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The 10-Year Treasury Note Market

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We study prices and repo specialness in the market for 10-year Treasury notes and STRIPS. The markets are becoming more closely integrated (less segmented) over time. The on-the-run premium is related to a factor that affects most notes. Since 2005, 80% of the variation in the price deviations between all notes and their replicating portfolios of fungible coupon STRIPS is explained by a single factor. We document that price premia, repo specialness, and liquidity are at least partially distinct phenomena. Those notes that are no longer available for delivery against a futures contracts (some with 6.5 year terms) have a price deviation from underlying STRIPS that is statistically indistinguishable from zero. This suggests that tax effects are not the cause of price deviations between notes and STRIPS.

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Research in finance has identified the fact that non-convexities in the trading process can materially impact prices–even creating astonishing anomalies and apparent departures from the law of one price. Perhaps the most notorious example is the 3Com carve-out of Palm on March 2, 2000, when it appeared that the stub value of the parent, 3Com, was negative.[1] In general, in order to open a short position[2] one must borrow the securities and post the sale proceeds as collateral in the repo market. For general collateral that cash earns the repo rate. When a security is on special, the cash collateral earns a lower rate. In extreme cases, such as Palm immediately after its carve-out, this rate can be negative. This suggests that both the all-in benefits of owning, as well as the all-in-costs of shorting, a security may be understated by its price.

Not surprisingly, in light of its size and liquidity, relative price premia and repo specialness were first identified in the market for US Treasury securities.[3] Indeed, this market provides a unique laboratory to explore the effects of non-convexities on financial asset prices for several reasons. First, the securities have no default risk so that the future cash flows are certain. Importantly for our study, there is also a redundancy in the market that allows us to benchmark Treasury notes to their fundamental values. Specifically, there exist stripped securities corresponding to the coupon and principal payments on all notes. Since we have alternative portfolios with identical future cash flows in all future states of nature, we do not have to rely on a pricing model to construct a valuation benchmark.[4] Third, derivatives are actively traded on the notes. Finally, there have been important technological enhancements to the trading process during the period under study that allow us to isolate an exogenous change in liquidity. All of this suggests that the short-selling institutions (and inelastic supply) are the predominant–if not the only–form of non-convexity in the market for US Treasury securities.

In this paper we put all outstanding 10-year US Treasury notes between May 1997 and June 2008 under the microscope to isolate and study the cross-sectional and time series properties of both violations of the law of one price, and repo specialness. As such, our paper is similar

[1] See Lamont and Thaler (2003) for the details of this case. For related discussions about short-sale institutions and the implications that these have for the equity market, see D'Avolio (2002), Geczy, Musto, and Reed (2002), and Jones and Lamont (2002).

[2] An interesting exception is the fact that under NASD Rule 3370(b) NASDAQ dealers may engage in naked shorting. See Evans, Geczy, Musto and Reed (2008).

[3] Early studies include: Cornell and Shapiro (1989), Amihud and Mendelson (1991), Daves and Ehrhardt (1993), Carayannopoulos (1995), Keane (1995), Duffee (1996), Duffie (1996), and Jordan and Jordan (1997).

[4] Carayannopoulos (1995), Jordan, Jordan, and Kuipers (1998) and Kuipers (2008) also discuss the advantages of using STRIPS to benchmark notes. Citing their liquidity, and lack of idiosyncracies, Sack (2000) suggests using coupon STRIPS to construct the yield curve.

to Duffee (1996). He analyzes monthly data on short-term rates from 1959 through 1994. He finds an increase in the idiosyncratic variation amongst bills–especially those with one and two months to maturity. He attributes this to increased market segmentation. That is, on the margin bills are not viewed as substitutes for other securities with virtually identical future cash flows and frictions prevent arbitrageurs from profiting from these differences.

Our findings include the following. The scale of idiosyncratic price deviations from the STRIPS benchmark across all outstanding 10-year notes has shrunk over time. This reflects the introduction of electronic trading and the exponential growth in trading in both the spot and futures markets that occurred alongside those institutional changes. Much of this growth in trading comes from hedge funds' convergence trades that seek to profit from price deviations in the market (Krishnamurthy 2002). The first principal component of the pricing deviations explains 53% of the total cross-sectional variation (across 31 notes) prior to 2003, 65% of total variation post-2003, and 80% post-2005. This result stands in sharp contrast to Duffee (1996). We find that a note's loading on this first factor decreases smoothly with its age. This suggests that the on-the-run premium is a systematic phenomenon, in the sense that all notes (relative to underlying STRIPS) respond to movements in a common factor. The on-the-run note is just the most responsive to this factor.

Our analysis has several implications for understanding the nature of the on-the-run premium as well as measuring it. One such implication is that identifying the on-the-run phenomenon with a liquidity premium is suspect.[5] In 2000, trading in on-the-run Treasuries started to shift to electronic clearing networks (Mizrach and Neely 2006, 2008). Mizrach and Neely (2006) estimate realized proportional bid-ask spreads using mean absolute price changes within a day. Using this estimate, they find that bid-ask spreads on on-the-run 10-year notes declined from 2 basis points in 1999 (on the old GovPx–voice–platform) to 0.4 basis points in 2004 (on eSpeed). 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. Despite this change in the nominal liquidity of a note as it ages, its pricing premium relative to the STRIPS does not drop precipitously. Furthermore, the price differential between the on-the-run note and its predecessors has gotten smaller over this period while the liquidity differential has

[5] Brunnermeier and Pedersen (2009) separate market liquidity–which is extremely high for on-the-run notes–from funding liquidity. The higher the specialness on a security, the lower is its funding liquidity–i.e., it is more expensive to acquire in the repo market. Tuckman (2002, esp. p.321) argues that the sources of market liquidity–which he says can induce a price premium, and funding illiquidity (high repo rates) are distinct.

gotten larger.

Figure 1 shows the time series of the price deviation from the replicating coupon STRIPS portfolio for Note 1–the on-the-run 10-year note, Note 2–the first off-the-run 10-year note, and Note 20 over our sample period (May 1997 - June 2008). We identify each note in terms of its position within the set of outstanding 10-year notes. Thus, if a note is re-issued three months after its original issue, we consider it to be on-the-run for six months (and designate it Note 1 over this term). Because of the irregularity of re-issuance over our sample period, Note 20 ranges in (remaining) term from 5.25 to 2.66 years, with a median term of 3.8 years. An important feature of this note is that it is never deliverable against a 10-year note futures contract.[6]

Rich patterns in these pricing deviations are evident in Figure 1. They are not constant over time, nor do they exhibit a pronounced seasonal pattern. All three notes' price deviations tend to move together. Nevertheless, there are cases where this is not true. The degree of commonality of these price deviations is higher in the second half of the sample than in the first. We see that the first off-the-run price deviation exceeds that of the on-the-run note from mid-August through mid-November 2003, the first half of August 2005, late October through mid-November 2007, 2008, and three of the last five days in our sample (ending on June 27, 2008).[7]

The average on-the-run premium has diminished in the post-electronic trading era, but this is not a secular trend. Instead, this premium tends to jump in times of financial distress, so we see it reaching historical high levels during the 2007 credit crisis. Finally, note that we are indeed analyzing the data with a powerful microscope. The scale of the ordinate is in cents, when par is \$100. So a value of 24 (the overall average price deviation across all notes in our sample) is about 0.24% of the price (which translates into a yield difference of 5.3 basis points for a five year old 10-year note with a 4% coupon, selling at par).

[6]We substitute Note 18 for Note 20 in the period August 2003 – February 2004 because of data availability. During this period, Note 20 corresponds to the 10-year issues in July and October 1996. Because these issues are unusual in terms of the regular auction cycle, there are no quoted STRIPS to benchmark them. For this reason, in our sample all of the ordered notes except numbers 1 and 2 have at least six months of missing data sequentially.

[7]Fleming and Garbade (2004) and (2005) note that there was a high rate of delivery fails in the summer and fall of 2003, on the May 2013 $3\frac{5}{8}\%$ note. They attribute this to heightened short selling of this note. They also document that this note traded at a negative implied specials rate throughout the fall of 2003. They did not analyze the pricing of this note during this period. The price premium documented here is consistent with the security's specialness. We explore the behavior of the first thirty weeks of this note's life in Section IV.E.2 below.

We also find a "lock-in effect" in the prices of the on-the-run notes. The difference between note prices and the replicating STRIPS portfolio is larger after a rise in yields, and smaller after a drop in yields. Traders have suggested that some market participants are reluctant to realize losses–curtailing supply. Traders have suggested further that this reluctance to sell at a loss is prevalent among foreign institutions, but we find no evidence of this in the data.

It is well known that the pricing deviations that we document herein may not imply that an arbitrage opportunity exists for two reasons. First, and consistent with the findings of Jordan, Jorgensen, and Kuipers (2000), Carayannopoulos (1995), and Daves and Ehrhardt (1993), the deviations between the note and the replicating portfolio of coupon STRIPS cannot be exploited by stripping and reconstituting, as the principal strip–necessary to reconstitute the note–inherits the price premium of the note itself. Indeed, it is evident in Figure 2 that in the early months of a note's life–when its price deviation from the replicating portfolio of coupon STRIPS is highest–there is virtually no stripping activity. The average stripped amount of a six-month old note is 0.024% of the note's issue size.

Second, since higher priced securities often trade on special in the repo market (Duffie (1996), Krishnamurthy (2002)), an arbitrageur seeking to short the overpriced security will earn a lower rate on the cash collateral than she would on general collateral. As in previous studies (Jordan and Jordan (1997) and Fisher (2002)) we find a strong correlation between the pricing deviation and specialness. Thus, the violation of the law of one price may be consistent with the absence of arbitrage opportunities in the market. Indeed, Krishnamurthy (2002) for 30-year Treasury bonds and Nashikkar (2007) for 10-year notes, demonstrate that average profits on convergence trades are negative when repo specialness is taken into account.

Nevertheless, as with liquidity, we see differences between specialness and price premia which suggest that equilibrium pricing is more complex than simply being the sum of expected future specialness and the (intrinsic) value of the security's cash flows. This becomes even more evident when we consider off-the-run notes. We see many cases where notes are trading on special in the repo market, with minimal and even negative pricing deviations, as well as notes with large positive pricing deviations that are not trading on special. Virtually all of the existing analysis that links specialness with price premia comes from GovPx data preceding the move to electronic networks, and looks at the specialness of the on-the-run securities. Jordan and Jordan (1997), for example look at all Treasury notes in the period

September 16, 1991 through December 31 1992, and find that 64% of specialness cases are for on-the-run notes. For 10-year notes, this ratio was 82%. In our study, we find that only 23% of the securities trading on special in the repo market are on-the-run.

We find that being deliverable against the 10-year note futures contract is valuable as well. The entire set of non-deliverable notes is on average fairly priced relative to the STRIPS. While the on-the-run premium has declined, the deliverability premium has increased in recent years–concurrent with an exponential growth in open interest in the futures markets (which now dwarfs the size of the cash market).[8] These findings provide a link between the conditions in the futures market to conditions in the spot market. A natural explanation for a delivery premium is that it reflects the risk of a supply squeeze –especially in light of the relative sizes of the futures and spot markets. However, over the entire period, there is no indication of any (ex-post) effective squeezes. Nevertheless, the storied case of the June 2005 contract gave rise to a large and persistent pricing deviation in the cheapest-to-deliver security (CTD, hereafter), the February 2012 note. We explore this episode in detail below since it allows us to evaluate the linkages between liquidity, price premia, and specialness.[9]

The paper proceeds as follows. Section I provides an institutional backdrop of the U.S. Treasury note and futures markets. Section II describes the data. Section III is the core of the paper and presents the empirical analysis in five parts. We: 1) Characterize the deviations between the note prices from those of the STRIPS-implied values. 2) Examine the specialness of all notes. 3) Conduct regressions to isolate causes of the pricing deviations. 4) Explore the principal components structure of the pricing deviations, and conduct formal inference on this structure using a posterior simulator. 5) Examine two case studies: the high levels of delivery fails in the summer and fall of 2003; and the storied squeeze related to the futures markets in the summer of 2005. Section IV concludes the paper.

I. Institutional Background

For the most part, the United States Treasury conducts an auction of 10-year (coupon-

[8] In June, 2007, the open interest in 10-year Treasury note futures was 2,954,456 contracts. Each contract is for $100,000 in Treasury notes: almost $300 billion in face value of futures contracts compared to 10-year note issue sizes of $18 billion, on average.

[9] Merrick, Naik, and Yadav (2005) examine the behavior of Gilts in London around the expiration of the March 1998 Long Gilt futures contract. The Bank of England intervened on February 23, 1998, by offering to lend the CTD (9% Gilt of 2008) in the repo market at a rate of 0%–diffusing the squeeze. Merrick, Naik, and Yadav estimate that the possibility of a squeeze affected the price of the CTD Gilt by 1% in late January, 1998.

bearing) notes every three months: in 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.[10] 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 to trade on-the-run until the next auction. The richness in price is consistent with the absence of arbitrage in the market, since the most recently auctioned security also tends to trade on special in the repo market. Dealers finance the purchase of notes by selling and agreeing to repurchase them for a fixed price at a future date. Fleming and Rosenberg (2008) show that dealer inventories of Treasury coupon issues tend to rise following issuance. On average however dealers tend to hold short positions in these securities–and these short positions have increased steadily between 2001 and 2006. From Fleming and Rosenberg's Figure 2B, it appears that these short positions are hedged by long positions in the futures market.

In early 1985, the United States Treasury introduced its STRIPS (Separate Trading of Registered Interest and Principal of Securities) program. This effectively transforms each of the separate payments promised by the note into a unique traded security. Bennett, Garbade, and Kambhu (2000) provide a complete description of STRIPS. Jordan, Jordan, and Kuipers (1998) find that for a portfolio of long-term, noncallable strippable bonds, a replicating STRIPS portfolio undervalues the bonds by 17 cents, on average. The mispricing is more pronounced for discount bonds. Their sample includes daily prices for the period 1990-1994. Jordan, Jordan, and Kuipers attribute this mispricing to a tax hypothesis posited by Jordan, Jordan, and Jorgensen (1995). The tax distinction is that as discount securities, the accretion to principal is taxed as interest income on a STRIPS. Of course the coupon interest payments on the underlying bond are also taxed so that the advantage for the note increases as the note sells at a deeper discount. By a similar argument, notes selling at a premium have a tax disadvantage relative to the STRIPS.

The Federal Reserve plays an important role in the repo market for US Treasury securities. The Fed started lending securities from its System Open Market Account (SOMA) in 1969. It started the current daily afternoon auction format on April 26, 1999. Dealers may bid on any Treasury securities at this auction. The Fed uses a multiple-price auction and the

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

loans are overnight in term. The bid corresponds to the specialness of the security (since this is not a repo market). The Fed imposes a minimum bid rate in an attempt to limit this program to securities trading on special in the repo market. This auction is late in the money market trading day. Primary dealers submit bids in increments of $1 million, via FedTrade (the Fed's electronic auction system). Bids are accepted until 12:15. The minimum bid rate was originally set at 150 basis points, was lowered to 100 bps on September 18, 2001, and to 75 bps on June 25, 2003. This rate was increased to 100 bps on July 1, 2004, and reduced to 50 bps on August 21, 2007, where it remained until the end of our sample.[11] The available supply comprised 45% of SOMA holdings (on a security-by-security basis) in 1999. This was raised to 65% on May 15, 2002, and to 90% on August 22, 2008. FedTrade provides this supply (called the theoretical amount available) to the primary dealers. In the event of a delivery fail, the Fed charges a penalty fee equal to the general collateral rate in addition to the lending fee. A Fed study published in February 2008, reports that the average daily awards over the period April 1999 through December 2007 were $2.1 billion. This had grown to $4.7 billion in 2007. Daily awards spiked to over $25 billion in September and October, 2008, and averaged about $7 billion for the first half of 2009. Fleming and Garbade (2007) provide a detailed description of this program.[12] Since the Fed does not want settlement to affect the monetary base (or reserves), borrowers are required to deliver collateral in the form of US Treasury securities (not cash) on the loan date.

The futures market in 10-year Treasury notes is very large and active. These contracts trade on the (old Chicago Board of Trade (CBOT), now part of the) CME Group. Contracts expire on a quarterly cycle: in 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 intraday version of the end-of-month option. The CME Group uses a standardization procedure that attempts to place all of the notes on a common footing. This is done with a conversion factor that, roughly

[11] This rate has since been lowered: to 10 bps on October 27, 2008, and to 1 bp on December 18, 2008. It was raised to 5 bps on April 7, 2009.

[12] On March 11, 2008 the Fed joined with other central banks in a unified effort to mitigate problems in the financial markets that stemmed from the credit crisis. In particular they started a Term Security Lending Facility wherein it auctions up to $200 billion of US Treasury securities to primary dealers for a 28-day term. These auctions are held on a weekly basis. On July 9, 2009, the Fed expanded the securities lending program to include direct obligations of Fannie Mae, Freddie Mac, and Ginnie Mae.

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.[13] The CBOT changed the notional yield from 8 to 6% starting with the March 2000 contract (which were first listed in April 1999). The relationship between market yields and the notional yield affects the CTD note. The CBOT made this change 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 (See Nordstrom (1999) and Burghardt, Belton, Lane and Papa (2005)).

II. Data

We tap multiple sources to obtain our data for this study. We get daily yields and prices on the 10-year and 7-year notes from Bloomberg.[14] Bloomberg provides bid, ask, and quote mid-point yields, as well as bid, ask, quote mid-point, low, high, open, and last prices. STRIPS market participants with whom we spoke suggest that bid quotes on STRIPS are reliable, whereas ask quotes have less economic meaning. In light of this, all of our analysis uses bid quotes from Bloomberg. Jordan, Jordan, and Kuipers (2000) also use only bid quotes, and describe the importance of using the correct settlement procedure (to compute accrued interest). Our sample starts on June 3, 1991 and ends on June 27, 2008. As noted above, much of our analysis of the 10-year Treasury note benchmarks its market price to a measure of its intrinsic value. To this end, we collect daily (generic) coupon STRIPS (bid) yields and bid quotes from Bloomberg. The availability of data on STRIPS constrains our time frame: our pricing analysis covers the period May 15, 1997 through June 27, 2008. In cases of missing STRIPS quotes from Bloomberg (usually a few days prior to the maturity of the STRIPS), we search for the data using the *Wall Street Journal* archives.

Detailed information from each of the auctions of the 10-year notes in our price deviation and specialness sample is presented in Appendix A. Ten-year Treasury notes were among the last issues to switch to a uniform price auction format in 1998. From 1997 through 2002 the cycle was characterized by many re-openings of three month old on-the-run notes. In these cases, the note is on-the-run for six months. Starting in August, 2003 through the

[13]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 (2005), p. 430 for the accuracy of this approximation.

[14]The U.S. Treasury discontinued auctioning 7-year notes in April, 1993. It reinstated these auctions on a monthly basis in February 2009.

end of our sample, the standard protocol includes a re-opening one month after issuance. In these cases, the note is on-the-run for three months.[15]

Table 1, Panel A provides descriptive statistics about our sample of Treasury notes with available pricing deviations. There are 69 distinct 10-year notes, with 36 re-openings. The oldest note in our sample was issued in August, 1987 and the latest one in May, 2008. Panel B presents descriptive statistics for our auction data: bid-to-cover ratio, percentage of issuance awarded to broker/dealers, percentage of issuance awarded to foreigners, original auction size, and reopening auction size. We divide the sample into pre- and post-2003 sub-periods. The number of auctions in the post-2003 sub-period is substantially larger as during most of this period the Treasury reopened every auction after one month. The original auction size is also larger, averaging approximately $17 billion compared to $14 billion for the pre-2003 era. Reopening auctions tend to be smaller than the original auction, averaging about $11 billion and $9 billion for the pre- and post-2003 period, respectively.

Our data on repo and lending rates come from various sources. Daily general collateral rates are obtained from Bloomberg (ask, low, high, open, and last rates). These are repo and reverse repo rates for overnight, 1-, 2-, and 3-week, and 1-, 2-, and 3-month terms. This sample runs from May 15, 1997 until June 27, 2008. For our analysis we employ the last rate. Wells Fargo, Inc. has also provided us with daily special financing rates on the on-the-run 10-year Treasury notes for the period January 2, 2004 to August 27, 2007 (low, high, open, close, and average rates). Furthermore, we utilize data on overnight lending rates for specific Treasury notes obtained from the Federal Reserve's Securities Lending program.

Table 1.C presents summary statistics for the special repo rates from Wells Fargo, as well as the corresponding data from the Federal Reserve. The small spread observed between the reverse repo and the repo rates serves as the compensation to a dealer for creating a matched book (borrowing a security in a reverse repo transaction and lending it out using a repo transaction). The specials sample from Wells Fargo covers 16 on-the-run 10-year Treasury notes (914 days). In this sample the average 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. These repo markets exhibit wide variation within the day.

[15]The current format started in November, 2008. Now the Treasury auctions 10-year notes on the February, May, August, November quarterly cycle, and re-opens the on-the-run note in each of the two months following its inception. The change in the auction format is revealed to market participants through public announcements usually about a quarter prior to the change.

The average daily spread between the high and low specialness across the 914 days is 114 basis points. The maximum spread is 510 basis points. Since the Federal Reserve data is available over a longer horizon, and for all Treasury securities, we want to benchmark it to the Wells Fargo data, which is the type of data (reflecting conditions in the private repo market) that has been used in earlier studies of specialness; for example Jordan and Jordan (1997), Krishnamurthy (2002), and Moulton (2004). Our assumption will be that specialness is zero if the Fed does not report a lending rate for that security. For the Wells Fargo (on-the-run) sample, we see that on average the Fed lending rate is 11 basis points lower than the average rate in the repo market. If we compare the Fed lending rate to the daily closing rate in the repo market the average difference widens to 19 basis points.

