as the Wells-Fargo special rates.

Panel A: General Collateral Rates

	Mean	Median	Minimum	Maximum
1-day repo rate	3.78	4.50	0.20	6.75
1-day reverse repo rate	3.83	4.55	0.50	7.50
1-week repo rate	3.77	4.55	0.89	6.70
1-week reverse repo rate	3.82	4.63	0.93	6.75
2-week repo rate	3.77	4.55	0.88	6.50
2-week reverse repo rate	3.82	4.65	0.90	6.55
3-week repo rate	3.77	4.51	0.87	6.49
3-week reverse repo rate	3.82	4.60	0.91	6.54
1-month repo rate	3.77	4.52	0.86	6.47
1-month reverse repo rate	3.82	4.60	0.91	6.53
2-month repo rate	3.78	4.55	0.83	6.50
2-month reverse repo rate	3.84	4.65	0.87	6.55
3-month repo rate	3.79	4.55	0.83	6.58
3-month reverse repo rate	3.85	4.60	0.87	6.65

Panel B: 1-day General Collateral Rates, Special Repo Rates, and Specialness of OTR 10-year Notes (16 Notes)

	Mean	Median	Minimum	Maximum
1-day general collateral rate	3.46	3.68	0.86	5.26
Special rate	2.53	2.48	0.02	5.12
Specialness	0.93	0.6	0.01	4.49

Panel C: 1-day General Collateral Rates, Fed Securities Lending Rates, and Differences between WF Specialness, Fed Rates, and Gen. Collateral Rates

	Mean	Median	Minimum	Maximum
1-day general collateral rate	3.16	2.90	0.20	6.65
Fed securities lending rate	1.20	1.00	0.50	5.71
Diff. in general collateral & fed lending rate	1.96	1.64	-2.05	5.15
Diff. in fed lending rate & WF specialness	0.40	0.26	-1.89	3.73

Table III

Summary Statistics for Deliveries and Rollover in the U.S. 10-year Treasury Futures Contract

We report summary statistics for the actual deliveries and rollover in the 10-year U.S. Treasury futures contracts. Our sample contains 68 contracts. The first contract is in September, 1991, and the last contract is in June, 2008. Panel A presents the mean value of all deliveries as a percentage of the peak open interest, the open interest at the first day of the delivery month, and the total size of all deliverables (contract equivalent). Panel B presents the actual deliveries of the most-delivered bond as a percentage of the peak open interest, the open interest at the first day of the delivery month, and its issue size (contract equivalent). Panel C divides the 68 contracts based on the number of different Notes delivered into the contract. Panel D presents the mean value of the day with the highest rollover per contract as a percentage of its peak open interest, as well as the mean value of the cumulative rollover per contract as a percentage of its peak open interest. The numbers in parentheses present the corresponding median values and the numbers in square brackets are t-statistics for differences in sub-samples. The superscripts ***, **, * indicate significance at the 1%, 5%, and 10% level, respectively. We use the methodology by Holmes and Rougier (2005) to construct an upper bound for the rollover measure. The delivery data can be found on the CME website (*http://www.cmegroup.com/market-data/datamine-historical-data/registrar-reports.html*).

Panel A: All Deliveries

	Percentage of:		
	Peak Open Interest	Open Interest at Beginning of Delivery Month	Deliverable Notes (Total Issuance)
Sept. 1991 - June 2008	4.1	14.1	1.3
	(2.8)	(8.7)	(0.9)
Pre-2003 Period	4.4	11.5	0.9
	(3.0)	(7.8)	(0.6)
Post-2003 Period	3.5	19.5	2.2
	(2.7)	(9.6)	(1.5)
	[0.99]	[2.01]**	[4.75]***

Panel B: Deliveries of the Most-Delivered Bond

	Percentage of:		
	Peak Open Interest	Open Interest at Beginning of Delivery Month	Issue Size
Sept. 1991 - June 2008	3.8	13.3	15.2
	(2.7)	(7.8)	(8.4)
Pre-2003 Period	3.9	10.4	8.1
	(2.7)	(6.8)	(6.6)
Post-2003 Period	3.5	19.5	30
	(2.7)	(9.6)	(17.9)
	[0.48]	[2.30]**	[6.17]***

Panel C: No. of Securities Delivered

Securities/Contract	No. of Contracts
1	39
2	16
3	9
4	3
5	1
Total	68

Panel D: Rollover

	Peak Rollover as a % of: Peak Open Interest	Cum. Rollover/Contr. as a % of: Peak Open Interest
Sept. 1991 - June 2008 (67 contracts)	20.6	154.9
	(18.8)	(151.6)
Pre-2003 Period (46 contracts)	16.8	148.8
	(16.8)	(149.7)
Post-2003 Period (21 contracts)	28.9	168.5
	(30.4)	(168.9)
	[10.86]***	[4.27]***