A more direct comparison reveals that for 542 of the 914 days with Wells Fargo data the Federal Reserve's lending rate is zero. The average specialness in the Wells Fargo data on these days is 47 basis points. The average specialness in the private repo market on the 372 days when the Fed reports a non-zero lending rate is 153 basis points. The Fed's minimum lending rate was 75 basis points for the first 124 days of this overlap sample, 100 basis points for the next 784 days, and 50 basis points for the last 6 days. Of the 914 days, the average (close) rate reported by Wells Fargo from the private repo market is greater than the Fed's minimum lending rate 298 (297) days, or 32.6% (32.5%). There are 42 days when the Wells Fargo data report the average private repo rate to be greater than or equal to the minimum lending rate and the note is not borrowed from the Fed, in which case we infer that the specialness is zero (4.6% of the sample). There are 33 days when the closing rate reported by Wells Fargo is greater than or equal to the Fed's minimum lending rate and Fed specialness is zero (3.6% of the sample). The correlation between the average specialness from Wells Fargo and the Fed lending rate is 83.4%. The correlation between the specialness from the close of the private repo market and the Fed lending rate is 90.1%. In the sequel we use the Fed's security lending rate as a proxy for the security's specialness. This comes with the caveat that when the specialness in the private repo market is below the Fed's minimum lending rate, we are likely to treat it as zero.

The use of Federal Reserve lending rates in lieu of rates from the private repo market has several advantages. First, there is no haircut associated with the Fed's securities lending program. In the private market, the terms of a repurchase agreement include the security, the repo rate, and the haircut (or margin); (see Ewerhart and Tapking (2008) and Jonas (2000)). Studies that use the rate from this market typically do not have information on haircuts, so they assume either that the haircut is zero so that the rate reflects the all-in return to lending the security, or at least that the haircut is constant across various repurchase agreements. In fact, haircuts vary widely over time (Jonas (2000)). Another advantage of the Fed data is that it is a weighted average of lending rates in a centralized auction. As noted, there can be large variations in repo rates on a single security, across deals within a day. Thus the Fed rates should also be less noisy than data from private repo markets.

Daily data on the 10-year U.S. Treasury futures contracts is obtained from the Chicago Board Of Trade until the September 2005 contract, and for the remainder of the sample from Bloomberg. The sample period is June 3, 1991 through June 30, 2008–covering 68 contracts. The data from the CBOT consist 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 from both the auction and electronic trading platform (whence 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, ask, low, high, open, and last prices, as well as the volume and open interest.[16]

Table 1 Panel D presents statistics for the 10-year futures contracts, and Panel E provides descriptive statistics for the notes eligible for delivery into these contracts. 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 expiring contract.[17] To highlight the explosive growth in activity 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, open interest and volume post-2003 are substantially and statistically significantly larger than in the pre-2003 period. We also report the gross basis difference between the CTD and the second-CTD issue on the first business day of the delivery month. The gross basis is defined as the difference between the quoted bond price and the futures settlement price adjusted by the conversion factor, in basis points. Furthermore, we isolate and present the special case of the June 2005 contract (see Section III.E.1) which highlights the unusually high gross basis difference that led to a "squeeze" fear. Panel E indicates that in our complete sample there are 68 10-year and eight 7-year notes eligible for delivery into the

[16]Bloomberg does not provide a settlement price so we use the last price as the settlement price.

[17]To construct these figures, our series starts three months prior to the beginning of the delivery month and rolls over into the next contract on the first business day of the delivery month.

futures contract, with the first note issued in May, 1988. Finally, the number of deliverables per contract fluctuates with a median, minimum, and maximum numbers of 12, 7, and 16 notes, respectively.

Table 1 Panel F provides information about the bid-ask spreads in the note market. These are constructed from dealer quotes in the over-the-counter market, as reported in Bloomberg. We do not report the spreads for STRIPS as these are universally two basis points in yield terms (consistent with the observation that the ask quotes are not economically meaningful). Within each age grouping, we report bid-ask spreads in ¢, yield-to-maturity, and proportional (as a percentage of the spread mid-point) terms. Recall that most trade in on-the-run issues takes place in the electronic markets, nevertheless, in the OTC market quoted spreads are significantly lower for the on-the-run note than for all other notes. Of course this is one of the most liquid markets in the world, and the largest spreads are 0.06% of the price. In the over-the-counter market, we see an increase in spreads for all notes except the two most recently issued, since 2003.

Table 1 Panel G and Figure 2 provide information on the stripping activity in the 10-year note. The table also provides stripping and reconstitution activity for all Treasury coupon securities during our sample period. As in Jordan, Jorgensen, and Kuipers (2000), we document that stripping is much more prevalent for the 20- and 30-year bonds than it is for the shorter term notes. For example, over the entire period, the average stripped portion of 30-year bonds was 32% of the principal amount. The average monthly stripping activity in the 30-year bonds was over 4.5% of face value. By contrast, the average stripped portion of 10-year notes is 6.7% of face value. Further, we see that stripping activity (as a percentage of face value) has diminished since 2003. From Figure 2 it is evident that there is virtually no stripping activity in 10-year notes for the first two and a half years of their existence. In Table 1G, we see that reconstitution is also much more common for the 30-year bonds, where the monthly amount reconstituted is similar to the amount stripped–the median is about 3% per month. By contrast, the median reconstitution of 10-year notes is half that of the stripping activity. We also isolate the period August 2001 through February 2006, as during this period, the 10-year note was the longest-term nominal security being issued by the Treasury. Despite this, there is no increase in stripping activity in the 10-year note during this period.

III. Results

A. Pricing Deviations

The basis for our empirical analysis is the deviation in price between the 10-year Treasury note and its component (interest only) STRIPS, given by:

$$\Delta_{i,t} = P_{i,t} + AI_{i,t} - SIV_{i,t}$$

where $P_{i,t}$ is the bid quote (flat price) for the ith note on day t, $AI_{i,t}$ is the associated accrued interest, and $SIV_{i,t}$ is the STRIPS-Implied-Value computed from bid quotes on the replicating portfolio of fungible coupon STRIPS.[18]

Table 2 reports properties of these price deviations for different categories of notes across our sample. There are 69 individual notes on which we have a total of 85,441 (daily) observations. The average price deviation is \$0.24 on a par value of 100, (which we report as 24¢). The average on-the-run deviation is 182¢ pre-2003 and 120¢ post-2003. This drop of 62¢ is statistically significant. We number the off-the-run securities relative to the on-the-run, so the first off-the-run note was on-the-run until the issuance of the current on-the-run note, etc. Looking at the four most recently issued notes, we see that since 2003, the price premium has flattened out. It is much smaller for the on-the-run note, significantly smaller for the first off-the-run, unchanged for the second off-the-run, and significantly higher for the third off-the-run. When we consider all deliverable securities (those with remaining terms of at least 6.5 years at the expiration of the next futures contract), and exclude the four most recently issued notes, the price deviation is significantly higher post-2003 (at 49¢) than pre-2003 (36¢)–consistent with the flattening out of these deviations across the set of deliverable securities. The CTD note is benchmarked to the next-to-expire futures contract each day. The average price deviation for this note (34¢) is the same pre- and post- 2003. We also see in this table that the pricing deviations on the non-deliverable notes are very close to zero.

Finally we consider the relative pricing of fungible coupon STRIPS and principal STRIPS.

[18] We replicated all of the analysis in this paper using the last transaction price for the note, coupled with bid-ask quote mid-points for the STRIPS; and the bid-ask quote mid-points for both the note and the STRIPS. Neither of these two alternative protocols affected the qualitative results in the paper.

As noted in the introduction, Jordan, Jorgensen, and Kuipers (2000), Carayannopoulos (1995), and Daves and Ehrhardt (1993) find that the pricing deviations may not imply arbitrage–even without taking repo specialness into account– since principal STRIPS are often priced differently from fungible coupon STRIPS, and reconstituting a note requires more value in principal STRIPS than in all coupon STRIPS combined. Panel J of Table 2 reports the pricing deviations from a reconstitutable portfolio that includes the required amount of principal STRIPS. These deviations are much smaller (averaging 24¢) for recently issued notes than the deviations from replicating portfolios formed from only coupon STRIPS. Note the paucity of available principal strip prices, pre-2003, for the recently issued notes, however. We have only 25 observations, compared to the 1,455 observations on the fungible coupon STRIPS. Data availability skews the sample away from the recently issued notes in this case. This is consistent with the patterns seen in Figure 2, and discussed above–that there is almost no stripping activity in the first two years of a 10-year note's life.

Table 2 Panel K contrasts the principal strip to its time-matched fungible coupon strip, by term. As with the deviations between the notes and the fungible STRIPS, we see a flattening of these deviations post-2003, although as noted above there is a paucity of data on the principal STRIPS prior to 2003 for 10-year notes with more than eight years to maturity. There is a tension in the literature on the source of the price difference between these two types of STRIPS. Daves and Ehrhardt (1993) argue that the principal STRIPS are more valuable for two reasons. First, unlike fungible coupon STRIPS, they include a reconstitution option. Second, they are larger and therefore more liquid than coupon STRIPS. By contrast, Jordan, Jorgensen, and Kuipers (2000) refute these hypotheses by noting that for Treasury bonds, the principal STRIPS are consistently priced *lower* than companion coupon STRIPS. They document, as we do, that as the note ages, the relationship switches–coupon STRIPS' values exceed those of corresponding principal STRIPS with less than five-year terms. While overall our evidence is consistent with Jordan, Jorgensen, and Kuipers, there are some differences in the data. Jordan, Jorgensen, and Kuipers find that 64.2% of the time the price of a principal STRIPS exceeds that of its companion coupon STRIPS. In our data this occurs only 48.2% of the time. Jordan, Jorgensen, and Kuipers find that the two STRIPS' prices are equal 5.8% of the time. This occurs in 3.9% of the pairs in our sample. The average (median) difference between the principal STRIPS and matched coupon STRIPS in Jordan, Jorgensen, and Kuipers is \$0.108 (\$0.084). In our sample these statistics are \$0.116 (\$0.00).

We see in Figure 2 that virtually no principal STRIPS exist in the first two years of a note's life, whereas the documented active stripping of 30-year bonds implies a large outstanding supply of the fungible coupon STRIPS. Similarly, it is hard to make the case that principal STRIPS equal a coupon STRIPS plus an option, since the price difference is negative for bonds and 10-year notes with less than five year terms. Instead the likely explanation is that dealers post (matrix) bid quotes for the principal STRIPS that inherit the price premia of the note itself, relative to the coupon STRIPS. The non-convexities that drive a wedge between the note and the identical cash-flow portfolio of coupon STRIPS are manifest in the principal STRIPS, which allow reconstitution of the note itself. The fact that there is virtually no stripping of 10-year notes while the price deviations from coupon STRIPS are at their highest levels is consistent with this explanation.

B. Specialness

As noted above, repo specialness is like a convenience yield that the owner of the note can earn, but which is not available on the note's substitutes.[19] Table 3 reports the Federal Reserve lending rates for our sample (starting on the day that the Fed inaugurated its daily securities lending auctions). Of the 32 on-the-run notes in this sample, all trade on special for at least one day. The average specialness pre-January 1, 2003 for the on-the-run notes is 93 basis points, and 68 basis points, post-January 1, 2003. Recall that the minimum lending rate was 50 basis points, pre-2003, and subsequently raised over our post-period.

While the literature has focused on the specialness of the on-the-run note, we see that only 23% of the specials in our sample are on-the-run notes. Non-deliverable notes account for 41% of the specials. Nevertheless, as a percentage of outstanding notes, 43% of the on-the-run notes have specialness of at least the minimum lending rate compared to 4% of the non-deliverable notes. Average specialness (counting missing observations as zero) is 3 basis points for the non-deliverable notes. Furthermore, there are many cases where a note is on special but the pricing deviation from the STRIPS is negative. There are 724 cases where a note's lending rate is greater than or equal to the minimum, and that note has a negative price deviation from its underlying STRIPS. This accounts for over 16% of all notes on special in our sample. These 724 cases are across 41 notes, with average terms of 4.1 years. The note's price deviation is less than 10 basis points in 26% of all specials. In

[19] Of course this feature is not enjoyed by all note owners. The beneficial owner has to participate in a securities lending program. Individual owners in the Treasury Direct program, for example, can derive no benefits from specialness of their securities. This institutional differentiation across the security's owners could potentially create a clientele effect.

these cases, 96% of the lending rates are within five basis points of the specified minimum lending rate. We examine these cases in more detail in the next section. Across all specials in our sample, 70% are within five basis points of the specified minimum lending rate.

Despite the increase in the minimum lending rate, older notes are more likely to be on special in the post-January 2003 period. For the deliverables excluding the four most recently issued notes, 1% were on special prior to 2003, and 8% were on special post January 1, 2003. 2% of the non-deliverable notes were on special prior to 2003, while post-2003 this ratio is 6%. Over time, we see specialness flattening out in the same way as the price deviations: The differences between the on-the-run note and its predecessors are shrinking.

C. Patterns in Pricing Deviations and Specialness

1. Pricing Deviations: All Notes

Table 4, Panel A reports the results of regressions of pricing deviations from the underlying STRIPS on sets of pre-determined variables, for four different sets of notes. The first three sets use all of the days in our sample, and include all notes, all deliverable notes (i.e., all outstanding notes which are eligible to deliver against the next expiring futures contract), and all non-deliverable notes, respectively. The fourth set is constructed using only each month prior to the expiration of a futures contract. In this set, the CTD is identified each day, and that note's pricing deviation is used as the dependent variable. In the regressions reported in Table 4, we conduct inference using three alternative means of computing the variance-covariance matrix: 1) Newey-West (1987) Generalized Method of Moments (GMM) using 30 lags; 2) clustering on each note; and 3) clustering on the note and the year. We report $t-$statistics using the first method, and only report the others in cases where qualitative inference is affected.

The coefficients on the indicator variables for the four most recently issued notes are all positive and statistically significant. In general when there is a qualitative difference between the clustered and unclustered standard errors, the clustered standard errors appear more robust. For example, using the unclustered Newey-West standard errors we see a change in the sign of the coefficient on issue size for the non-deliverable sample relative to the other samples. By contrast, the clustered standard errors imply that this coefficient is statistically insignificant in all samples. The age indicator variable is negative and significant. The indicator variable for deliverability is significantly positive. The interaction between the post-2003 and on-the-run indicator variables is significantly negative.

In the third column, we estimate a specification that identifies an age indicator for all outstanding notes. As in the other specifications, the deliverability and post-2003 indicator variables are significantly positive. Price deviations decrease with age, but after exiting the set of deliverables a note's price deviations vibrate around zero. Thus the effect of age on the price deviations is non-linear.

To explore more fully the effects of the futures market on note valuation, we measure the calendar spread for each date, and the gross basis for each note, on each date. The calendar spread is the difference between the closing price of the second shortest term contract and the shortest term contract, in ¢. Defined in this manner it is usually negative (the nearby contract being less expensive than the expiring one), although it can be positive. In general, for the CTD note, the gross basis approaches zero towards the end of the delivery month and is positive and negative prior to that. It is generally positive for all other deliverable notes. For the "all deliverable notes" and CTD samples, the calendar spread is significantly negatively related to the pricing deviation. The difference in gross basis between the CTD and second CTD has a positive and significant effect on the pricing deviation of the CTD note. These results suggest that there is a link between the futures market and the spot market that is related to the relative scarcity of the CTD note. This effect is subtle however, since the CTD indicator variable has a significantly negative coefficient. The relative availability of notes to deliver against outstanding futures contracts is also significantly negatively related to the pricing deviation for the CTD notes and all deliverables.

Table 4B compares notes' average price deviations in the last half of the delivery month to that in the latter half in the month after delivery, for notes that exit the deliverability set. Since the regression results suggest that deliverability adds value to the note relative to its underlying cash flows, we explore the immediate valuation impact of losing the deliverability feature. We use two different samples. First, all notes that age beyond deliverability (Sample 1: 33 cases) and also only the set of notes that were the CTD to the expired futures contract (Subsample 2: 27 cases). Curiously over the entire sample there is a small increase in the relative value of the notes that age beyond deliverability. Thus the relative valuation effect of deliverability is not lost immediately. As we will see in Section 3.E.1 below when we look at the June 2005 futures contract in more detail, this may be because repo settlement continues for several weeks after the futures contract expires. The fact that there is a larger relative value increase after losing deliverability for the set that includes notes that were not CTD is curious, and suggests that settlement is not the whole story here.

2. Pricing Deviations and Specialness: On-the-Run Notes

Keane (1996), Fisher (2002), Cherian, Jacquier, and Jarrow (2004), and Moulton (2004) document a pattern in the specialness of the on-the-run issue relative to the auction cycle during the early 1990s. Figures 3 through 6 show the behavior of weekly average price deviations and specialness through the auction cycle. The figures correspond to the three auction formats highlighted in Appendix A. Figure 3 reports average results for the ten auctions (five notes) which were reopened after three months–so that the notes are on-the-run for six months (subsequent to the availability of specialness data). These five notes were issued from August 1999 through February 2002. The pattern here is similar to that documented on data from the early 1990s. Price deviations tend to decline as the issue ages. Specialness tends to rise from the original issue date through the reopening. Specialness declines upon reopening, and gradually increases before the issue goes off-the-run.

Figures 4 and 5 show the patterns for all cases where the note was not reopened, and hence the note is on-the-run for three months. Figure 4 averages the three cases of this format in the pre-2003 period, and Figure 5 averages the two cases post-January 2003. In the pre-2003 period, we note the pattern seen in earlier data (e.g., Keane (1996) and Fisher (2002)) that there is no specialness for the first month of the note's life. Unlike earlier data, the price deviation remains virtually flat over the entire three-month period. Specialness tends to increase up until the point when the announcement for the auction of a new note arrives. For the two cases post-2003 (in Figure 5), the price premium remains flat over the 90-day on-the-run period.

Figure 6 averages the 19 cases where the note is reopened after one month, and is on-the-run for three months.[20] As seen in Appendix A, this is the standard format from August 2003 through June 2008. We see the same pattern as in Figure 3–that reopening reduces a note's specialness. To examine this in more detail, we consider the percentage of the public offer that is awarded to broker/dealers across all auctions. For the 26 auctions from May, 1997 through May 2003, the average of this percentage (standard error) is 78.1% (2.29%). For the 20 new auctions of 10-year notes from August, 2003 through June, 2008, the mean percent of auction awarded to broker/dealers (standard error) is 61.0% (3.87%). By contrast, over

[20]While we show 20 such cases in Appendix A, we do not include the $3\frac{7}{8}$ May 2018 in the sample used to compute the summary statistics in Figure 6 since our sample ends in June, 2008.

this same period, for the 20 re-openings of 9-year, 11-month notes, the mean (standard error) is 84.4% (2.07%). Thus, dealer note acquisition is statistically significantly higher in the reopening auctions than in the average before August, 2003, and than in the new 10-year note auctions since August, 2003. This can explain why specialness declines following the reopening auction. Specialness reflects the costs in obtaining the on-the-run note and dealers substitute notes obtained from the reopening auction for the notes acquired in the repo market. This pattern is consistent with Fleming and Rosenberg's (2008) finding that dealer inventories increase after issuances. By contrast, there is no evidence of price deviation decline around the reopening auctions. Price deviations remain fairly flat–around 120¢ over the entire 90-day on-the-run period, dropping to 103¢ three days before the next note is issued, and to 86¢ on the day that the next 10-year note is issued.

Table 5 reports regression results for the on-the-run notes' price deviations (from the STRIPS-implied value) and specialness. The dependent variable is averaged across a two-week window. We use the same three alternative methods to compute standard errors as in the Table 4 regressions, and we similarly report $t-$statistics using the first method, and only report the others in cases where qualitative inference is affected. We use two alternative measures of the auction size. The total note issuance (which adds the allocation to the Fed and other central banks to the public auction) is unambiguously significantly positively related to pricing deviations and also significantly negatively related to specialness. The amount offered to the public is also significantly negatively related to specialness, but only weakly positively related to pricing deviations. This is consistent with the notion that specialness is in part a result of relative scarcity. However, the fact that larger issues have *larger* price deviations, suggests that the forces that affect price deviations are (at least in part) distinct from (current and expected) specialness.[21]

Both price premia and specialness decline significantly after 2003. The bid-to-cover ratio from the note's auction (most recent auction in the case of a reopening), negatively affects the price deviation but does not statistically affect the note's specialness. By contrast, Jordan and Jordan (1997) found that specialness was increasing in the bid-to-cover ratio. They linked specialness to dealers' needs to cover short positions: A higher bid-to-cover ratio may imply that the issue is in scarce supply. We do not replicate their finding on specialness but

[21]Jordan and Jordan (1997) analyze daily data from September 1991 through December 1992 on 2-, 5-, and 10-year notes that traded on special. They regress the price deviation on future specialness and obtain a coefficient close to 1. They also find that being on-the-run has an incremental positive effect on a note's price premium. They infer that the on-the-run premium and the specialness-induced premium are distinct effects.

once again find the opposite effect on price deviations. Graveline and McBrady (2005) also find that the bid-to-cover ratio is either negatively or insignificantly related to specialness for 5- and 10-year on-the-run notes.[22]

The on-the-run notes' price deviations and specialness are not significantly affected by the percentage of the issue awarded to broker/dealers–either at the note level (where we average over the auctions, in the event of re-openings), or as of the latest auction. Jordan and Jordan (1997) found that repo specialness was decreasing in the percentage awarded to broker/dealers. This supported their contention that specialness for on-the-run issues is driven by dealers' excess needs to cover short exposures–much of which are created during the when-issued trading prior to the auction. According to this hypothesis dealers' inability to cover this exposure from the auction leads to heightened pressure in the repo markets. We find no evidence in support of this hypothesis in our sample.

There is no link between an on-the-run note's specialness and the percentage of the note that was awarded to foreigners at the auction. The price premium is (weakly) increasing in this aspect of the note–and only when averaged over multiple auctions for each note. The yield difference variable is meant to pick up a lock-in effect. If rates rise after the auction, some note owners may be unwilling to sell the note and realize a loss. Some market professionals have suggested that this lock-in effect may be due to foreign accounting rules–which create a loss constraint. We see that the lock-in effect exists in both price deviations and specialness, but that the effect is reduced by foreigners. So when we interact the percent awarded to foreigners with the rate change the effect itself becomes much more prominent, and we see that this interaction term has a negative coefficient.

As we saw in Figures 3–6, the price premium declines as the note ages through its on-the-run term. Similarly, the note's specialness increases over this term. After a reopening, notes tend to have higher price premia and lower specialness, although the specialness effect is much more robust statistically. Price deviations are not statistically different for notes that will be reopened in the future. In marked contrast, such notes do have statistically higher specialness. This interesting contrast might result if dealers are more aggressive in shorting notes that will be reopened–expecting to cover the positions at the auction (recall that on average, over 84% of the re-opening auctioned securities are allocated to dealers). Furthermore because this excess demand for (loanable) securities will likely be relieved by

[22]Graveline and McBrady (2005) use this result to infer that specialness is largely the result of demand to short–as opposed to heightened liquidity.

the re-opening auction, there is no price impact.

The price deviation regressions in Table 5 have adjusted R^2 values of over 50%, while these values in the specialness regressions average 28%. This suggests that our ability to explain the variation in price deviations is much higher than our ability to account for the variation in specialness, using pre-determined variables that characterize the auction structure and results. This is further evidence that the two phenomena are not isomorphic.

3. Specialness with Low and Negative Price Deviations

As discussed above, we see many cases where repo specialness and price premia are disentangled. There are 1,147 cases where a note is (specially) borrowed from the Fed, and where the price deviation is less than 10¢. The average price deviation in these cases is -5.9¢, the average lending rate is 96 basis points, and the average spread over the Fed's minimum lending rate is 1 basis point. Only 237 of these cases occur prior to January 1, 2003, so 79% of them occur after January 1, 2003. The mean spread over the minimum lending rate prior to 2003 is 1.3 basis point, and this is 0.9 basis points after January 1, 2003.

Amongst the notes that trade on special with price deviations less than 10¢ the maximum spread over the minimum lending rate is 255 basis points–for the 4%, November 15, 2012 note on June 21, 2007 (at which point the minimum lending rate was 1%, so the specialness was 3.55%). This note's price deviation was 2.3¢ on this date. This note is on special 41 times with a price deviation less than 10¢ between August 2, 2006 and March 17, 2008. There were no outstanding loans of this security on June 19, 2007, and it had not been borrowed from the Fed since May 21, 2007. On June 19, 2007, the Fed received and accepted (all) bids for $112 million of this note, at a weighted average rate of 1.22%. On June 20, $29 million was outstanding, and the Fed received and accepted (all) bids for $69 million at a weighted average rate of 1.609%. On June 21, there were $60 million outstanding, and the Fed received bids for $193 million, and accepted $153 million (which was the entire amount available to borrow) at the weighted average rate of 3.55%.[23] This note was not borrowed from the Fed again until July 16, 2007. This note was on-the-run from November 15, 2002 through February 18, 2003. It was on special for the entire month of January, and much of February, 2003, for an average lending rate of 1.11% (11 basis points above the minimum lending rate). Over most of this on-the-run period the Fed's loans totaled $72 million of

[23]The Fed's data on holdings, available to borrow, outstanding loans, and par submitted does not start until November, 2005.

notes.

When a non-deliverable note with a negative (or low) price deviation shows up on special at the Fed, it tends to show up for several days, as in the preceding example. As another example of this phenomenon from the beginning of the sample period, 52 of the first 60 cases of specialness reported for 10-year notes with price deviations less than 10¢, between May, 1999 and May, 2000, are for the $8\frac{7}{8}$, May 15, 2000 note. This note was borrowed from the Fed at an average rate of 1.55% every day in the two-week period April 3, 2000 through April 14, 2000–just one month prior to its maturity. The note's average price deviation over this period was -2.4¢. Similarly, the $7\frac{1}{2}$, February 15, 2005 note traded special on 32 days between November 12, 2004 and January 18, 2005–again a month prior to maturity. Over this period, the average lending rate was 1.01%–a basis point above the minimum. The maximum par accepted over this period was $854 million on November 18.

As a final case of notes with trivial or negative price deviations and specialness, consider the $5\frac{3}{4}$ of August 15, 2010, which shows up in this set 64 times, starting on June 20, 2003.[24] For these 64 cases when the note is on special and has a pricing deviation less than 10¢, its average price deviation is -35.7¢. The average lending rate is 94 basis points, or 0.9 basis points above the minimum lending rate. This note was reopened in November, 2000. It traded at high lending rates in December, 2000 and January, 2001, before going off-the-run. On January 26, 2001, its lending rate was 5.31%, and there were $1,135.5 million bids accepted by the Fed. This note first appears in the special and low price deviation set on June 20, 2003. After which its appearance on this list is sporadic, although it trades on special every day for the three weeks between March 16, 2005 and March 31, 2005, during which time its average price deviation was -53.6¢. Over this period, the average special rate was 101.4 basis points, (and the minimum rate was 100 basis points). After March 31, 2005, it does not go on special until May 12, 2005. This note also trades on special every day between May 31, 2005 and June 8, 2005. Over this period, the average price deviation was -61.9¢.

Once again, these cases demonstrate a distinction between the origins of specialness and price deviation. Ten-year notes that are more than four years old are not excessively liquid, and have no demand that can be linked to the futures market. Nevertheless there are non-trivial times when dealers are willing to pay a premium (in the securities lending market) for

[24]This note also is on special on January 29, 2003, (two and one-half years since its origination), when its price deviation is 40.3¢.

these notes–in many cases for stretches of time. This is evidence that the supply of loanable securities is not perfectly elastic, yet we do not observe any upward pressure on prices in this case. Perhaps this is because in these cases, the heightened demand for loanable securities is not predictable.

D. Principal Components Analysis

As described above, on each date in our sample, we arrange the outstanding notes in order from newest to oldest. We construct the variance-covariance matrix of the daily pricing deviations for the newest 31 notes in order to examine the commonality of the pricing deviations using principal components analysis. Since we are interested in statistically meaningful comparisons of aspects of the principal components, we use a posterior simulator as follows. We impose a prior that the deviations are normally distributed with mean vector μ and variance-covariance matrix Σ, and that Σ is of full rank. We use the Gibbs sampler to draw sequentially from μ and Σ:

$$\mu|\Sigma \sim N(\bar{x}\,,\, K^{-1}\bar{\Sigma}) \tag{1}$$

$$\Sigma|\mu \sim IG(\hat{\Sigma}\,,\, K) \tag{2}$$

Here K is the symmetric matrix that contains the number of observations available in the sample to compute each element of the variance-covariance matrix: $K_{i,j}$ is the sample size used to compute the covariance between notes i and j. $\hat{\Sigma}$ is the maximum likelihood estimator of Σ (which is conditional on μ). $\bar{x}$ is the sample mean. IG refers to the inverse gamma distribution. For each draw in the conditional posterior of Σ we evaluate the eigenvalues and eigenvectors. This produces a set of 100,000 realizations of these values–comprising the marginal posteriors.

Table 6 provides distributional properties of the percentages explained by the first six eigenvalues for the periods: May 1997 – December 2002; January 2003 – June 2008; and January 2005 – June 2008. In the first period the first eigenvalue accounts for an average 53% of the total variation in the price deviations across the 31 notes. The 95%ile range for this value is $[51\%, 54\%]$. The relative importance of the first common factor is higher in the post January 2003 period, with a mean explanatory power of 65%. This is statistically significantly higher than in the pre-2003 period. The first component's relative importance is even higher in the post-January 2005 period–the mean explained percentage is 80% in this period.

Thus, the market for 10-year notes has less idiosyncratic variation in 2003-2008 period than in the 1997-2002 period. Figure 7 provides information that may explain this reduced segmentation. As noted above, trading in both the (on-the-run) notes and the futures contracts was switching to electronic networks around this time. The exponential increase in volume and open interest in the futures market cannot be explained by hedging demand resulting from mortgage originations (contrast the trend in the futures market, Figure 7 showing the evolution of open interest and volume, with the leveling off and drop in mortgage originations in 2007-2008, from Figure 8). It is likely due to hedge funds attempting to profit from idiosyncratic price movement in the complex (Krishnamurthy (2002) provides the example of Long Term Capital Management pursuing a strategy to short on-the-run securities).[25]

Figures 9 - 11 show properties of the posterior of the eigenvectors (or factor loadings) for the first three eigenvalues, respectively, on all 31 notes, in the pre- and post-January 2003 periods. These plots show the median (the bar inside the box), interquartile range (R) (the box) and 95% confidence interval around the median (the "whiskers"). This non-parametric confidence interval is: $+/-1.58 \times \frac{R}{\sqrt{K_{i,j}}}$, (see e.g., McGill, Tukey, and Larsen (1978)).

It is clear from Figure 9 that the first principal component, which explains over 80% of the total variation in all notes' price deviations post January 2005, is an aging factor, in both periods. A note's sensitivity to this factor tends to decline with age. In the first sub-period, the loadings on the first two notes are statistically indistinguishable, around 0.48. These two loadings are statistically higher than the loading on the third note. In the latter sub-period, the decline with age is smoother. The loading on each of the second through fifth notes is statistically indistinguishable from the loading on that note's successor. The range of loadings is also lower in this later sub-period. The loadings on Notes $7-31$ are similar across the two sub-periods, although there is a discernible grouping of Notes 7–17, all with mean loadings around .18, in the later sub-period. In both sub-periods the four oldest bonds in this analysis have loadings on this component close to zero.

From Figure 10, we see that in both sub-periods the second component differentiates the

[25] In Figure 8 we also explore the bank participation in these contracts but do not find a similar trend as observed in the futures markets.

newest notes from notes that are "middle-aged," but loads close to zero on the oldest notes. In the first sub-period, this factor differentiates the on-the-run and the first- and second-off-the-run notes from Notes 12–20, those with 7 - 3 year terms. In the second sub-period, where the spread on the loadings is wider (ranging from -.4 to .45), this factor differentiates the four newest notes from Notes 8–13–this latter group roughly corresponding to the oldest deliverable notes. In both sub-periods this factor accounts for $12-13\%$ of the total variation in the 31 notes.

The third factor explains 6% of the total (co-)variation in the 31 notes in the first sub-period and 5% in the latter sub-period. From Figure 11, we see that in both periods this factor differentiates recently off-the-run notes (aged from one - three years) from middle-aged notes (aged from three - five years). In the first sub-period, the on-the-run note loads on this factor positively–like Notes 11 and 18. In the second sub-period the most recently issued and the oldest notes do not load on this factor.

From a statistical perspective we see that the precision of the loadings tends to be higher in the second sub-period than in the first. As notes age their loadings approach zero and are estimated more precisely on all three factors.

Most of the variation in the price deviations across all notes is related to the on-the-run premium, suggesting that this premium is not an idiosyncratic phenomenon of a single note. Whatever moves this up and down over time affects all outstanding notes in a similar, albeit reduced manner. With the exception of the third factor in the first sub-period, the three major factors do not differentiate the first note (i.e., the on-the-run) from its three immediate predecessors.[26]

[26] An implication of this result is that using the spread between the on-the-run note and its neighbor(s) will tend to understate both the level and scale of the on-the-run premium.

E. Two Case Studies

1. The June 2005 "Squeeze"

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 the CTD against the June, 2005 futures contract. For this contract, the cost of delivering the second CTD was much higher than this note (see Table 1.D). 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*.[27] 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).

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. The article implies that 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

[27] "Hedge Funds Role Dents Market Theory," by Mark Whitehouse and Gregory Zuckerman, August 18, 2005.

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 12 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 68¢ 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 13 and Table 7 show the total deliveries against the 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 (the same February 15, 2012 note) were delivered. However the proportional deliveries in September (87%), and December (65%), 2006 all exceeded the June 2005 level. After the June 2005 episode, the CBOT imposed a limit that long positions cannot request delivery of more than 10% of the outstanding note.[28]

This episode clearly differentiates the price deviation and specialness on the one hand from liquidity on the other. This note is almost 3 1/2 years old, and its potential shortage can hardly be linked to heightened liquidity. However, in this case, the positive price deviations and specialness do move together. Appendix B looks at futures contract rollovers and deliveries in more detail. By benchmarking this June 2005 episode, we note that the

[28]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.

most unusual feature was the high calendar spread. While this does give rise to increased deliveries, the actual deliveries were still unusually high.

2. Summer and Fall 2003 Delivery Fails

Fleming and Garbade (2004) discuss the unusually high level of delivery fails on the May 15, 2013 $3\frac{5}{8}$ note in the second half of 2003. The Treasury issued \$18.25 billion of this note on May 15, 2003. Figure 14 shows the price deviations and specialness for this note for the 164 business days from its issuance until the end of 2003. The average price deviation over this period is 190¢, and the average lending rate is 89 basis points. For the 65 days that this note was on-the-run, the average price deviation is 165¢ and the average Fed lending rate is 76 basis points. So, both the specialness and price deviations for this note are higher in the 99 days *after* it went off-the-run than while it was on-the-run.

To put this episode in context, Figure 8 shows mortgage originations reaching record high levels of \$1.2 trillion in the second and third quarters of 2003. Thirty year fixed rate mortgages are typically priced relative to 10-year Treasuries, so there was unusually heavy short selling of the May 2013 note for hedging purposes. Since the Treasury never reopened the May 2013 issue this led to a chain of delivery fails that took months to unravel. The maximum price deviation is 256¢ on November 11. The maximum Fed lending rate is 252 basis points on September 29.

Once again, in this episode the increased price deviation and specialness do move together, yet this cannot be attributed to increased liquidity.

IV. Conclusions

We find three important features in the manner by which 10-year US Treasury note prices deviate from the value of their underlying cash flows (measured using fungible coupon STRIPS) over the period May 1997 through June 2008. In a frictionless market, these values would always be zero, and in a market with trivial frictions, they would vibrate randomly around zero. Indeed, these price deviations on non-deliverable notes–those with less than 6.5 years to maturity–do tend to fluctuate around zero, and have a standard deviation of 24¢ (about 8 basis points in yield terms on a 3% par note with 3.5 years until maturity). This pattern means that the different tax treatment of notes and STRIPS (described in

Jordan, Jordan, and Jorgensen (1995) and Jordan, Jordan, and Kuipers (2000)) does not cause the price discrepancies in our sample.

Principal components analysis of the price deviations reveals that the market is becoming less segmented in recent years. We show that the proportion of the total variation across the price deviations in all outstanding Treasury securities that is explained by the first principal component increased from 53% pre-2003 to 65% post-January 2003, to 80% post-January 2005; the small sample standard deviations of these percentages are all around 1%. The first factor is age-related, and it shows that in terms of pricing, there is nothing special about the on-the-run note. The on-the-run premium is not an idiosyncratic feature of the most recently auctioned note. Its value–relative to underlying cash flow–moves together with its four immediate predecessors since 2003. This flattening of the on-the-run price premia is consistent with the growth in convergence trades by hedge funds over the period. The second factor separates the four youngest notes from the oldest deliverable notes. Here we also see the idiosyncratic behavior of the on-the-run note greatly diminished in the period post-2002.

These patterns have important implications for measuring the on-the-run premium. For example, if we measure the on-the-run premium by benchmarking the on-the-run security to one of its predecessors, we will generally understate the premium. Also, such a procedure will overstate the decline in the premium over time.

Despite the fact that the distinction in liquidity between the on-the-run note and older notes has increased with the proliferation of electronic trading in the former, the *relative* pricing deviations between the on-the-run note and its predecessors has shrunk. This casts doubt on the notion that the on-the-run price premium is solely the result of this note being more liquid than older notes. The behavior of the May 2013 note throughout the second half of 2003 also demonstrates that the price premia for recently-issued notes is not (solely) a liquidity premium. After this note went off-the-run, it became difficult to find and delivery fails proliferated–manifestations of funding illiquidity. At the same time, the note's price deviation and specialness increased above their on-the-run levels.

Although our data on specialness is not as rich as our pricing data, the patterns in prices are also reflected in specialness. The average daily specialness of the on-the-run note declines from 93 to 68 basis points after 2003. By contrast (and consistent with the price deviations pattern), the specialness of the third (fourth) newest note increases from 5 (3) to 10 (9) basis points. Specialness, like relative price deviations, is flattening out across the set of outstanding notes–with the on-the-run note is becoming less distinct from its predecessors. Our analysis suggests that present and expected future specialness are not the sole cause of price deviations from underlying cash flows. Auction size and whether an issue has been reopened have an inverse relationship with an on-the-run note's specialness but an increasing relationship with its price deviation. The bid-to-cover ratio in the note's auction has a negative impact on the note's pricing deviation, while on-the-run, but no effect on its specialness. If a note will be reopened its specialness is higher, while on-the-run, but there is no effect on its price deviations. Our simple linear specifications explain twice as much (54% vs 28%) of the variance of the price deviations from STRIPS than the variance of specialness. These two features are also differentiated in the case of the CTD around the June 2005 contract expiration. Specialness was twice as high as the then on-the-run notes, but price deviations were only half as large.

We find evidence of a lock-in effect in the price deviations and specialness, as these are both larger following run-ups in yields. Market professionals suggest that price elasticity is affected by the unwillingness of certain note owners to realize a loss. We find that this lock-up effect is not attributable to foreign investors–if anything their presence tends to mitigate it.

Despite enormous changes in trading institutions and behavior, the price premium in recently-issued notes is a remarkably robust phenomenon. We see in these notes the surprising juxtaposition of extremely liquid trading but illiquid funding. Perhaps, as with equities, where benchmarking to fundamental value is much more complex, supply inelasticities related to short selling institutions create upward pressure on prices–relative to fundamental values. If this is the case then it is important that such price pressure tends to vanish when notes are no longer deliverable against futures contracts. Thus suggests that uniqueness–which in the Treasury note market derives from non-endemic characteristics–is a necessary condition for such price pressure to exist. We also conjecture that (as in Duffie 1996), equilibrium is complicated. The evidence from non-deliverable specials suggests that for such inelasticities to exert upward pressure on prices they must be predictable. This is also consistent with the observation that specialness is higher for notes that will be re-opened, but there is no concurrent price impact (as shown in Section 2).

Appendix A. 10-Year Treasury Note Auctions in our Sample.

Issue Date	Nature of Auction	Auction Format	$ (Billion) Issued to Public	Total $ (Billion) Issue	Bid-to-Cover	% Awarded to Dealers	% Awarded to Foreigners
5/15/97	Not reopened (3-mos of OTR)*	Multiple Price	12	13.958	1.86	79.2	1.5
8/15/97	Reopened after 3 months**	Multiple Price	12	13.036	2.24	89.6	1.3
11/17/97	–reopening of previous issue	Multiple Price	11	12.601	2.44	90.7	2.4
2/17/98	Not reopened (3 mos of OTR)*	Multiple Price	12	13.583	2.49	77.8	1.3
5/15/98	Reopened after 3 months**	Multiple Price	12	14.775	2.39	47.5	0.4
8/17/98	–reopening of previous issue	Multiple Price	11	12.416	2.12	80.5	0.8
11/16/98	Reopened after 3 months**	Single Price	12	13.488	1.52	93.6	3.2
2/16/99	–reopening of previous issue	Single Price	10	11.595	2.04	77.3	3.1
	< Begin Fed Specialness data on next auction: >						
5/17/99	Not reopened (3-mos of OTR)*	Single Price	12	14.795	1.62	83.0	5.1
8/16/99	Reopened after 3 months**	Single Price	12	14.757	2.07	77.0	9.8
11/15/99	–reopening of previous issue	Single Price	10	12.643	2.48	88.5	6.3
2/15/00	Reopened after 3 months**	Single Price	10	12.278	1.45	87.1	9.3
5/15/00	–reopening of previous issue	Single Price	8	11.078	2.62	83.3	7.6
8/15/00	Reopened after 3 months**	Single Price	10	12.360	1.95	92.1	9.6
11/15/00	–reopening of previous issue	Single Price	8	10.078	2.63	97.7	8.8
2/15/01	Reopened after 3 months**	Single Price	11	11.976	2.1	80.6	9.6
5/15/01	–reopening of previous issue	Single Price	9	11.460	2.56	70.3	4.5
8/15/01	Reopened after 2 & 3 months (9/11 – related)	Single Price	11	12.046	2.85	64.0	17.4
10/05/01	–reopening of previous issue (emergency)	Single Price	6	6.000	2.36	77.5	2.9
11/15/01	–reopening of previous issue	Single Price	7	8.590	2.01	79.2	11.4
2/15/02	Reopened after 3 months**	Single Price	13	13.389	1.8	62.5	11.8
5/15/02	–reopening of previous issue	Single Price	11	11.390	2.15	72.9	5.1

Issue Date	Nature of Auction	Auction Format	$ (Billion) Issued to Public	Total $ (Billion) Issue	Bid-to-Cover	% Awarded to Dealers	% Awarded to Foreigners
8/15/02	Not reopened (3-mos of OTR)*	Single Price	18	19.648	1.29	74.2	11.1
11/15/02	Not reopened (3-mos of OTR)*	Single Price	18	18.113	1.90	74.5	11.6
2/18/03	Not reopened (3-mos of OTR)*	Single Price	18	19.498	1.85	54.8	11.9
5/15/03	Not reopened (3-mos of OTR)*	Single Price	18	18.254	1.22	75.9	8.5
8/15/03	Reopened after 1 month (3-mos of OTR)***	Single Price	18	20.521	2.00	68.7	17.4
9/15/03	–reopening of previous issue	Single Price	13	13.000	2.23	76.2	6.0
11/17/03	Reopened after 1 month (3-mos of OTR)***	Single Price	17	18.636	1.90	62.0	17.2
12/15/03	–reopening of previous issue	Single Price	12	12.001	1.78	76.5	9.9
2/17/04	Reopened after 1 month (3-mos of OTR)***	Single Price	16	17.081	2.00	54.6	28.2
3/15/04	–reopening of previous issue	Single Price	11	11.000	1.81	80.4	11.2
5/17/04	Reopened after 1 month (3-mos of OTR)***	Single Price	15	17.298	2.78	56.4	26.0
6/15/04	–reopening of previous issue	Single Price	10	10.005	2.93	61.9	30.0
8/16/04	Reopened after 1 month (3-mos of OTR)***	Single Price	14	15.721	2.90	45.3	28.3
9/15/04	–reopening of previous issue	Single Price	9	9.000	2.12	97.1	2.2
11/15/04	Reopened after 1 month (3-mos of OTR)***	Single Price	14	16.472	2.05	58.6	24.0
12/15/04	–reopening of previous issue	Single Price	9	9.000	2.68	90.3	0.7
2/15/05	Reopened after 1 month (3-mos of OTR)***	Single Price	14	15.215	2.05	72.0	18.4
3/15/05	–reopening of previous issue	Single Price	9	9.000	2.35	82.2	2.3
5/16/05	Reopened after 1 month (3-mos of OTR)***	Single Price	14	16.471	2.33	50.0	16.4
6/15/05	–reopening of previous issue	Single Price	8	8.001	2.50	89.0	7.1
8/15/05	Reopened after 1 month (3-mos of OTR)***	Single Price	13	14.473	2.59	52.8	28.0
9/15/05	–reopening of previous issue	Single Price	8	8.000	2.68	77.9	6.0
11/15/05	Reopened after 1 month (3-mos of OTR)***	Single Price	13	15.221	2.24	44.1	14.8
12/15/05	–reopening of previous issue	Single Price	8	8.000	2.19	83.1	3.2