Table IV

Determinants of Deliveries in the U.S. 10-year Treasury Futures Contract

We report results from ordinary least squares regressions on the determinants of deliveries in the U.S. 10-year Treasury Futures Contract. Our sample contains 68 contracts. The first contract is in September, 1991, and the last contract is in June, 2008. The dependent variables include the proportion of total deliverable Notes delivered, as well as the proportion of the delivery of the most delivered bond as a function of its original issue size. The independent variables include the calendar spread on the first business day of the delivery month (difference between the closing prices of the nearby contract and the expiring one, in percentage points), the squared calendar spread on the first business day of the delivery month, the gross basis of the cheapest-to-deliver bond on the first business day of the delivery month (difference between the quoted bond price and the futures settlement price adjusted by a conversion factor, in percentage points), and a dummy that captures the post-2003 period. Seasonal (quarterly) dummies are also included, but not reported. The delivery data can be found on the CME website (*http://www.cmegroup.com/market-data/datamine-historical-data/registrar-reports.html*). The superscripts ***, **, * indicate significance at the 1%, 5%, and 10% level, respectively.

Dependent Variable	**No. of Obs.**	**Intercept**	**Calendar Spr.**	**Calendar Spr. Squared**	**Gross Basis**	**Post-2003 Period**	**Adj. R^2**
All Deliveries as a Percentage of Deliverable Notes	67	1.20 (3.70)***	0.89 (2.88)***	0.07 (2.60)***	0.30 (0.47)	1.52 (5.21)***	0.31
Deliveries of Most-Delivered Bond as a Percentage of its Issue Size	67	11.67 (3.18)***	12.15 (3.46)***	0.97 (3.19)***	0.68 (0.09)	23.18 (7.01)***	0.47

Table V

Summary Statistics for the Difference in Pricing between the Market Value of the 10-Year Treasury Notes and a STRIPS-Implied-Value

We report summary statistics for the difference in pricing between the market value of our sample of 10-year Treasury Notes and a STRIPS-Implied-Value (SIV). The time span of our sample covers the period from May 15, 1997 until June 30, 2008 (daily obs.). The summary statistics include the no. of unique Notes in each sub-sample, the number of observations, the mean no. of obs./day, as well as the mean, median, std. dev. , minimum, maximum, 5th and 95th percentiles of the difference in pricing between the market value of the 10-year Treasury Notes and a STRIPS-Implied-Value (SIV) (in cents per $100 par). The numbers in square brackets are t-statistics for differences in mean of sub-samples for the pre- and post-2003 period. The superscripts ***, **, * indicate significance at the 1%, 5%, and 10% level, respectively.

	No. of Unique Notes	No. of Obs.	No. of Obs./Day	Mean	Median	Std. Dev.	Minimum	Maximum	5th Percentile	95th Percentile
Panel A: All Notes*										
1997-2008	69	85,160	29	22	4	49	-150	327	-28	122
Pre-2003 Period	47	43,166	29	18	1	52	-150	327	-37	129
Post-2003 Period	49	41,994	29	25	8	45	-84	294	-18	117
				[23.03]***						
Panel B: On-the-Run Notes										
1997-2008	37	2,883	1	145	135	63	24	327	55	255
Pre-2003 Period	15	1,451	1	176	177	60	24	327	88	267
Post-2003 Period	23	1,432	1	113	109	49	33	294	50	213
				[30.58]***						
Panel C: 1st-Off-the-Run Notes										
1997-2008	36	2,860	1	105	96	55	-29	300	37	208
Pre-2003 Period	14	1,446	1	115	113	57	-29	300	35	221
Post-2003 Period	23	1,414	1	94	84	50	22	259	37	202
				[10.89]***						