Issue Date	Nature of Auction	Auction Format	$ (Billion) Issued to Public	Total $ (Billion) Issue	Bid-to-Cover	% Awarded to Dealers	% Awarded to Foreigners
2/15/06	Reopened after 1 month (3-mos of OTR)***	Single Price	13	13.842	2.32	57.9	23.8
3/15/06	–reopening of previous issue	Single Price	8	8.000	2.87	94.0	0.3
5/15/06	Reopened after 1 month (3-mos of OTR)***	Single Price	13	15.294	2.53	69.2	15.5
6/15/06	–reopening of previous issue	Single Price	8	8.000	2.73	85.6	5.9
8/15/06	Reopened after 1 month (3-mos of OTR)***	Single Price	13	14.557	2.23	69.1	22.4
9/15/06	–reopening of previous issue	Single Price	8	8.000	2.91	84.0	8.2
11/15/06	Reopened after 1 month (3-mos of OTR)***	Single Price	13	15.294	2.21	65.8	24.6
12/15/06	–reopening of previous issue	Single Price	8	8.000	2.48	87.2	6.7
2/15/07	Reopened after 1 month (3-mos of OTR)***	Single Price	13	14.193	2.41	69.0	23.6
3/15/07	–reopening of previous issue	Single Price	8	8.000	2.64	83.9	10.8
5/15/07	Reopened after 1 month (3-mos of OTR)***	Single Price	13	17.586	2.30	55.2	19.8
6/15/07	–reopening of previous issue	Single Price	8	8.000	2.55	91.7	5.5
8/15/07	Reopened after 1 month (3-mos of OTR)***	Single Price	13	20.000	2.30	66.7	15.5
9/17/07	–reopening of previous issue	Single Price	8	8.000	2.95	77.8	2.4
11/15/07	Reopened after 1 month (3-mos of OTR)***	Single Price	13	19.675	2.34	70.2	15.0
12/17/07	–reopening of previous issue	Single Price	8	8.000	2.23	92.0	2.2
2/15/08	Reopened after 1 month (3-mos of OTR)***	Single Price	13	19.205	2.34	62.0	21.1
3/17/08	–reopening of previous issue	Single Price	10	10.000	1.79	91.2	2.6
5/15/08	Reopened after 1 month (3-mos of OTR)***	Single Price	15	23.078	2.21	71.1	14.6
6/16/08	–reopening of previous issue	Single Price	11	11.000	2.33	86.9	4.9

Excluding re-openings, there are three cases indicated by asterisks:
* "Standard Case" The issue is never reopened. It is on-the-run for three months.
** "Old Reopened Standard" – on-the-run for six months, re-opened after three months.
*** "Newer Standard" – on-the-run for three months, but re-opened after one month. 20 cases – all since 8/15/03.
There is one emergency case relating to 9/11/01. It has aspects of both the newer standard and the old reopened standard (it was on-the-run for six months).
Percentage awarded to dealers is based on the public offer, while percentage awarded to foreigners is based on the total offer.

Appendix B. Analysis of Futures Rollover and Delivery

Table 7.D provides summary statistics for position rollovers in the 10-year Treasury note futures market. We use the method 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:

$$0 \leq r \leq min\{\frac{1}{2}(\nu' - \Delta'), \frac{1}{2}(\nu'' - \Delta'')\} \quad (3)$$

where ν' (ν'') 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 nearby to the next contract.

We saw in Table 7.B that deliveries of the CTD as a percentage of that note's availability increased almost four-fold from the pre- to the post-2003 period. Here we observe that futures position rollover as a percent of peak open interest increased (statistically significantly) from 17 to 29% over the same period. This is a consequence of the exponential growth in this market. The maximum percentage rollover (38.4%) occurred between the March and June 2007 contracts. The cumulative rollover per contract as a percentage of the peak open interest has increased from 149% to 169%, with the maximum percentage occurring at the beginning of 2003 (between the March and June 2003 contracts) coinciding with the introduction of the electronic trading platform. The June 2005 contract rollover percentages are lower than the mean values in the post-January 2003 period, but they are not outliers.

We follow Peck and Williams (1992) in modeling deliveries.[29] The independent variables include the gross basis on the first business day of the delivery month and the calendar spread on the first business day of the delivery month. Following Peck and Williams, we also include the calendar spread squared. 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.

Descriptive statistics of the calendar spread and gross basis are reported in Table 8, Panel A. Regressions results are reported in Table 8.B. Our dependent variables are the proportion of total deliverable notes outstanding that are delivered and the proportion of the delivery of the most delivered note as a function of its original issue size. While 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. The

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

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.[30]

Overall, we see that this simple model has an R^2 of 47% in explaining the ratio of deliveries to issue size of the most delivered bond. In general, this ratio–after accounting for the calendar spread– is three times larger in the post-January 2003 period than in the earlier period. The gross basis on the June 2005 contract is in line with the sample. However, the calendar spread is unusually high at \$0.39, the average in the post-January 2003 period is -\$0.71. Plugging the independent variables for the June 2005 contract into the second regression in Table 8.B, gives a predicted value of 39.9%. The actual value of this (Table 7.B) is 59.2%. Thus high level of deliveries documented in the press reports cannot be attributed to the high calendar spread at the time this contract expired.

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

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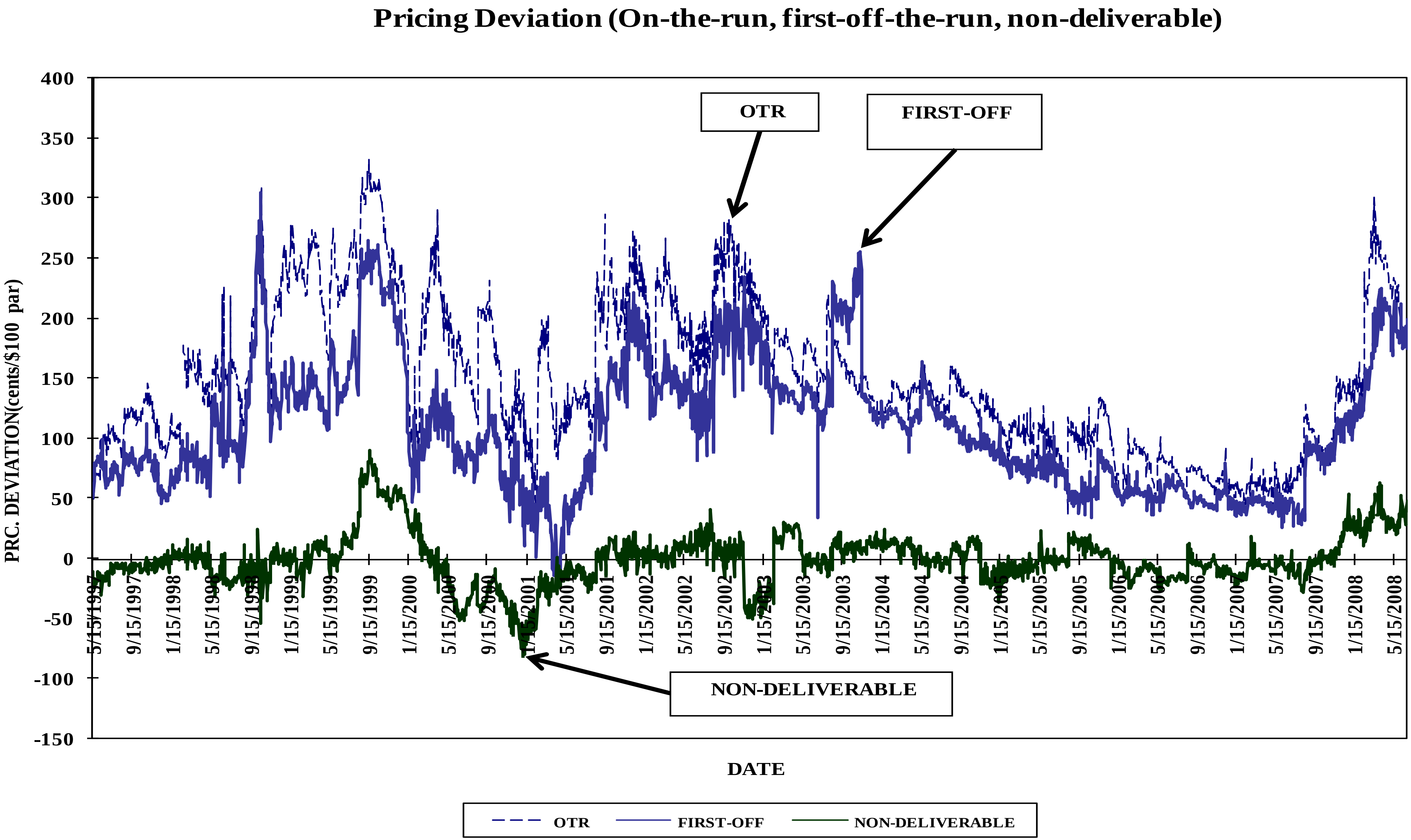

Figure 1 – This graph depicts the daily deviations between the bid quotes of the on-the-run 10-year note, the first off-the-run 10-year note, and Note 20 (a non-deliverable 10-year note with 2.66 to 5.25 years to maturity) and the notes' replicated value from bid quotes on fungible coupon STRIPS in cents per $100 par. The sample covers the period May 15, 1997 through June 27, 2008.

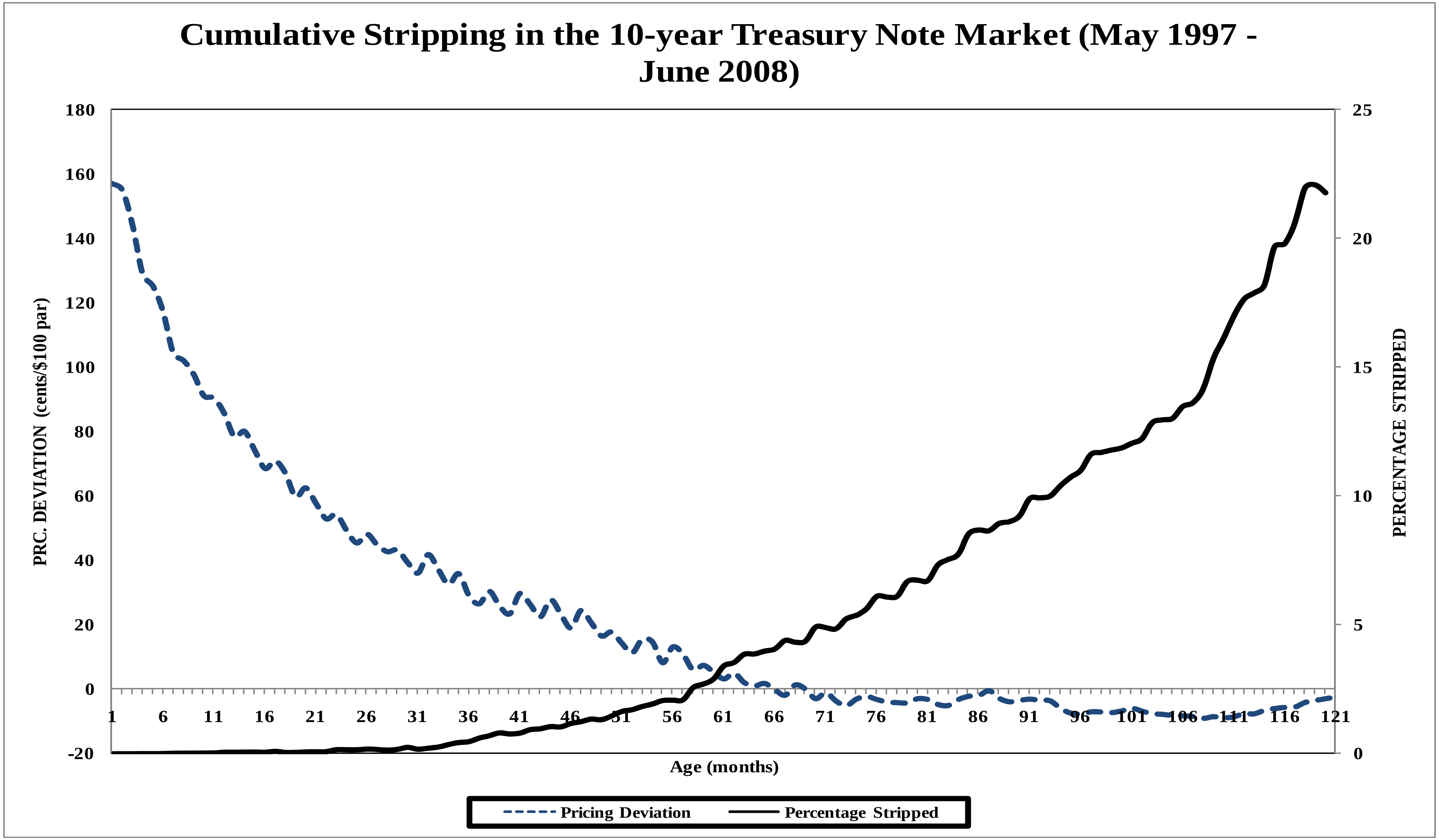

Figure 2 – This graph depicts the cumulative stripping activity as a percentage of the total issue size for the 10-year Treasury notes for the period May 1997 to June 2008 (right vertical axis). The stripping activity is measured as a function of the age of the note (in months from original issue date). The left vertical axis depicts the difference between the bid quote of the note and its replicated value from bid quotes on fungible coupon STRIPS, in cents per $100 par.

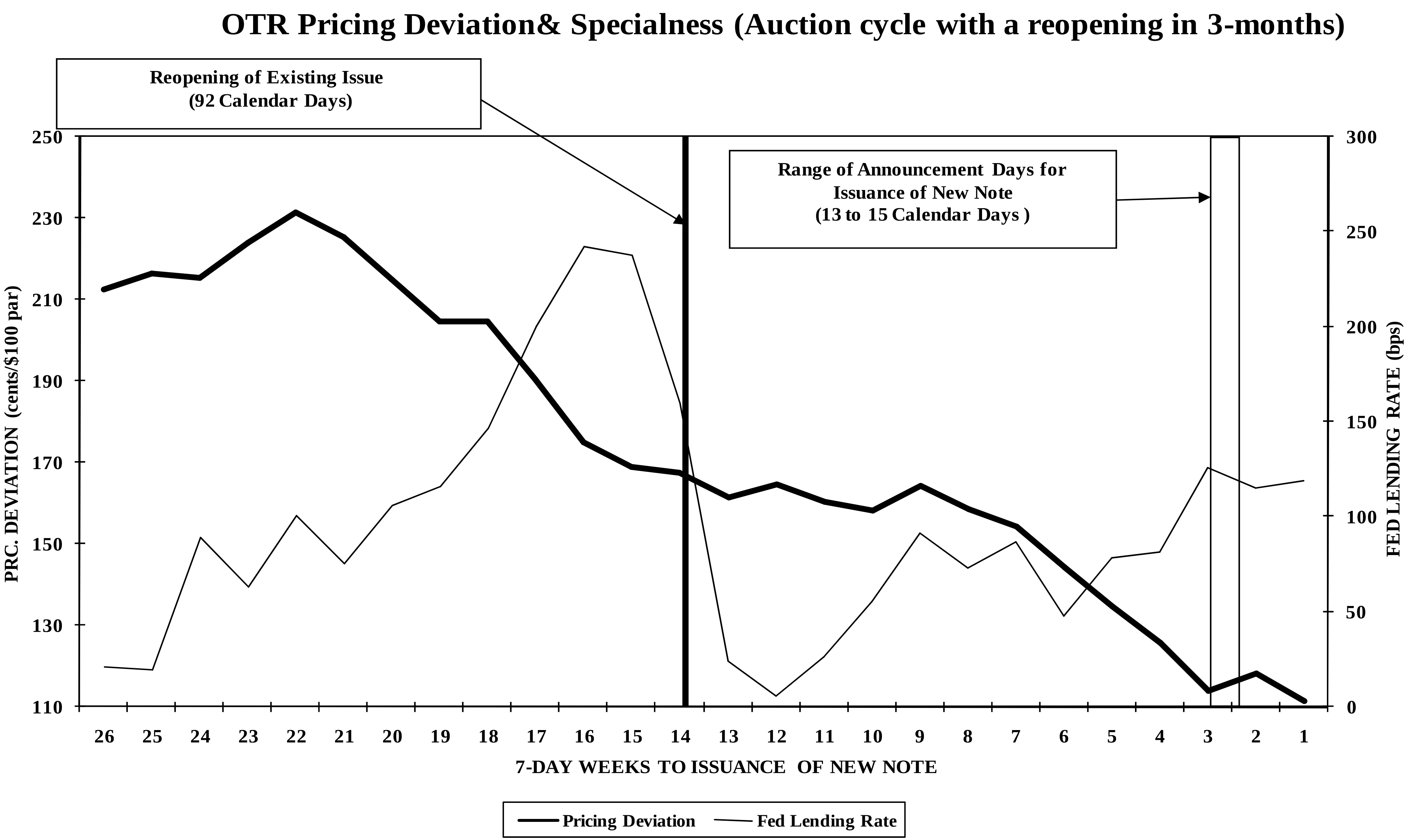

Figure 3 – This graph depicts the average deviation between the bid quote of the on-the-run 10-year note and its replicated value from bid quotes on fungible coupon STRIPS (shown on the left vertical axis), along with the Fed lending rate (specialness) (shown on the right vertical axis) for all notes from the auction cycle with a reopening after three months. There are five cases of this auction format - all in the pre-2003 period.

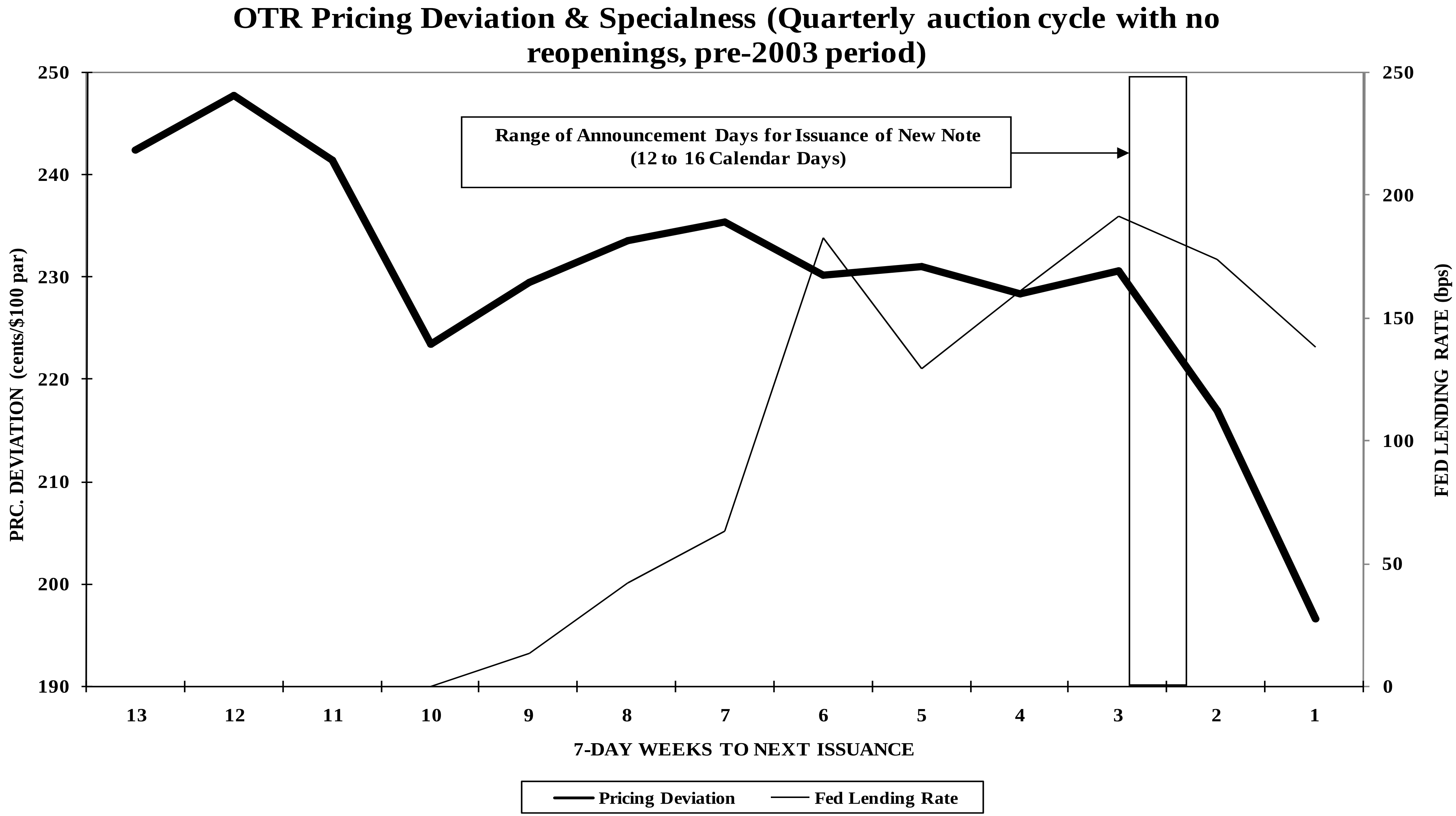

Figure 4 – This graph depicts the average deviation between the bid quote of the on-the-run 10-year note and its replicated value from bid quotes on fungible coupon STRIPS (shown on the left vertical axis), along with the Fed lending rate (specialness) (shown on the right vertical axis) for all notes from the auction cycle with no reopenings in our pre-2003 period. There are three cases of this auction format in the pre-2003 period.

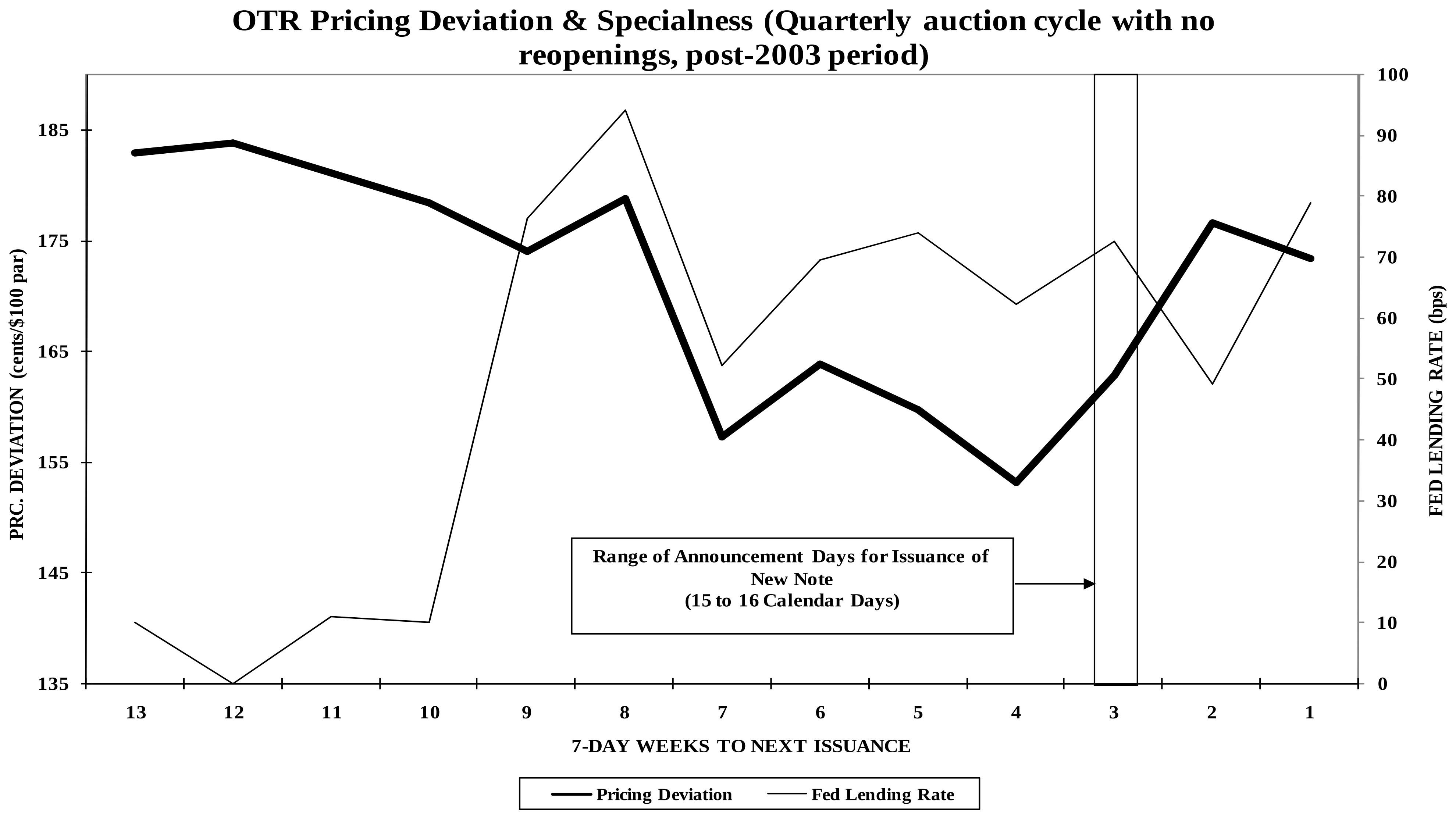

Figure 5 – This graph depicts the average deviation between the bid quote of the on-the-run 10-year note and its replicated value from bid quotes on fungible coupon STRIPS (shown on the left vertical axis), along with the Fed lending rate (specialness) (shown on the right vertical axis) for all notes from the auction cycle with no reopenings in our post-2003 period. There are two cases of this auction format in the post-2003 period.

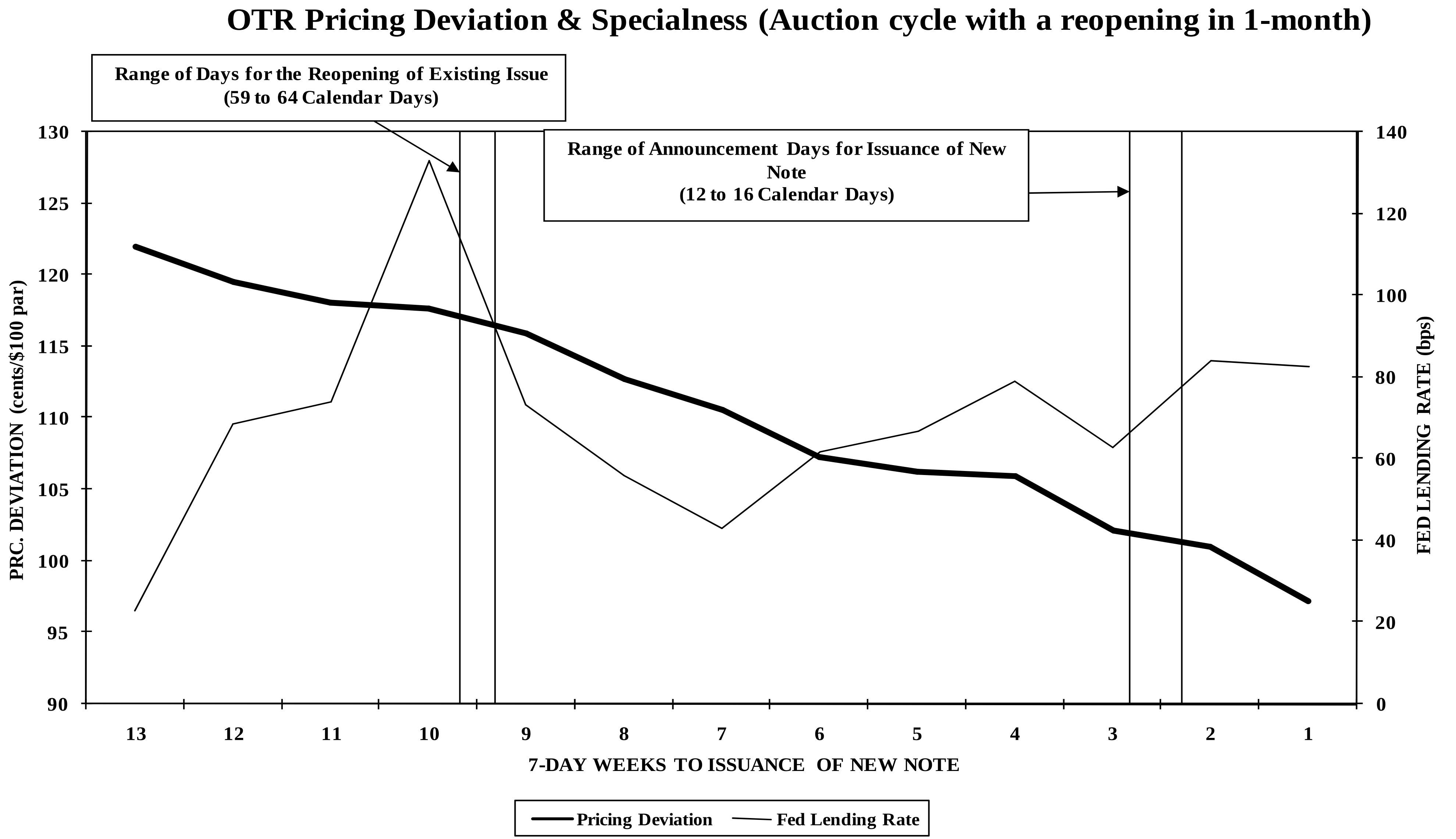

Figure 6 – This graph depicts the average deviation between the bid quote of the on-the-run 10-year note and its replicated value from bid quotes on fungible coupon STRIPS (shown on the left vertical axis), along with the Fed lending rate (specialness) (shown on the right vertical axis) for all notes from the auction cycle with a reopening in one month. There are 19 cases of this auction format - all in our post-2003 period.

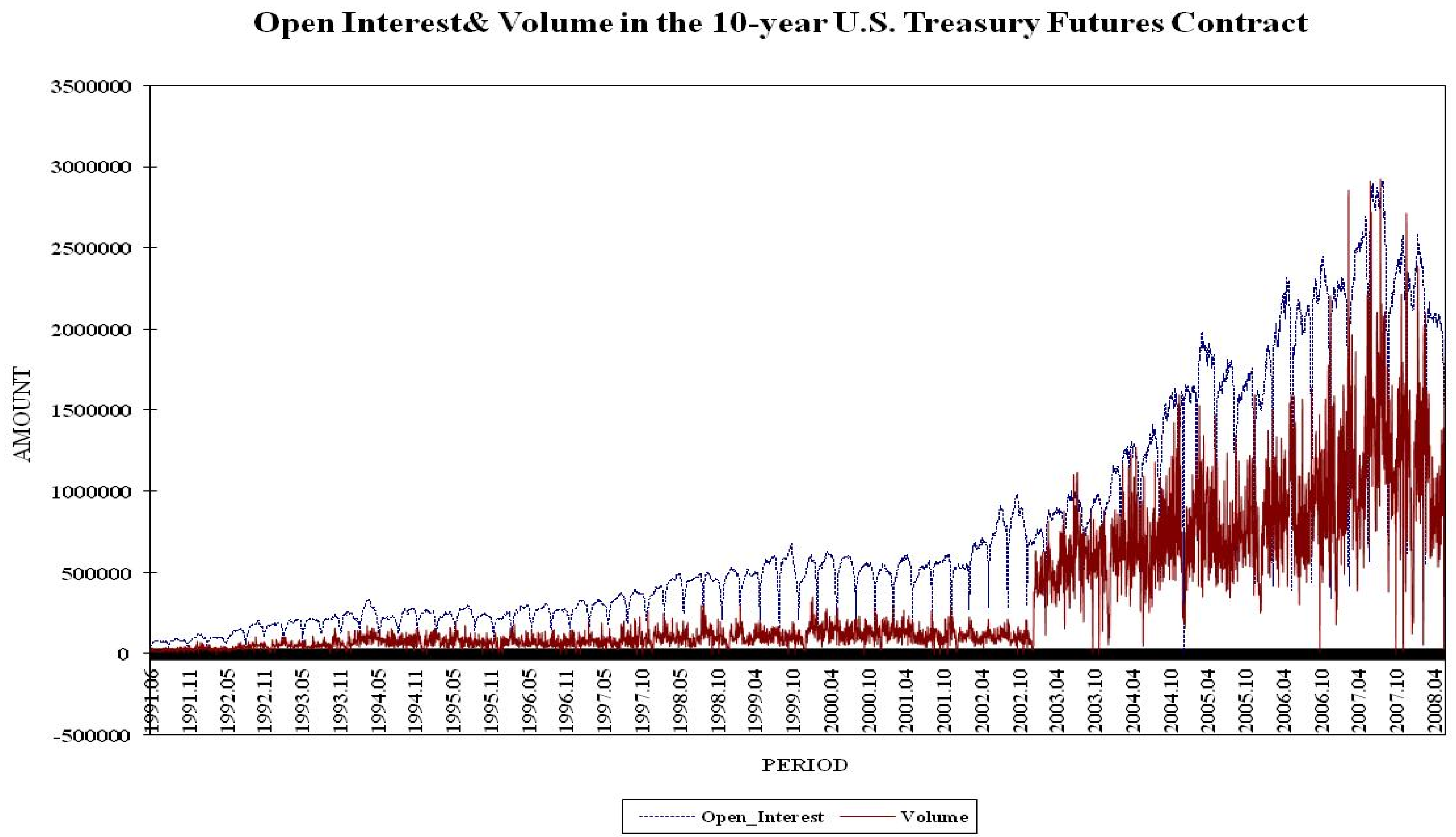

Figure 7 – This graph depicts the evolution of the open interest and volume in the 10-year U.S. Treasury futures contract. The sample covers the period June 3, 1991 - May 30, 2008. Our sample includes each futures contract in the three months prior its delivery month, and then rolls over into the next contract. Our data sources are the CME Group through the June 2005 contract, and Bloomberg Services for subsequent contracts.

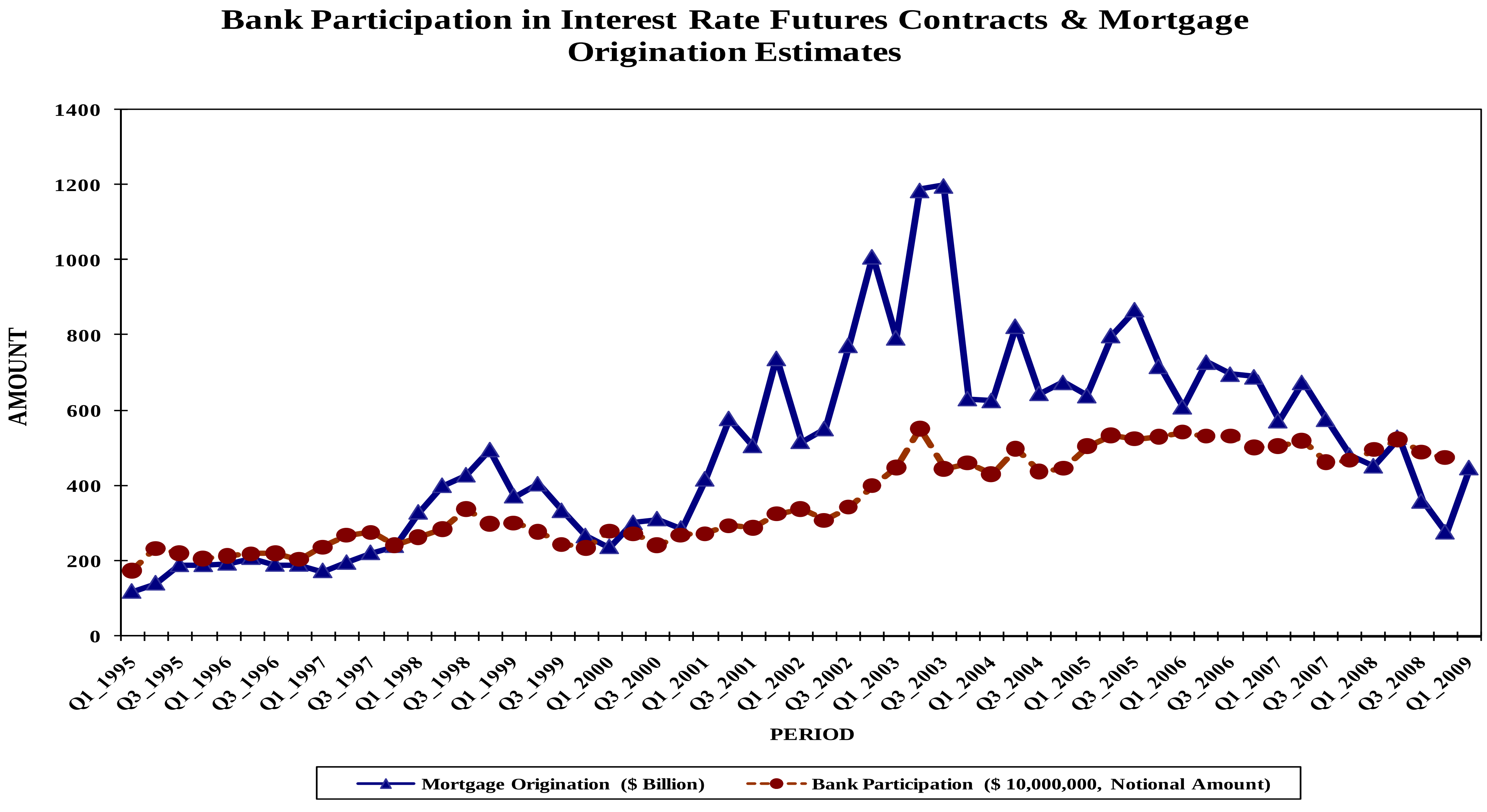

Figure 8 – This graph depicts the notional amount of bank participation in interest rate futures contracts as well as estimates of mortgage origination (for single-family residences). These are all quarterly data. The bank participation data are taken from the "*Call Reports*" available from the *Commercial Bank Database* (from the Federal Reserve Bank of Chicago). At each quarterly statement, we sum the aggregated par value of futures contracts (open contracts) reported by each entity. The sample covers the first quarter of 1995 until the end of 2008. The mortgage origination estimates are provided by the Mortgage Bankers Association and the sample covers the first quarter of 1995 until the first quarter of 2009.

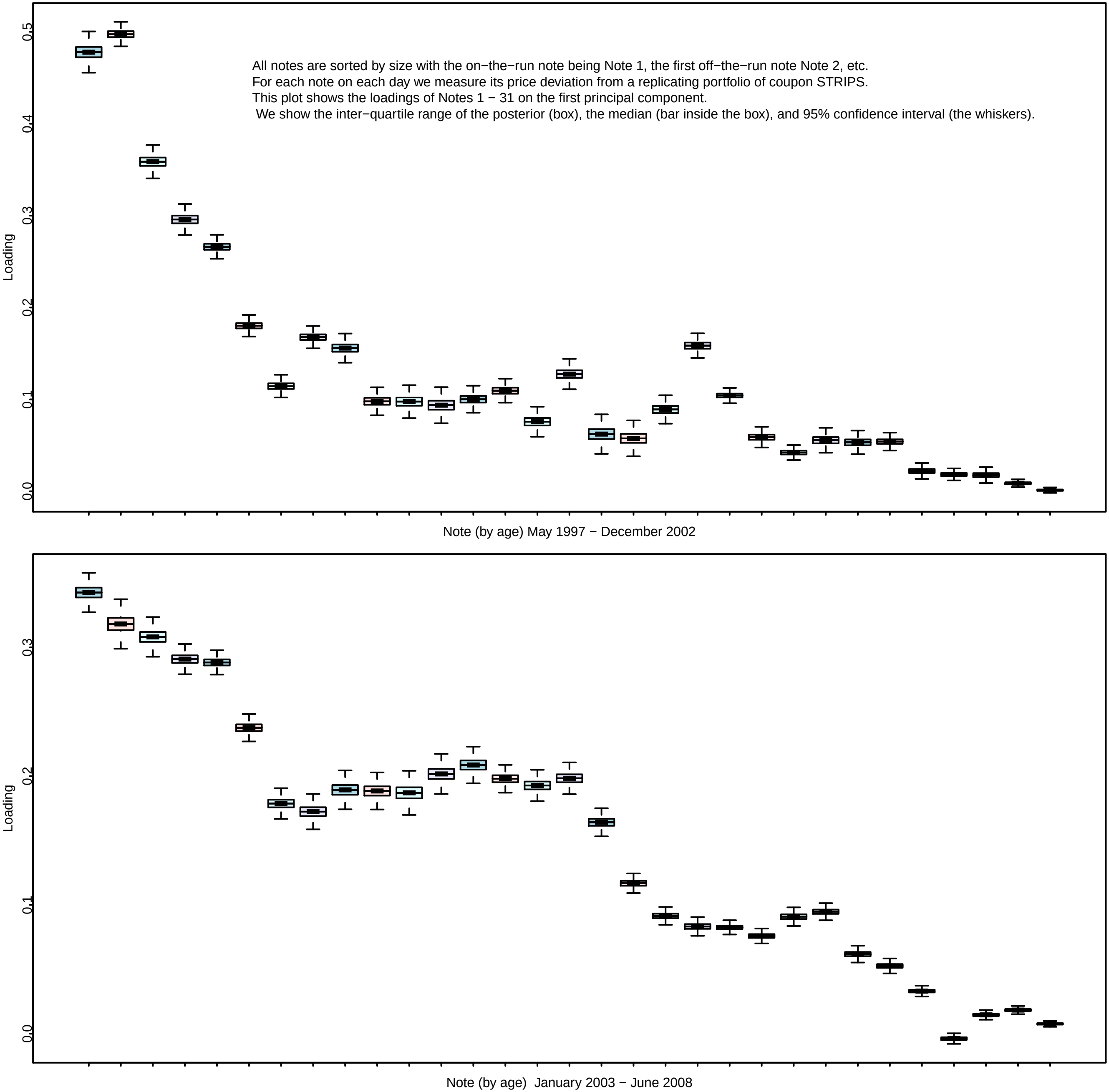

Figure 9. Loadings on the first principal component of price deviations from STRIPS