Table V...Continued

	No. of Unique Notes	No. of Obs.	No. of Obs./Day	Mean	Median	Std. Dev.	Minimum	Maximum	5th Percentile	95th Percentile
Panel D: 2nd-Off-the-Run Notes										
1997-2008	35	2,816	1	85	75	46	-39	261	22	169
Pre-2003 Period	13	1,385	1	87	81	47	-39	184	11	158
Post-2003 Period	23	1,431	1	84	70	46	-2	261	28	180
				[1.82]*						
Panel E: 3rd-Off-the-Run Notes										
1997-2008	35	2,674	1	68	63	42	-68	224	10	149
Pre-2003 Period	13	1,259	1	63	60	42	-68	179	-1	138
Pre-2004 Period	23	1,415	1	73	65	42	-13	224	18	157
				[6.16]***						
Panel F: All Deliverables										
1997-2008	47	27,404	10	64	51	55	-74	327	-4	174
Pre-2003 Period	25	11,796	8	69	51	65	-74	327	-8	208
Post-2003 Period	29	15,608	12	60	51	46	-66	294	-1	146
				[12.40]***						
Panel G: All Deliverables, excluding On-the-Run, 1st, 2nd, and 3rd Off-the-Run Notes										
1997-2008	43	16,366	8	40	37	36	-74	235	-9	106
Pre-2003 Period	21	6,172	4	33	31	33	-74	235	-17	87
Post-2003 Period	25	10,194	8	45	41	37	-66	234	-5	111
				[21.06]***						
Panel H: CTD Notes										
1997-2008	37	2,688	1	31	28	36	-74	192	-17	106
Pre-2003 Period	20	1,339	1	33	27	39	-74	192	-17	122
Post-2003 Period	21	1,349	1	30	28	34	-66	178	-17	96
				[2.11]**						
Panel I: All Non-Deliverables										
1997-2008	71	57,084	20	1	-2	26	-150	303	-34	46
Pre-2003 Period	49	31,370	23	-1	-3	28	-150	303	-42	47
Post-2003 Period	51	25,714	20	3	-2	23	-84	275	-21	46
				[19.62]***						

[*]: There exists two securities issued by the Treasury that we are not able to price using the STRIPS approach due to lack of necessary STRIPS prices.

These are the 10-year Notes issued on July and Oct. 1996, respectively.

Table VI

Determinants of the Difference in Pricing between the Market Value of the 10-Year Treasury Notes and a STRIPS-Implied-Value

We report results from Generalized Method of Moments (GMM) regressions on the difference in pricing between the market value of our sample of 10-year Treasury Notes and a STRIPS-Implied-Value (SIV). The time span of our sample covers the period from May 15, 1997 until May 30, 2008 (daily obs.). The dependent variable is the difference in pricing between the market value of the Notes and their SIV (in cents per $100 par). The independent variables are explained below the table. Seasonal (quarterly) dummies are also included, but not reported. Newey-West standard errors with thirty lags are estimated and the corresponding t-statistics are reported in parentheses. The numbers in square and curly brackets represent any deviations in the significance of our variables when we use clustered standard errors in one dimension (Note) and two dimensions (Note and year), respectively. The superscripts ***, **, * indicate significance at the 1%, 5%, and 10% level, respectively.

Variables	**All Notes (84,488 obs.)**	**All Deliv. (26,447 obs.)**	**All Non-Deliv. (57,084 obs.)**	**OTR Notes (2,749 obs.)**	**CTD Note (2,610 obs.)**
α	2.24	49.13	1.28	188.11	19.24
	(3.33)***	(16.25)***	(1.92)*	(12.21)***	(2.80)***
β^1	-0.10	-0.79	0.37	1.20	-0.35
	(2.63)***	(5.80)***	(6.38)***	(0.86)	(0.63)
	[0.26]	[0.86]			
	{0.22}	{0.82}			
β^2		-0.09			-0.26
		(12.15)***			(5.93)***
β^3					0.10
					(0.91)
β^4	4.70	20.30	3.27	-36.71	-5.49
	(9.76)***	(6.71)***	(5.75)***	(3.75)***	(0.80)
	1.61	[1.89]*			
	{0.89}	{1.06}			
β^5	39.54				
	(49.92)***				
β^6	140.36	139.55			
	(111.28)***	(64.33)***			
β^7	65.53	62.44			
	(72.17)***	(41.99)***			
β^8	46.29	43.08			
	(58.52)***	(35.69)***			

Table VI...Continued

Variables	All Notes (84,488 obs.)	All Deliv. (26,447 obs.)	All Non-Deliv. (57,084 obs.)	OTR Notes (2,749 obs.)	CTD Note (2,610 obs.)
β^{9}	29.39	25.95			
	(42.64)***	(25.85)***			
β^{10}	-12.50	-8.51			
	(15.32)***	(7.02)***			
		[1.70]*			
		{2.27}**			
β^{11}				-6.05	-0.69
				(4.58)***	(0.77)
β^{12}		-38.91			
		(5.83)***			
		{1.14}			
β^{13}	1.62				
	(1.49)				
β^{14}	-69.79	-75.42			
	(48.66)***	(32.87)***			
β^{15}	-2.41	-8.17			
	(2.40)**	(5.33)**			
	[0.27]	[0.99]			
	{0.31}	{1.11}			
Adj. R^2	0.589	0.568	0.016	0.311	0.196