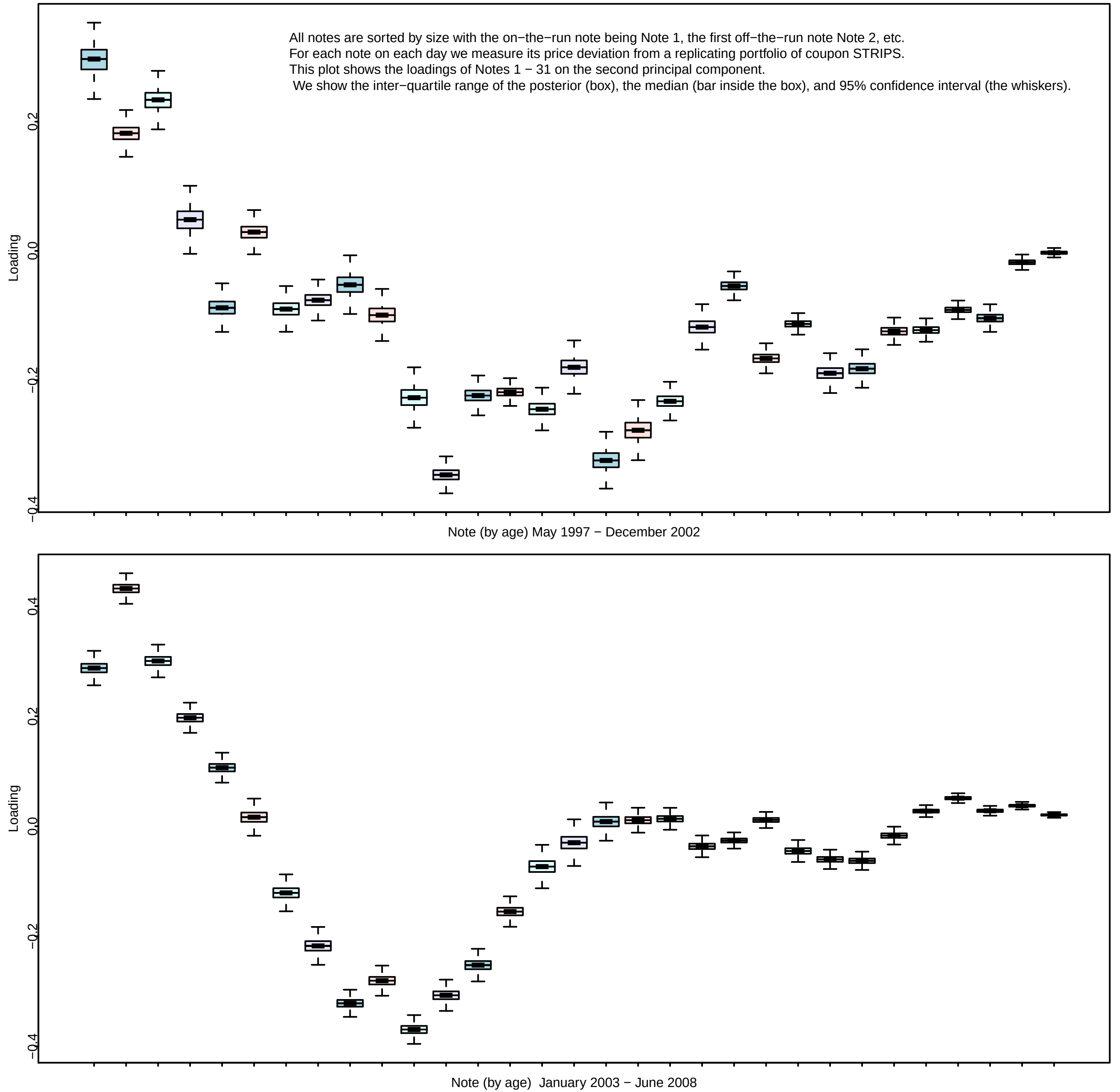

Figure 10. Loadings on the second principal component of price deviations from STRIPS

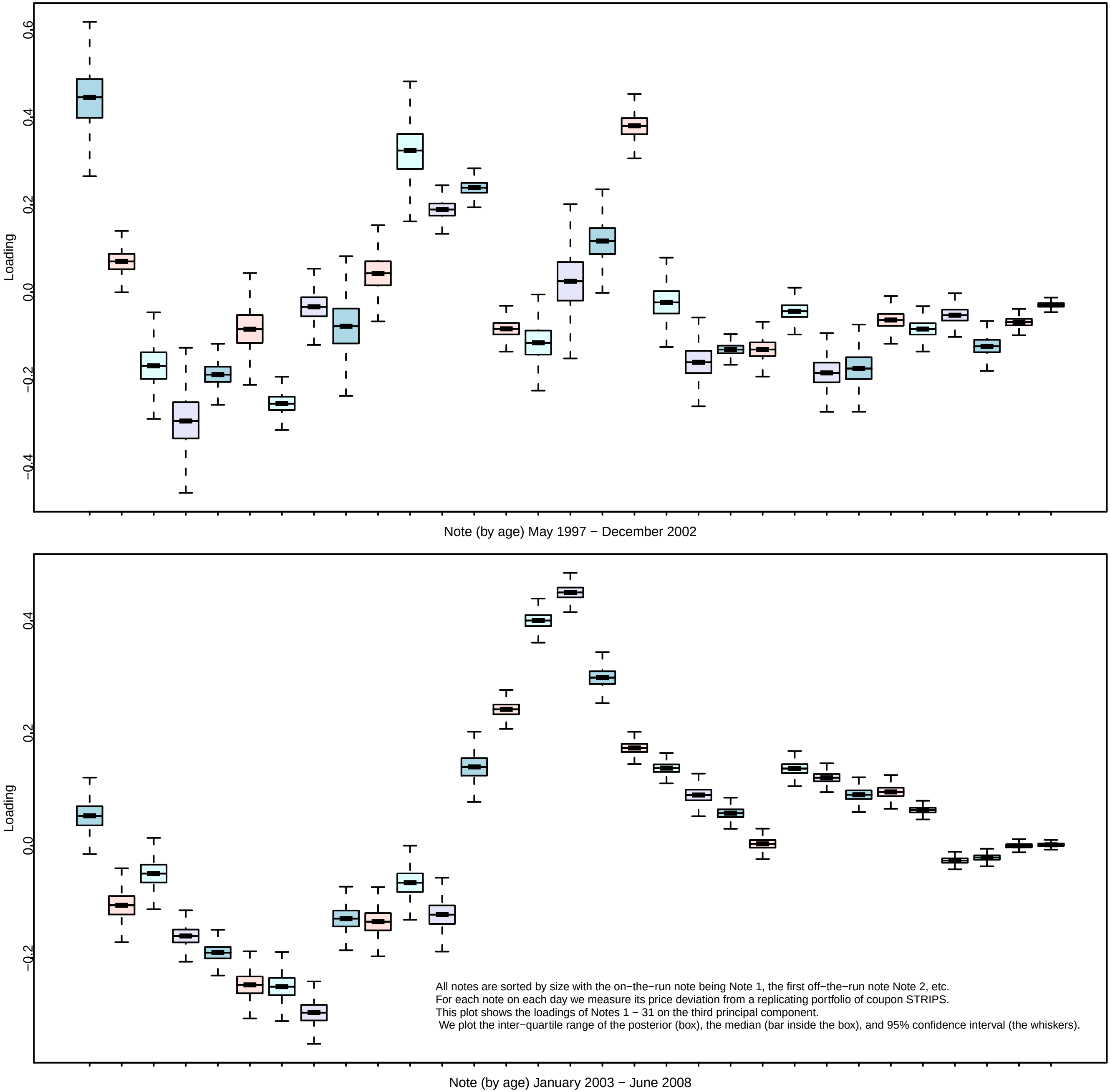

Figure 11. Loadings on the third principal component of price deviations from STRIPS

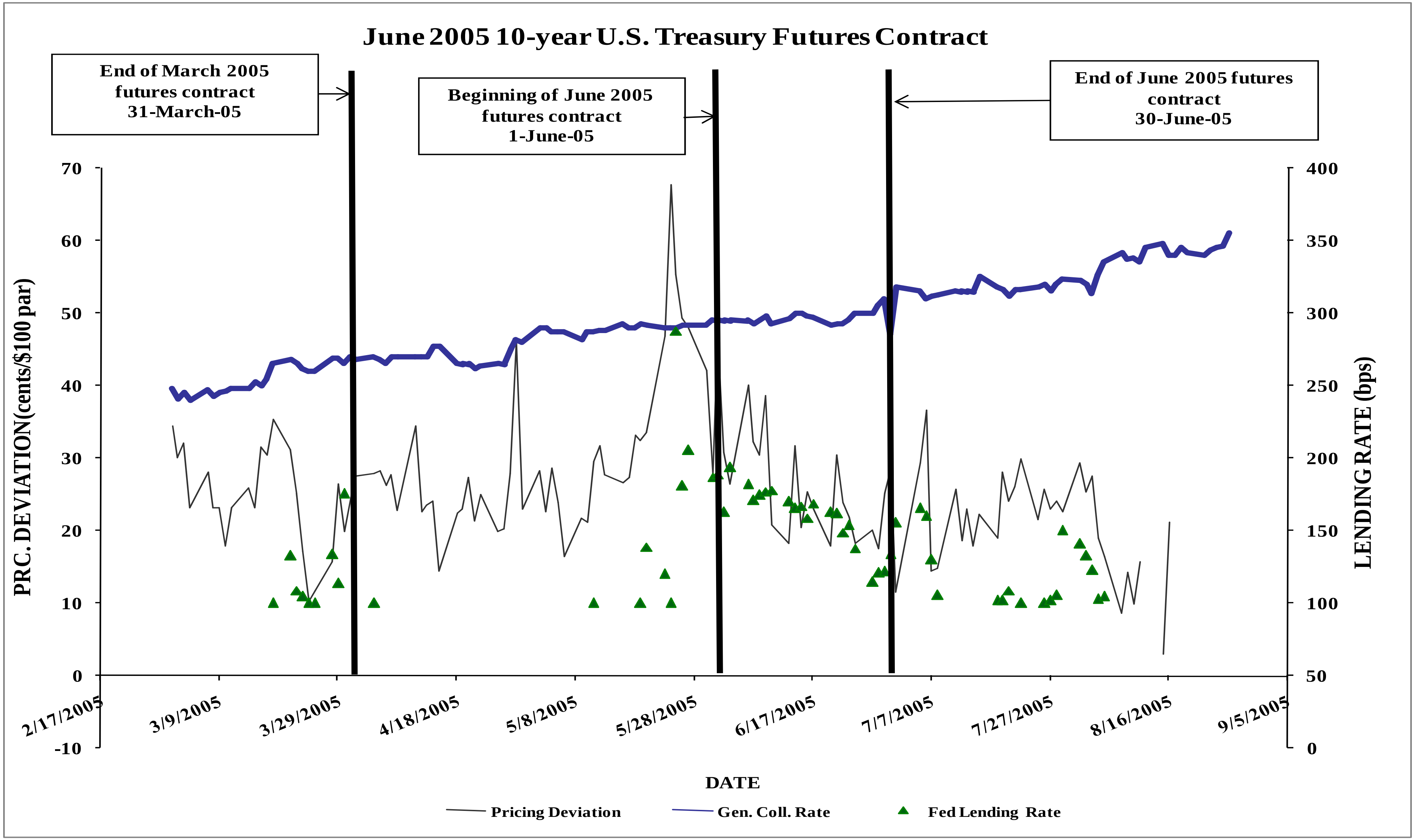

Figure 12 – This graph depicts the average deviation between the bid quote of the February 2012 4 7/8 note issued on February 15, 2002 and its replicated value from bid quotes on fungible coupon STRIPS (shown on the left vertical axis), along with the Fed lending rate for this note (its specialness),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

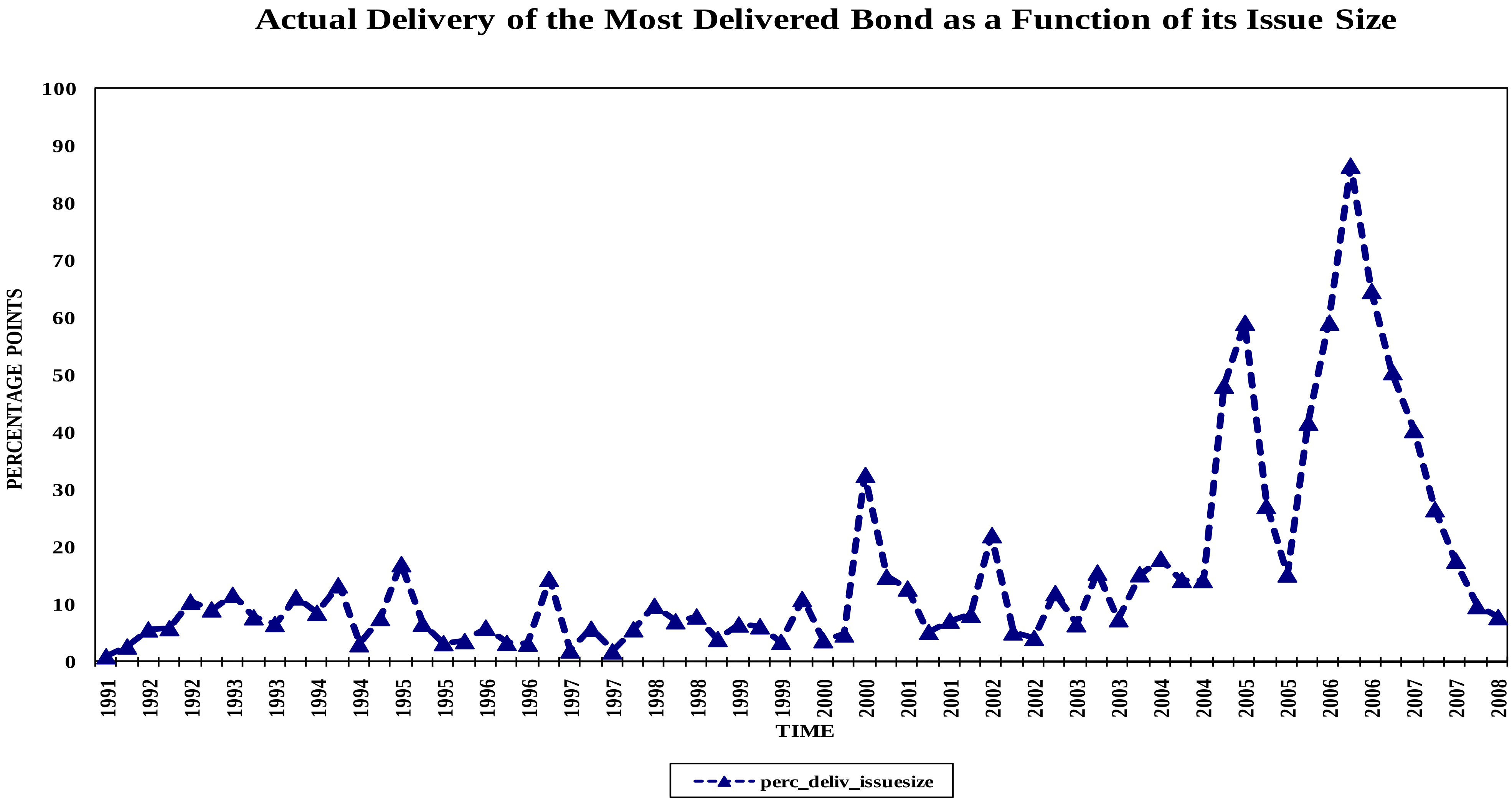

Figure 13 – This graph depicts the delivery of the most delivered bond as a function of its original issue size (offered to the public). Our sample contains 68 contracts. The first contract expires in September, 1991 and the last contract expires in June, 2008. The delivery data can be found on the CME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

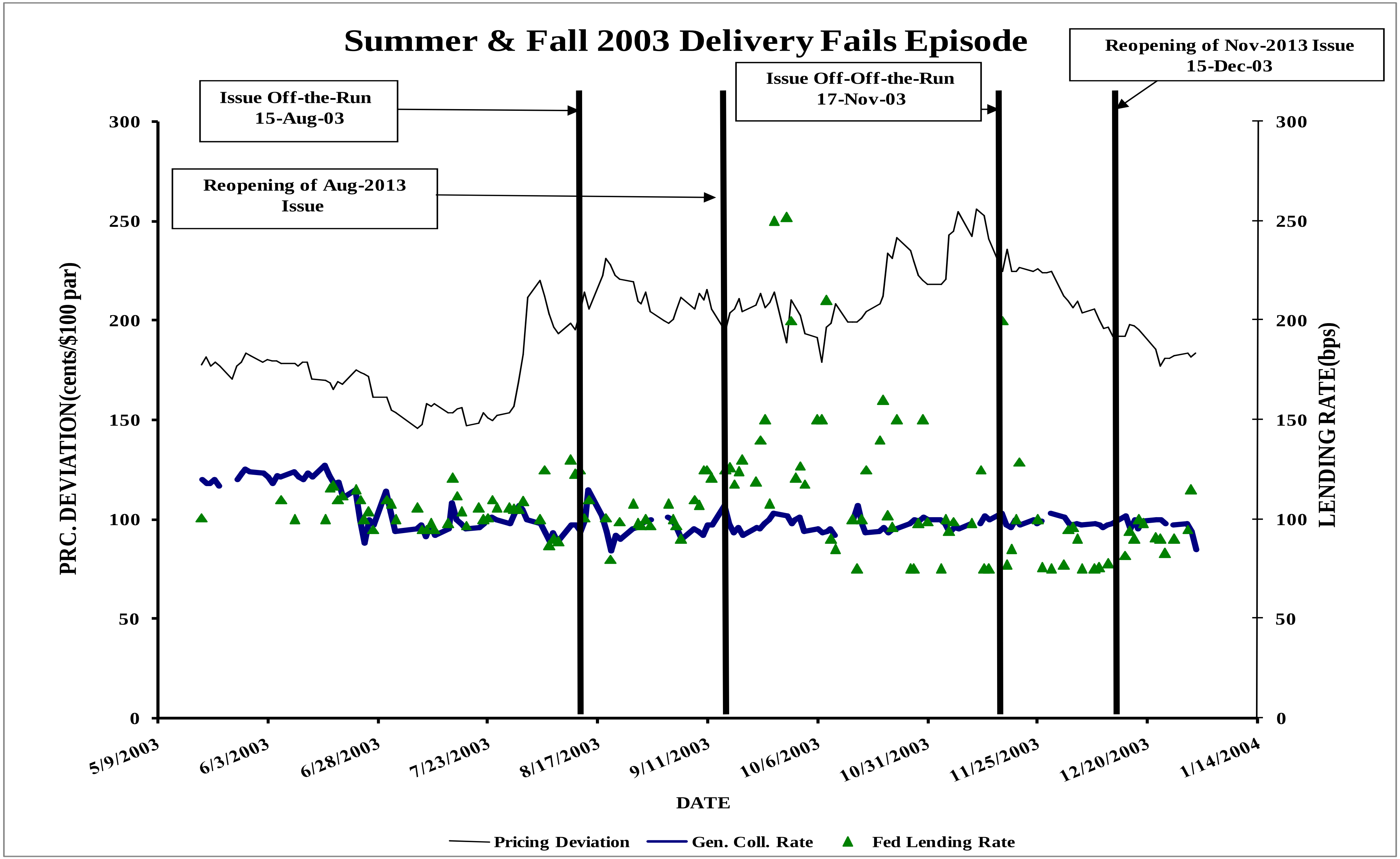

Figure 14 – This graph depicts the average deviation between the bid quote of the May 2013 3 5/8 note issued on May 15, 2003 and its replicated value from bid quotes on fungible coupon STRIPS (shown on the left vertical axis), along with the Fed lending rate for this note (its specialness), and the general collateral rate from May 15, 2003 to December 31, 2003.

Table 1

Summary Statistics for U.S. 10-Year Treasury Notes, Lending Rates, and Futures Contracts & Stripping Activity in the U.S. Treasury STRIPS Market

Panel A presents summary statistics for the 10-year U.S. Treasury notes with available pricing deviations for the period May 15, 1997 - June 27, 2008. Panel B presents auction results. Panel C compares the security lending rates from Federal Reserve Bank of New York's Securities Lending program with private lending rates provided by Wells-Fargo, Inc. Panel D presents summary statistics for the 10-year U.S. Treasury futures contract. Our sample covers each contract for the three months prior to delivery, and then rolls-over into the next contract. The first contract is September 1991 and the last contract is June 2008. Panel E presents summary statistics for the Treasury notes eligible for delivery into the futures contract. The numbers in parentheses for panels A, B, C, D, and E present the corresponding median values, while the numbers in square brackets are t-statistics for differences in mean for the pre-2003 and post-2003 sub-samples. Panel F provides summary statistics on the quoted bid-ask spreads in cents / $100 par, basis points (in yield terms) in parentheses, and proportional terms (as % of the quote mid-point) in square brackets, for the 10-year notes in term-to-maturity classes, pre- and post-2003. The superscripts ***, **, * indicate significance at the 1%, 5%, and 10% level, respectively. Panel G reports the mean, median, standard deviation, and maximum values for measures of STRIPS balances, new stripping and reconstitution activity in the U.S. Treasury STRIPS market during the period May 1997 to June 2008. The variable *STRIPPED* captures the face value of the strippable note or bond that is held in stripped form. The variables *NEWSTRIP* and *NEWRECON* capture the face value of the strippable note or bond that is newly stripped and reconstituted per month. We report the results both in billions of dollars as well as percentages of the face value of the security. We report separately results for the 10-year notes (entire period, pre- and post-2003, and August 2001 to February 2006, when the auction of the 30-year bond was discontinued), 2-, 3-, and 5-year notes, as well as for the 20-year and 30-year bonds. The data used to construct this panel are obtained from *The Monthly Statement of the Public Debt of the United States* and can be accessed through the following website: *www.treasurydirect.gov/*.

Table 1…Cont'd.

Panel A: U.S. Treasury Notes with Available Pricing Deviations		Panel B: Auction Results (May 1997 - June 2008)			
	10-yr T-Notes		**Mean**	**Median**	**Std. Dev.**
No. of Notes[1]	69	**Pre-2003 (24 Auctions):**			
No. of Reopenings (TOTAL)	36	**Bid-to-Cover Ratio**	2.13	2.11	0.4
3-month Reopening	13	**% of Issuance Awarded**	79.83	79.23	9.65
2-month Reopening	1 (Oct. 2001)	**to Dealers/Brokers**			
1-month Reopening	22	**% of Issuance Awarded**	6.5	5.71	4.53
Avg. Offer. Amount to Public (Includ. Reopenings)	17.04	**to Foreigners**			
Avg. Total Amount Offered (Includ. Reopenings)	19.05	**Orig. Auction Size (total amt.)**	14,157	13,536	2,246
First Issuance Date	8/17/1987	**(14 auctions, in millions)**			
Last Issuance Date	5/15/2008	**Reopening Auction Size (total amt.)**	10,785	11,425	2,087
Ave. Coupon Rate	6.12	**(10 auctions, in millions)**			
		Post-2003 (42 Auctions):			
		Bid-to-Cover Ratio	2.33	2.33	0.37
		% of Issuance Awarded	72.39	71.54	14.38
		to Dealers/Brokers			
		% of Issuance Awarded	13.42	13.24	8.98
		to Foreigners			
		Orig. Auction Size (total amt.)	17,163	16,777	2,442
		(22 auctions, in millions)			
		Reopening Auction Size (total amt.)	9,100	8,000	1,553
		(20 auctions, in millions)			
			[2.11]** (Bid-to-Cover)		
			[2.00]** (% of Issuance Awarded to Dealers/Brokers)		
			[3.52]** (% of Issuance Awarded to Foreigners)		

Table 1…Cont'd.

Panel C: Security Lending Rates (Private Repo Vs. Fed)
16 OTR Notes (1/2/2004 - 8/28/2007)

	Mean	Median	Std. Dev.	Minimum	Maximum	25th %ile	75th %ile
1-day Repo Rate (General Collateral)	346	368	159	86	526	192	511
1-day Reverse Repo Rate (General Collateral)	350	373	159	535	89	196	527
1-day Specialness (WF, low rate)	157	101	134	3	523	62	218
1-day Specialness (WF, high rate)	43	15	72	-95	387	1	53
1-day Specialness (WF, close rate)	100	31	142	-45	523	5	139
1-day Specialness (WF, average rate)	93	60	91	1	449	32	118
Daily Spread between High & Low (WF)	114	75	102	0	510	45	150
1-day Fed Lending Rate[2]	81	0	127	0	498	0	387
Diff. in Specialness (Fed - WF (average))	-11	-21	71	-347	373	-48	120
Diff. in Specialness (Fed - WF (close))	-19	-10	61	-357	430	-35	75

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

	1991-2008	Pre-2003 Contracts	Post-2003 Contracts	June 2005 Contract
No. of Contracts	68	46	22	1
Futures Return	0.0001	0.0000	0.0001	0.0004
	(0.0003)	(0.0003)	(0.0001)	(0.0006)
			[0.48]	
Open Interest	763,690	351,768	1,630,156	1,746,504
	(491,737)	(292,453)	(1,641,195)	(1,849,917)
			[102.77]***	
Δ in Open Int.	505	313	910	133
	(478)	(479)	(477)	(1,934)
			[0.19]	
Volume	331,675	87,815	844,257	850,719
	(110,945)	(81,305)	(763,007)	(875,484)
			[95.44]***	
Gross Basis Difference between the CTD & 2nd CTD	21	18	27	127
(on the first business day of the delivery month)[3]	(13)	(7)	(19)	
			[1.51]	

[1] We are unable to obtain STRIPS quotes for the 10-year note issued in July and October 1996.

[2] If the Fed lending rate is missing for the particular note, we assume it is zero.

[3] Gross basis is the difference between the quoted bond price (last price) and the futures settlement price adjusted by a conversion factor, in basis points.

Table 1…Cont'd.

Panel E: U.S. Treasury Notes Eligible for Delivery into 10-Year U.S. Futures Contract

	10-yr T-Notes	7-yr T-Notes
No. of Notes	68	8
No. of Reopenings	36	0
Avg. Offer. Amount to Public (Includ. Reopenings)	17.47	9.56
Avg. Total Amount Offered (Includ. Reopenings)	19.56	10.19
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 F: Bid-Ask Spreads

	10-Year Notes					
	No. of Obs.	**Mean**	**Median**	**Std. Dev.**	**5th %ile**	**95th %ile**
Pre-2003:						
On-the-Run Note	1,447	3.3	3.1	0.9	3.1	6.3
	1,447	(0.4)	(0.4)	(0.1)	(0.4)	(0.8)
	1,447	[0.03]	[0.03]	[0.01]	[0.03]	[0.06]
1st Off-the-Run Note	1,444	5.6	6.3	0.8	4.7	6.3
	1,444	(0.8)	(0.8)	(0.1)	(0.6)	(0.9)
	1,444	[0.06]	[0.06]	[0.01]	[0.04]	[0.07]
2nd Off-the-Run Note	1,384	5.6	6.3	0.8	4.7	6.3
	1,384	(0.8)	(0.8)	(0.1)	(0.6)	(1.0)
	1,384	[0.06]	[0.06]	[0.01]	[0.04]	[0.07]
3rd Off-the-Run Note	1,258	5.5	6.3	0.8	4.7	6.3
	1,258	(0.8)	(0.8)	(0.1)	(0.6)	(1.0)
	1,258	[0.05]	[0.06]	[0.01]	[0.04]	[0.07]
0 to 3 yrs old	10,968	5.4	6.3	1.3	3.1	6.3
	10,968	(0.8)	(0.9)	(0.2)	(0.4)	(1.1)
	10,968	[0.05]	[0.06]	[0.01]	[0.03]	[0.07]
3 to 5 yrs old	8,652	5.6	6.3	1.3	4.7	6.3
	8,652	(1.1)	(1.1)	(0.3)	(0.8)	(1.4)
	8,652	[0.05]	[0.06]	[0.01]	[0.04]	[0.06]
5 to 7 yrs old	8,913	4.9	6.3	1.9	3.1	6.3
	8,913	(1.4)	(1.5)	(0.6)	(0.7)	(2.1)
	8,913	[0.05]	[0.06]	[0.02]	[0.03]	[0.06]
7 to 10 yrs old	14,606	4.5	3.1	1.9	3.1	6.3
	14,606	(8.1)	(3.6)	(25.8)	(1.2)	(23.1)
	14,593	[0.04]	[0.03]	[0.02]	[0.03]	[0.06]
Post-2003:						
On-the-Run Note	1,430	3.4	3.1	0.8	3.1	6.3
	1,430	(0.4)	(0.4)	(0.1)	(0.3)	(0.8)
	1,430	[0.03]	[0.03]	[0.01]	[0.03]	[0.06]
1st Off-the-Run Note	1,414	6.2	6.3	0.0	6.3	6.3
	1,414	(0.8)	(0.8)	(0.0)	(0.7)	(0.9)
	1,414	[0.06]	[0.06]	[0.00]	[0.06]	[0.07]
2nd Off-the-Run Note	1,431	6.3	6.3	0.0	6.3	6.3
	1,431	(0.8)	(0.8)	(0.1)	(0.7)	(0.9)
	1,431	[0.06]	[0.06]	[0.00]	[0.06]	[0.07]
3rd Off-the-Run Note	1,415	6.2	6.3	0.1	6.3	6.3
	1,415	(0.8)	(0.8)	(0.1)	(0.8)	(0.9)
	1,415	[0.06]	[0.06]	[0.00]	[0.06]	[0.07]
0 to 3 yrs old	15,299	6.0	6.3	0.9	3.1	6.3
	15,299	(0.9)	(0.9)	(0.2)	(0.4)	(1.0)
	15,299	[0.06]	[0.06]	[0.01]	[0.03]	[0.07]
3 to 5 yrs old	7,858	6.3	6.3	0.0	6.3	6.3
	7,858	(1.1)	(1.2)	(0.1)	(1.0)	(1.4)
	7,858	[0.06]	[0.06]	[0.00]	[0.05]	[0.07]
5 to 7 yrs old	6,689	6.2	6.3	0.5	6.3	6.3
	6,689	(1.6)	(1.6)	(0.3)	(1.3)	(2.1)
	6,689	[0.06]	[0.06]	[0.01]	[0.05]	[0.06]
7 to 10 yrs old	12,145	5.1	6.3	1.5	3.1	6.3
	12,145	(8.2)	(3.9)	(26.3)	(2.3)	(21.2)
	12,129	[0.05]	[0.06]	[0.01]	[0.03]	[0.06]

Table 1…Cont'd.

Panel G: Monthly STRIPS activity in strippable U.S. Treasury notes and bonds, May 1997 - June 2008

		STRIPPED **($B of face)**	***STRIPPED*** **(% of face)**	***NEWSTRIP*** **($B of face)**	***NEWSTRIP*** **(% of face)**	***NEWRECON*** **($B of face)**	***NEWRECON*** **(% of face)**
10-year notes							
May 1997 - June 2008	**Mean**	0.947	6.69	0.054	0.33	0.035	0.21
71 notes	**Median**	0.209	1.00	0.004	0.02	0.001	0.01
(4,198 obs.)	**Std. Dev.**	1.403	11.79	0.115	0.74	0.085	0.52
	Max.	5.837	55.61	1.700	11.77	1.701	11.78
May 1997 - Dec. 2002	**Mean**	1.297	10.25	0.057	0.40	0.038	0.27
49 notes	**Median**	0.194	1.49	0.006	0.04	0.002	0.01
(2,160 obs.)	**Std. Dev.**	1.748	15.14	0.118	0.85	0.089	0.62
	Max.	5.837	55.61	1.700	11.77	1.701	11.78
Jan. 2003 - June 2008	**Mean**	0.578	2.92	0.051	0.26	0.032	0.15
51 notes	**Median**	0.222	0.89	0.002	0.01	0.001	0.00
(2,038 obs.)	**Std. Dev.**	0.741	4.02	0.112	0.60	0.080	0.36
	Max.	4.131	30.95	1.445	10.44	0.902	3.65
Aug. 2001 - Feb. 2006	**Mean**	0.535	3.07	0.042	0.24	0.022	0.13
44 notes	**Median**	0.090	0.45	0.001	0.00	0.000	0.00
(1,617 obs.)	**Std. Dev.**	0.850	5.10	0.103	0.63	0.056	0.33
	Max.	5.441	39.46	1.445	10.44	0.704	4.75
2-year notes	**Mean**	0.037	0.20	0.003	0.01	0.000	0.00
May 1997 - June 2008	**Median**	0.000	0.00	0.000	0.00	0.000	0.00
139 notes	**Std. Dev.**	0.094	0.52	0.034	0.14	0.006	0.03
(3,072 obs.)	**Max.**	1.360	4.16	1.358	4.16	0.298	1.31
3-year notes	**Mean**	0.374	1.25	0.032	0.12	0.012	0.04
May 1997 - June 2008	**Median**	0.184	0.73	0.001	0.00	0.000	0.00
20 notes	**Std. Dev.**	0.629	1.55	0.084	0.30	0.040	0.16
(652 obs.)	**Max.**	4.072	8.04	0.685	2.46	0.551	2.36
5-year notes	**Mean**	0.179	0.88	0.017	0.08	0.007	0.03
May 1997 - June 2008	**Median**	0.008	0.05	0.000	0.00	0.000	0.00
92 notes	**Std. Dev.**	0.405	1.89	0.085	0.38	0.038	0.19
(3,106 obs.)	**Max.**	3.417	13.53	2.026	7.09	1.110	5.20
20-year bonds	**Mean**	2.276	33.33	0.108	1.50	0.103	1.42
May 1997 - June 2008	**Median**	2.416	38.98	0.047	0.78	0.036	0.59
4 bonds	**Std. Dev.**	1.385	18.95	0.182	2.29	0.183	2.30
(390 obs.)	**Max.**	4.515	61.33	1.562	18.81	1.592	19.18
30-year bonds	**Mean**	3.930	31.52	0.584	4.63	0.583	4.66
May 1997 - June 2008	**Median**	3.142	30.60	0.337	2.92	0.336	2.96
43 bonds	**Std. Dev.**	3.758	22.01	0.849	6.00	0.843	6.01
(5,079 obs.)	**Max.**	27.409	83.57	16.835	87.50	16.696	89.71
All notes/bonds	**Mean**	1.560	12.45	0.201	1.57	0.193	1.53
May 1997 - June 2008	**Median**	0.224	1.32	0.005	0.03	0.000	0.00
369 notes/bonds	**Std. Dev.**	2.762	19.56	0.542	3.95	0.539	3.96
(16,497 obs.)	**Max.**	27.409	83.57	16.835	87.50	16.696	89.71

Table 2

Summary Statistics for Pricing Deviations

In Panels A to I, we examine the pricing deviation (in cents per $100 par) between the bid quote on a 10-year Treasury note and its STRIPS-Implied-Value (SIV) (also using STRIPS bid quotes) from a replicating portfolio of coupon STRIPS. In Panel J the SIV is constructed using a reconstituting coupon and principal STRIPS portfolio. Panel K reports pricing differences between principal and coupon STRIPS of matched maturity (i.e., principal STRIPS bid quote - coupon STRIPS bid quote, in cents per $100 par). Our sample consists of daily observations from the period: May 15, 1997 - June 27, 2008. The numbers in square brackets are t-statistics for differences in the means of sub-samples from the pre- and post-2003 periods. 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.	Min.	Max.	5th %ile	95th %ile
Panel A: All Notes[1]										
1997-2008	69	85,441	29	24	6	49	-107	333	-23	126
Pre-Jan. 1, 2003	47	43,339	29	20	3	51	-107	333	-31	132
Post-Jan. 1, 2003	49	42,102	29	28	9	46	-82	301	-16	121
				[21.99]***						
Panel B: On-the-Run Notes										
1997-2008	37	2,886	1	151	141	63	28	333	61	261
Pre-Jan. 1, 2003	15	1,455	1	182	183	60	28	333	93	273
Post-Jan. 1, 2003	23	1,431	1	120	116	50	37	301	56	219
				[30.41]***						
Panel C: 1st-Off-the-Run Notes										
1997-2008	36	2,877	1	109	100	54	-25	305	42	212
Pre-Jan. 1, 2003	14	1,454	1	120	117	57	-25	305	39	226
Post-Jan. 1, 2003	23	1,423	1	98	89	49	26	256	42	206
				[10.75]***						
Panel D: 2nd-Off-the-Run Notes										
1997-2008	35	2,820	1	90	80	46	-35	236	27	174
Pre-Jan. 1, 2003	13	1,389	1	91	85	47	-35	187	15	162
Post-Jan. 1, 2003	23	1,431	1	88	75	46	3	236	32	183
				[1.60]						

Table 2…Cont'd.

	No. of Unique Notes	No. of Obs.	No. of Obs./Day	Mean	Median	Std. Dev.	Min.	Max.	5th %ile	95th %ile
Panel E: 3rd-Off-the-Run Notes										
1997-2008	35	2,684	1	72	67	42	-64	219	14	153
Pre-Jan. 1, 2003	13	1,261	1	67	63	42	-64	184	3	142
Post-Jan. 1, 2003	23	1,423	1	77	70	41	-8	219	22	160
				[6.43]***						
Panel F: All Deliverables										
1997-2008	47	28,638	10	68	54	55	-66	333	2	179
Pre-Jan. 1, 2003	25	12,294	9	71	51	64	-66	333	3	211
Post-Jan. 1, 2003	29	16,344	12	65	56	47	-61	301	1	154
				[10.23]***						
Panel G: All Deliverables, excluding On-the-Run, 1st, 2nd, and 3rd Off-the-Run Notes										
1997-2008	43	17,849	8	44	39	35	-66	229	-3	110
Pre-Jan. 1, 2003	21	6,958	5	36	32	29	-66	193	-2	86
Post-Jan. 1, 2003	25	10,891	8	49	45	38	-61	229	-3	118
				[23.83]***						
Panel H: CTD Notes										
1997-2008	38	2,797	1	34	30	36	-64	219	-11	100
Pre-Jan. 1, 2003	22	1,415	1	34	29	31	-64	144	-7	92
Post-Jan. 1, 2003	20	1,382	1	34	30	40	-61	219	-12	112
				[0.01]						
Panel I: All Non-Deliverables										
1997-2008	69	56,803	21	2	-2	24	-107	308	-29	45
Pre-Jan. 1, 2003	47	31,045	21	0	-2	25	-107	308	-35	42
Post-Jan. 1, 2003	49	25,758	18	4	-2	23	-82	256	-19	49
				[19.67]***						

[1] We are unable to obtain STRIPS quotes for the 10-year note issued in July and October 1996.

Table 2…Cont'd.

Panel J: Pricing Deviation from SIV (coupon/principal STRIP portfolio)

	No. of Obs.	Mean	Median	Std. Dev.	Min.	Max.	5th %ile	95th %ile
All Notes								
1997-2008	63,101	3	1	32	-419	733	-18	26
Pre-Jan. 1, 2003	26,347	2	0	11	-158	181	-9	19
Post-Jan. 1, 2003	36,754	4	1	41	-419	733	-27	36
		[7.68]***						
On-the-Run Notes								
1997-2008	643	24	12	49	-190	201	-40	113
Pre-Jan. 1, 2003	25	17	9	44	-50	181	-43	57
Post-Jan. 1, 2003	618	24	12	49	-190	201	-40	114
		[0.77]						
1st-Off-the-Run Notes								
1997-2008	904	19	13	71	-253	288	-111	152
Pre-Jan. 1, 2003	82	10	10	21	-71	58	-33	34
Post-Jan. 1, 2003	822	20	13	74	-253	288	-113	160
		[1.27]						

Panel K: Pricing Deviation between Principal vs. Coupon STRIP

	No. of Obs.	Mean	Median	Std. Dev.	5th %ile	95th %ile
Pre-2003:						
0 to 1 yrs to maturity	4,745	-4	-2	8	-20	1
1 to 2 yrs to maturity	4,482	-8	-4	14	-34	3
2 to 3 yrs to maturity	3,989	-9	-5	15	-34	6
3 to 4 yrs to maturity	3,403	-13	6	23	-64	15
4 to 5 yrs to maturity	3,100	-9	-7	25	-61	30
5 to 6 yrs to maturity	2,812	2	0	21	-33	36
6 to 7 yrs to maturity	2,007	14	13	24	22	60
7 to 8 yrs to maturity	1,203	22	20	28	-20	68
8 to 9 yrs to maturity	434	50	47	45	-14	137
9 to 10 yrs to maturity	137	145	148	32	101	188
Post-2003:						
0 to 1 yrs to maturity	3,235	-3	-2	5	-13	3
1 to 2 yrs to maturity	3,210	-4	-3	6	-13	5
2 to 3 yrs to maturity	3,181	-2	-1	11	-20	15
3 to 4 yrs to maturity	3,275	2	2	21	-21	27
4 to 5 yrs to maturity	3,403	1	0	22	-32	39
5 to 6 yrs to maturity	3,727	9	0	31	-30	72
6 to 7 yrs to maturity	4,086	21	9	38	-20	91
7 to 8 yrs to maturity	4,444	39	36	42	-11	105
8 to 9 yrs to maturity	4,655	59	59	65	-1	152
9 to 10 yrs to maturity	3,553	69	67	116	-112	218

Table 3

Summary Statistics for Fed Lending Rates

We report summary statistics for the specialness (in basis points) for our sample of Fed lending rates obtained from the Federal Reserve Bank of New York's Securities Lending program (*http://www.newyorkfed.org/markets/securitieslending.html*). The time span of our sample covers the period from April 29, 1999 until June 30, 2008. 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 Obs.	No. of Obs. with Specialness	No. of Unique Notes	No. of Unique Notes with Specialness	Mean (incl. zeros)	Mean Spread (above min. lending rate)	Mean (excl. zeros)	Std. Dev. (incl. zeros)	Min. (excl. zeros)	Max. (incl. zeros)
Panel A: All Notes										
1999-2008	73,023	4,480	64	57	7	28	120	36	50	571
Pre-Jan. 1, 2003	28,857	1,007	42	34	6	50	179	38	100	571
Post-Jan. 1, 2003	44,166	3,473	51	45	8	22	102	34	50	515
					[6.69]***	[11.07]***	[27.20]***			
Panel B: On-the-Run Notes										
1999-2008	2,390	1,026	32	32	78	79	182	119	50	571
Pre-Jan. 1, 2003	957	407	10	10	93	89	219	133	100	571
Post-Jan. 1, 2003	1,433	619	23	23	68	73	158	108	50	498
					[5.00]***	[2.31]**	[8.25]***			
Panel C: 1st-Off-the-Run Notes										
1999-2008	2,390	443	32	29	28	54	151	111	50	515
Pre-Jan. 1, 2003	957	151	10	8	33	77	208	91	100	506
Post-Jan. 1, 2003	1,433	292	23	22	25	42	122	64	50	515
					[2.52]***	[3.69]***	[8.28]***			
Panel D: 2nd-Off-the-Run Notes										
1999-2008	2,390	175	32	26	9	26	118	37	50	508
Pre-Jan. 1, 2003	957	28	10	8	5	56	183	37	100	508
Post-Jan. 1, 2003	1,433	147	23	18	10	20	105	37	50	370
					[3.48]***	[2.68]***	[5.25]***			

Table3…Cont'd.