Table VI...Continued

Variable Definition:

α = Intercept

β^1 = Issue Size (de-trended using a linear analysis)

β^2 = Calendar Spread (difference between the closing prices of the nearby contract and the expiring one, in basis points)

β^3 = Gross Basis Difference between the CTD & 2nd CTD Note (basis is the difference between the quoted bond price and the futures settlement price adjusted by a conversion factor, in basis points)

β^4 = Post-2003 Period Dummy

β^5 = Deliverable Dummy

β^6 = On-the-Run Dummy

β^7 = First Off-the-Run Dummy

β^8 = Second Off-the-Run Dummy

β^9 = Third Off-the-Run Dummy

β^{10} = Cheapest-to-Deliver Dummy

β^{11} = Ratio of Open Interest to Issue Size (contract equivalent)

β^{12} = Ratio of Open Interest to Size of All Deliverable Issues (contract equivalent)

β^{13} = Interaction Dummy between the Deliverables & the post-2003 Period

β^{14} = Interaction Dummy between the OTR & the post-2003 Period

β^{15} = Interaction Dummy between the CTD & the post-2003 Period

Table VII
Principal Component Analysis

We report the principal components of the daily differences in pricing between the market value of a sample of 10-year Treasury Notes and a STRIPS-Implied-Value (SIV). The time span of our sample covers the period from May 15, 1997 until June 30, 2008.

Cumulative Proportion Explained by the first six Principal Components

PC	1997-2008 (2,899 obs.)	Pre-2005 (1,990 obs.)	Post-2005 (910 obs.)	Post-2003 (1,433 obs.)
1	52.06%	42.87%	79.22%	64.81%
2	68.76%	60.01%	85.46%	76.74%
3	75.60%	69.29%	88.39%	81.94%
4	81.01%	76.75%	90.26%	84.93%
5	84.00%	80.43%	91.88%	87.58%
6	86.18%	83.85%	93.35%	89.57%

Table VIII
Effect of Repo Specialness

We report results from Generalized Method of Moments (GMM) regressions examining the impact of repo specialness on the difference in pricing between the market value of our sample of 10-year Treasury Notes and a STRIPS-Implied-Value (SIV). The time span of our sample covers the period from April 29, 1999 until May 30, 2008. The dependent variable is the difference in pricing between the market value of the Notes and their SIV (in cents per $100 par). The independent variables are explained below the table. Seasonal (quarterly) dummies are also included, but not reported. Newey-West standard errors with thirty lags are estimated and the corresponding t-statistics are reported in parentheses. The numbers in square and curly brackets represent any deviations in the significance of our variables when we use clustered standard errors in one dimension (Note) and two dimensions (Note and year), respectively. The superscripts ***, **, * indicate significance at the 1%, 5%, and 10% level, respectively.

Variables	All Notes (68,001 obs.)	All Notes (68,001 obs.)	All Notes (68,001 obs.)
α	2.73	3.69	-2.65
	(3.08)***	(4.12)***	(2.01)**
β^1	0.78	-0.66	1.81
	(0.10)	(0.80)	(1.42)
β^2	59.50	59.76	49.29
	(91.16)***	(91.83)***	(27.06)***
β^3	75.59	78.45	67.46
	(67.29)***	(70.28)***	(10.33)***
β^4	-27.26	-27.39	-26.95
	(38.95)***	(39.12)***	(7.64)***
β^5	40.24		
	(19.09)***		
β^6	-26.83		
	(11.28)***		
β^7		0.09	
		(10.48)***	
		[1.89]*	
		{2.30}**	
β^8			0.003
			(13.79)***
Adj. R^2	0.513	0.504	0.553

Table VIII…Contd.

Variable Definition:
α = Intercept

β^1 = Post-2003 Period Dummy

β^2 = Deliverable Dummy

β^3 = On-the-Run Dummy

β^4 = Cheapest-to-Deliver Dummy

β^5 = Specialness Dummy

β^6 = Interaction Dummy between Specialness & the Post-2003 Period

β^7 = Degree of Repo Specialness (calculated by multiplying the intrinsic value for issue *i* with the one-day general collateral rate and then subtracting the market price of the issue multiplied by the implied special rate from the Fed's lending program)

β^8 = Total Future Specialness (computed by summing the degree of repo specialness on the current and all future days, until the last trade for issue *i*, or the end of the sample period)