	No. of Obs.	No. of Obs. with Specialness	No. of Unique Notes	No. of Unique Notes with Specialness	Mean (incl. zeros)	Mean Spread (above min. lending rate)	Mean (excl. zeros)	Std. Dev. (incl. zeros)	Min. (excl. zeros)	Max. (incl. zeros)
Panel E: 3rd-Off-the-Run Notes										
1999-2008	2,390	137	32	20	7	24	114	32	50	450
Pre-Jan. 1, 2003	957	20	10	8	3	18	155	23	100	286
Post-Jan. 1, 2003	1,433	117	23	12	9	25	107	36	50	450
					[4.19]***	[0.45]	[2.86]***			
Panel F: All Deliverables										
1999-2008	24,090	2,661	41	34	16	47	142	56	50	571
Pre-Jan. 1, 2003	7,700	644	19	12	17	77	208	67	100	571
Post-Jan. 1, 2003	16,390	2,017	29	29	15	37	121	50	50	515
					[3.28]***	[10.30]***	[20.43]***			
Panel G: All Deliverables, excluding On-the-Run, 1st, 2nd, and 3rd Off-the-Run Notes										
1999-2008	14,979	885	37	29	6	14	99	26	50	416
Pre-Jan. 1, 2003	4,045	40	15	8	1	5	132	14	100	286
Post-Jan. 1, 2003	10,934	845	25	24	8	14	97	29	50	416
					[13.08]***	[1.62]	[4.72]***			
Panel H: CTD Notes										
1999-2008	2,308	161	30	17	8	28	119	34	50	288
Pre-Jan. 1, 2003	925	15	15	6	2	9	139	18	100	230
Post-Jan. 1, 2003	1,383	146	19	14	12	31	117	41	50	288
					[7.12]***	[1.78]*	[1.38]			
Panel I: All Non-Deliverables										
1999-2008	48,933	1,819	64	43	3	2	87	18	50	355
Pre-Jan. 1, 2003	21,157	363	42	25	2	2	128	17	100	243
Post-Jan. 1, 2003	27,776	1,456	51	31	4	2	77	18	50	355
					[11.43]***	[0.41]	[34.60]***			

Table 4

Determinants of Pricing Deviations/Event Study on the Note Exiting the Deliverability Basket

We report results from Generalized Method of Moments (GMM) regressions on the pricing deviations (for all notes, all observations on notes that are deliverable in the futures contract, all observations on notes that are non-deliverable in the futures contract, and on the CTD note) (panel A). The time span of our sample covers the period from May 15, 1997 until June 27, 2008 (daily obs.). 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. Panel B is an event study on the note that is exiting the deliverability basket (changes in pricing deviations).

Panel A: Regressions on Pricing Deviations

Variables	All Notes (82,589 obs.)	All Notes (82,589 obs.)	All Notes (82,589 obs.)	All Deliv. (25,933 obs.)	All Non-Deliv. (53,951 obs.)	CTD Notes[1] (866 obs.)
Intercept	4.79	2.15	51.44	55.90	-0.61	0.62
	(6.22)***	(3.37)***	(52.27)***	(19.57)***	(0.72)	(0.96)
	[1.04]	[0.40]			[0.14]	
	{0.62}	{0.50}			{0.08}	
Total Issue Size (offered to public) (linearly de-trended)		-0.15	-0.46			
		(4.10)***	(10.88)***			
		[0.40]	[1.00]			
		{0.33}	{0.86}			
Outstanding Issue Size (offered to public)	-0.21			-0.97	0.13	-0.15
	(7.13)***			(8.69)***	(2.95)***	(0.79)
	[0.73]			[1.53]	[0.46]	
	{0.60}			{1.34}	{0.32}	
Calendar Spread				-0.09		-0.35
				(11.06)***		(5.66)***
Gross Basis between CTD & 2nd CTD						0.40
						(2.97)***
Post-2003 Dummy	4.58	4.23	4.90	14.46	3.31	-8.12
	(10.74)***	(9.92)***	(10.96)***	(6.04)***	(6.67)***	(0.87)
	[1.56]	[1.41]	[1.67]*	[1.79]*	[1.14]	
	{0.89}	{0.82}	{0.89}	{0.99}	{0.66}	
Deliverable Dummy	43.75	43.57	41.08			
	(68.94)***	(68.97)***	(48.62)***			
Age Indicator			-2.25			
			(87.08)***			
OTR Dummy	140.13	140.39		140.24		
	(119.58)***	(118.00)***		(67.76)***		
1st Off-the-Run Dummy	64.14	64.01		65.07		
	(77.69)***	(77.58)***		(43.42)***		
2nd Off-the-Run Dummy	44.80	44.68		44.90		
	(64.31)***	(64.09)***		(37.17)***		
3rd Off-the-Run Dummy	28.50	28.38		27.71		
	(46.62)***	(46.23)***		(28.25)***		
CTD Dummy	-15.61	-15.68	-35.76	-11.35		
	(21.64)***	(21.69)***	(38.28)***	(9.84)***		
Open Interest/Issue Size (contract equiv.)						0.26
						(0.82)
Open Interest/Size of All Deliv. Issues (contract equiv.)				-14.51		
				(3.70)***		
				{1.69}*		
Deliv. x Post-2003 Period	3.12	2.94	-9.11			
	(3.16)***	(2.99)***	(7.57)***			
	[0.45]	[0.43]	[1.19]			
	{0.26}	{0.24}	{0.62}			
OTR x Post-2003 Period	-69.30	-69.07		-73.41		
	(51.96)***	(51.40)***		(32.75)***		
CTD x Post-2003 Period	-0.88	-0.83	13.44	-6.06		
	(0.94)	(0.88)	(11.48)***	(4.05)***		
			[1.16]	[0.71]		
			{1.10}	{0.72}		
Adj. R^2	0.630	0.630	0.510	0.570	0.012	0.370

[1]: The CTD sample includes observations for the month prior to delivery.

Table 4…Cont'd.

Variable Definition:

Total Issue Size (offered to public, linearly de-trended): Total size of issue offered to the public that includes reopenings (in billions of dollars) de-trended using a linear analysis (first issuance is Aug. 1987 and last issuance is May 2008)

Outstanding Issue Size (offered to public): Outstanding issue size offered to the public (in billions of dollars)

Calendar Spread: Difference between the closing prices of the nearby contract and the expiring one, in cents

Gross Basis between CTD & 2nd CTD: Basis difference of the cheapest-to-deliver (CTD) and 2nd CTD in the expiring futures contract (basis is the difference between the quoted bond price and the futures settlement price adjusted by a conversion factor, in basis points)

Post-2003 Dummy: Dummy that takes the value of 1 if period is post-2003 and 0 otherwise

Deliverable Dummy: Dummy that takes the value of 1 if the issue is deliverable into the expiring futures contract and 0 otherwise

OTR Dummy: Dummy that takes the value of 1 if the issue is on-the-run and 0 otherwise

1st Off-the-Run Dummy: Dummy that takes the value of 1 if the issue is the 1st off-the-run and 0 otherwise

2nd Off-the-Run Dummy: Dummy that takes the value of 1 if the issue is the 2nd off-the-run and 0 otherwise

3rd Off-the-Run Dummy: Dummy that takes the value of 1 if the issue is the 3rd off-the-run and 0 otherwise

CTD Dummy: Dummy that takes the value of 1 if the issue is the cheapest-to-deliver in the expiring futures contract and 0 otherwise

Open Interest/Issue Size (contract equiv.): Ratio of open interest (number of contracts outstanding) of the expiring futures contract to the outstanding issue size (available to the public)

Open Interest/Size of All Deliv. Issues (contract equiv.): Ratio of open interest (number of contracts outstanding) to the outstanding size of all deliverable issues into the expiring futures contract

Deliv. x Post-2003 Period: An interaction dummy between the deliverability and post-2003 dummies; takes the value of 1 if the deliverability and post-2003 dummies have a value of 1 and 0 otherwise

OTR x Post-2003 Period: An interaction dummy between the on-the-run (OTR) and post-2003 dummies; takes the value of 1 if the OTR and post-2003 dummies have a value of 1 and 0 otherwise

CTD x Post-2003 Period: An interaction dummy between the cheapest-to-deliver (CTD) and post-2003 dummies; takes the value of 1 if the CTD and post-2003 dummies have a value of 1 and 0 otherwise

Table 4…Cont'd.

Panel B: Event Study on the Note Exiting the Deliverability Basket

	Mean	Median	Minimum	Maximum	25th %ile	75th %ile	No. of Obs.	No. of Events
Panel A: Includes both CTD & Non-CTD Notes								
May 1997 - April 2008 (Pre-Event Window)*	22	18	-31	98	6	43	334	33
May 1997 - April 2008 (Post-Event Window)**	25	21	-26	116	9	36	375	33
May 1997 - April 2008 (Pre-Event - Post-Event Window)	-4	-2	-41	31	-14	6	33	33
Panel B: Includes only CTD Notes								
May 1997 - April 2008 (Pre-Event Window)*	21	17	-26	77	5	42	267	27
May 1997 - April 2008 (Post-Event Window)**	23	18	-26	114	7	32	306	27
May 1997 - April 2008 (Pre-Event - Post-Event Window)	-3	-1	-41	31	-11	13	27	27

*: The pre-event window consists of the *last* 15 calendar days of the month prior to delivery.

**: The post-event window consists of the *last* 15 calendar days of the month after delivery.

Table 5

Determinants of Pricing Deviations & Specialness for the On-the-Run Notes

We report results from Generalized Method of Moments (GMM) regressions where the dependent variables are average pricing deviation and specialness over two week windows. For each on-the-run note, the first window starts on the issuance date and ends at that month end, and the last window starts on the first day of the month of a new 10-year note issuance and ends when the new note is issued. The Newey-West standard errors with two 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 by note and auction, respectively. The superscripts ***, **, * indicate significance at the 1%, 5%, and 10% level, respectively.

Table 5…Cont'd.

Variables	OTR Notes[1] Av. Prc. Dev.	OTR Notes[1] Av. Prc. Dev.	OTR Notes[1] Av. Prc. Dev.	OTR Notes[1] Av. Prc. Dev.	OTR Notes[2] Av. Spc.	OTR Notes[2] Av. Spc.	OTR Notes[2] Av. Spc.	OTR Notes[2] Av. Spc.
Intercept	207.48 (3.24)*** [1.73]* {1.96}**	218.91 (3.51)*** [1.89]* {2.16}**	199.92 (3.92)*** [2.36]**	247.37 (3.69)*** [1.95]* {2.28}**	474.38 (3.33)***	474.38 (3.32)***	376.63 (3.48)***	354.24 (3.80)***
Auction Size (offered to public)	5.66 (2.90)*** [1.62] {1.76}*	5.90 (3.18)*** [1.80]* {1.97}**		4.90 (2.17)** [1.17] {1.38}	-18.10 (4.07)***	-18.10 (4.05)***		
Auction Size (total)			6.61 (5.04)***				-14.34 (4.99)***	-12.92 (4.62)***
Post-2003 Dummy	-57.65 (6.72)***	-57.03 (6.66)***	-51.74 (6.23)***	-51.16 (6.45)***	-32.70 (2.32)**	-32.69 (2.35)**	-49.85 (3.60)***	-50.53 (3.89)***
Bid-to-Cover Ratio	-58.87 (6.30)***	-60.26 (6.49)***	-61.85 (6.93)***	-65.83 (6.35)***	-14.92 (1.15)	-14.94 (1.13)	-1.69 (0.13)	-0.70 (0.06)
% of Issuance Awarded to Dealers/Brokers				-0.48 (1.49)				0.83 (1.37)
% of Issuance Awarded to Foreigners				0.72 (1.32)				-0.94 (0.85)
Average % of Issuance Awarded to Dealers/Brokers (per note)	-0.31 (0.71)	-0.41 (0.94)	-0.50 (1.19)		0.04 (0.04)	0.04 (0.04)	0.80 (0.98)	
Average % of Issuance Awarded to Foreigners (per note)	2.12 (3.33)*** [2.00]**	1.20 (1.71)* [1.07] {1.30}	1.29 (1.93)* [1.23] {1.44}		0.40 (0.29)	0.39 (0.22)	-0.28 (0.17)	
Yield Difference	8.04 (2.03)** [1.38] {1.50}	24.61 (3.39)***	24.82 (3.56)***	14.73 (2.41)** [1.94]* {1.83}*	16.24 (2.11)**	16.46 (0.68)	16.51 (0.73)	34.37 (2.93)***
Average % of Issuance Awarded to Foreigners x Yield Difference		-2.02 (2.97)*** [2.39]** {2.30}**	-2.03 (3.15)***			-0.02 (0.01)	-0.06 (0.03)	
% of Issuance Awarded to Foreigners x Yield Difference				-0.93 (1.47)				-2.50 (2.26)**
Periods (2-weeks) until Off-the-Run	5.83 (3.80)***	5.67 (3.70)***	7.09 (4.59)***	6.84 (4.37)***	-18.64 (5.20)***	-18.64 (5.19)***	-21.16 (5.87)***	-21.92 (6.26)***
Reopened Issue Dummy	35.51 (2.03)** [1.17] {1.22}	41.76 (2.52)*** [1.48] {1.55}	51.17 (3.32)*** [2.09]** {2.15}**	43.70 (2.49)*** [1.45] {1.51}	-137.64 (3.40)***	-137.59 (3.42)***	-129.86 (4.11)***	-125.32 (4.00)***
Future Reopening Issue Dummy	0.60 (0.05)	7.01 (0.54)	-2.24 (0.19)	-7.42 (0.49)	35.61 (1.23)	35.66 (1.22)	65.97 (2.62)*** [2.40]** {2.39}**	87.48 (3.62)***
Adj. R^2	0.524	0.534	0.560	0.519	0.264	0.261	0.286	0.305

[1]: The sample for pricing deviations covers the period 05/19/1997 - 06/27/2008. The dependent variable is the average pricing deviation for 2-week windows. There are 267 observations.

[2]: The sample for specialness covers the period 05/19/1999 - 06/27/2008. The dependent variable is the average specialness for 2-week windows.There are 219 observations.

Table 5…Cont'd.

Variable Definition:

Auction Size (offered to public): Auction size offered to the public (in billions of dollars)

Auction Size (total): Total size of auction offered (in billions of dollars)

Post-2003 Dummy: Dummy that takes the value of 1 if period is post-2003 and 0 otherwise

Bid-to-Cover Ratio: Ratio of amount of total bids received during the auction to total amount accepted, as reported in the *Treasury auction results* (obtained through *www.treasurydirect.gov/*)

% of Issuance Awarded to Dealers/Brokers: Percentage of the issue awarded to dealers/brokers (includes primary dealers, other commercial bank dealer departments, and other non-bank dealers and brokers), computed by dividing the amount awarded to this investor class with the total amount auctioned to the public. Data are obtained through the *Treasury Bulletins* found on *http://www.fms.treas.gov* (table PDO-4)

Average % of Issuance Awarded to Dealers/Brokers (per note): The above variable is averaged over the auctions, in the event of reopenings

% of Issuance Awarded to Foreigners: Percentage of the issue awarded to foreigners (includes private foreign entities, non-private foreign entities placing tenders external of the Federal Reserve Bank of New York (FRBNY), and official foreign entities placing tenders through FRBNY), computed by dividing the amount awarded to this investor class with the total amount auctioned. Data are obtained through the *Treasury Bulletins* found on *http://www.fms.treas.gov* (table PDO-4)

Average % of Issuance Awarded to Foreigners (per note): The above variable is averaged over the auctions, in the event of reopenings

Yield Difference: Difference between the logarithm of the bid yield of generic coupon strip (with same maturity date as the note) and the logarithm of the bid yield of the same strip at the issuance date. The variable takes the value of -1 if the difference between the yields is less than 10 basis points (bp) and +1 if the difference is more than 10 bp

% of Issuance Awarded to Foreigners x Yield Difference: Percentage of the issue awarded to foreigners is interacted with the yield difference variable

Average % of Issuance Awarded to Foreigners x Yield Difference: Percentage of the issue awarded to foreigners (per CUSIP) is interacted with the yield difference variable

Periods (2-weeks) until Off-the-Run: Number of periods (2-weeks) until the note becomes off-the-run

Reopened Issue Dummy: Dummy that takes the value of 1 if the note has been reopened and 0 otherwise

Future Reopening Issue Dummy: Dummy that takes the value of 1 if the note *will* be reopened in the future and 0 otherwise

Table 6

Principal Component Analysis

We report the posterior distributions of the cumulative percentage of total variation explained by the first six principal components obtained from daily deviations in bid quotes between a 10-year Treasury note and its replicating portfolio of fungible coupon STRIPS. 31 notes - identified by age - comprise the sample.

Panel A: Cumulative Proportion Explained by the first six Principal Components (May 1997 - December 2002), (1,466 obs., 31 Notes)

PC	2.5th %ile	5th %ile	25th %ile	Median	75th %ile	95th %ile	97.5th %ile	Mean	Std. Dev.
1	50.72%	51.03%	52.01%	52.68%	53.37%	54.34%	54.65%	52.69%	1.00%
2	64.06%	64.30%	65.04%	65.56%	66.07%	66.81%	67.06%	65.56%	0.76%
3	70.58%	70.78%	71.40%	71.84%	72.26%	72.87%	73.07%	71.83%	0.64%
4	76.12%	76.29%	76.81%	77.16%	77.51%	78.02%	78.18%	77.16%	0.52%
5	80.57%	80.71%	81.13%	81.42%	81.71%	82.13%	82.26%	81.42%	0.43%
6	84.38%	84.49%	84.84%	85.07%	85.31%	85.64%	85.75%	85.07%	0.35%

Panel B: Cumulative Proportion Explained by the first six Principal Components (January 2003 - June 2008), (1,433 obs., 31 Notes)

PC	2.5th %ile	5th %ile	25th %ile	Median	75th %ile	95th %ile	97.5th %ile	Mean	Std. Dev.
1	63.27%	63.59%	64.52%	65.17%	65.82%	66.76%	67.07%	65.17%	0.97%
2	75.90%	76.10%	76.73%	77.16%	77.59%	78.21%	78.41%	77.16%	0.64%
3	81.24%	81.40%	81.89%	82.22%	82.55%	83.03%	83.19%	82.22%	0.50%
4	84.33%	83.46%	84.87%	85.14%	85.42%	85.82%	85.95%	85.14%	0.41%
5	87.12%	87.23%	87.57%	87.80%	88.03%	88.36%	88.47%	87.80%	0.34%
6	89.20%	89.30%	89.58%	89.77%	89.97%	90.24%	90.33%	89.77%	0.29%

Panel C: Cumulative Proportion Explained by the first six Principal Components (January 2005 - June 2008), (910 obs., 31 Notes)

PC	2.5th %ile	5th %ile	25th %ile	Median	75th %ile	95th %ile	97.5th %ile	Mean	Std. Dev.
1	78.56%	78.85%	79.69%	80.28%	80.85%	81.67%	81.92%	80.27%	0.86%
2	85.26%	85.45%	86.03%	86.43%	86.82%	87.38%	87.55%	86.42%	0.58%
3	88.46%	88.61%	89.07%	89.38%	89.68%	90.12%	90.26%	89.37%	0.46%
4	90.39%	90.52%	90.90%	91.15%	91.41%	91.77%	91.88%	91.15%	0.38%
5	91.96%	92.06%	92.38%	92.60%	92.81%	93.11%	93.21%	92.59%	0.32%
6	93.24%	93.33%	93.60%	93.78%	93.96%	94.21%	94.29%	93.77%	0.27%

Table 7

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

We report summary statistics for the actual deliveries 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 represent median values and the numbers in square brackets are t-statistics for differences in sub-samples. 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 available to public)**
Sept. 1991 - June 2008	4.1	14.1	1.3
	(2.8)	(8.7)	(0.9)
Pre-2003 Contracts	4.4	11.5	0.9
	(3.0)	(7.8)	(0.6)
Post-2003 Contracts	3.5	19.5	2.2
	(2.7)	(9.6)	(1.5)
	[0.99]	[2.01]**	[4.75]***
June 2005 Contract	7.1	35.3	4.8
Contract with Max. Percentage	20.1 (Sept. 1991)	83.3 (Dec. 2006)	6.1 (Dec. 2006)

Panel B: Deliveries of the Most-Delivered Bond

	Percentage of:		
	Peak Open Interest	**Open Interest at Beginning of Delivery Month**	**Issue Size (available to public)**
Sept. 1991 - June 2008	3.8	13.3	15.2
	(2.7)	(7.8)	(8.4)
Pre-2003 Contracts	3.9	10.4	8.1
	(2.7)	(6.8)	(6.6)
Post-2003 Contracts	3.5	19.5	30.0
	(2.7)	(9.6)	(17.9)
	[0.48]	[2.30]**	[6.17]***
June 2005 Contract	7.1	35.3	59.2
Contract with Max. Percentage	20.1 (Sept. 1991)	82.9 (Dec. 2006)	86.6 (Sept. 2006)

Table 7…Cont'd.

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 % 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 Contracts (46 contracts)	16.8	148.8
	(16.8)	(149.7)
Post-2003 Contracts (21 contracts)	28.9	168.5
	(30.4)	(168.9)
	[10.86]***	[4.27]***
June 2005 Contract	18.9	151.5
Contract with Max. Percentage	38.4 (March 2007)	206.0 (March 2003)

Table 8

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

We report summary statistics and 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 expires in September, 1991, and the last contract expires in June, 2008. Panel A presents the statistics on the variables used in the regressions and panel B presents the regression results. 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 (in cents), 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 (in basis points), and a dummy that captures the post-2003 period. Seasonal (quarterly) dummies are also included, but not reported. The numbers in curly brackets present median values while the numbers in square brackets are t-statistics for differences in sub-samples. The numbers in parentheses are the t-statistics from the OLS regressions. 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.

Panel A: Descriptive Statistics

	Calendar Spread			Gross Basis		
	Mean	**Median**	**Std. Dev.**	**Mean**	**Median**	**Std. Dev.**
Sept. 1991 - June 2008 (67 contracts)	-85	-69	147	19	19	25
Pre-2003 Contracts (46 contracts)	-91	-66	172	19	18	25
Post-2003 Contracts (21 contracts)	-71	-70	67	18	22	26
	[0.51]			[0.22]		
June 2005 Contract	39			23		
Contract with Min. Value	-1180 (Dec. 1999)			-51 (Sept. 1999)		
Contract with Max. Value	39 (June 2005)			69 (March 1999)		

Panel B: OLS Regressions

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	0.01	0.00001	0.003	1.52	0.31
		(3.70)***	(2.88)***	(2.60)***	(0.47)	(5.21)***	
Deliveries of Most-Delivered Bond as a Percentage of its Issue Size	67	11.67	0.12	0.0001	0.01	23.18	0.47
		(3.18)***	(3.46)***	(3.19)***	(0.09)	(7.01)***	