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# Enhancing the Liquidity of U.S. Treasury Securities in an Era of Surpluses

## 1. Introduction and Summary

The market for U.S. Treasury debt provides a highly liquid underpinning for the broader markets in dollar-denominated fixed-income securities. However, liquidity in the Treasury market has become an increasing concern as the federal government's funding needs have lessened because trading is concentrated in recently issued, "on-the-run" securities (Chart 1). In August 1999, the U.S. Treasury Department outlined a strategy to maintain the supply of new notes and bonds by repurchasing "off-the-run" debt.[1] This paper describes several additional, complementary approaches to enhancing liquidity.

Our first suggestion is to reduce the fragmentation of trading in STRIPS by assigning the same CUSIP number to all STRIPS maturing on a common date—thus making those STRIPS fungible with each other. In addition to enhancing the liquidity of the STRIPS market, this action would ensure that STRIPS promising to pay the same amount on the same future date will trade at the same price, and it would enhance the internal integration of the market for notes and bonds as well as the integration of that market with the STRIPS market. In particular, it would result in very nearly identical market prices for identical cash flow streams, regardless of whether the flows are derived from notes or bonds or from portfolios of STRIPS.

We also suggest a reexamination of the structure of issue maturities, because heterogeneity with respect to maturity date can fragment trading and reduce liquidity. In particular, we suggest eliminating end-of-month maturities for two-year debt and integrating that debt with either bills (by issuing 104-week bills on a quad-weekly basis) or longer term notes and bonds (by issuing two-year notes with mid-month maturities on a monthly or quarterly basis). It would also be desirable to enhance the integration of bills with longer term notes and bonds, but aligning the maturity dates of those securities may be impractical.

The first two proposals can be viewed as extensions of steps taken previously by the Treasury Department. Our third proposal—a facility to allow market participants to exchange (with the Treasury) single-payment securities with similar but not identical maturities—is a more adventurous approach to enhancing liquidity. The proposal would result in more similar prices for securities with similar but not identical cash flows, and would further integrate the markets for Treasury debt. In particular, it would materially enhance the integration of the markets for bills and coupon-bearing notes and bonds.

The paper proceeds as follows. Section 2 defines liquidity, identifies its determinants, and comments on its benefits. Section 3 describes how recent Treasury debt management practices have promoted the goal of a liquid government securities market. Section 4 presents our proposal for the STRIPS program, Section 5 outlines two alternatives for reducing heterogeneity of issue maturity dates, and Section 6 describes the exchange facility. Section 7 summarizes our findings.

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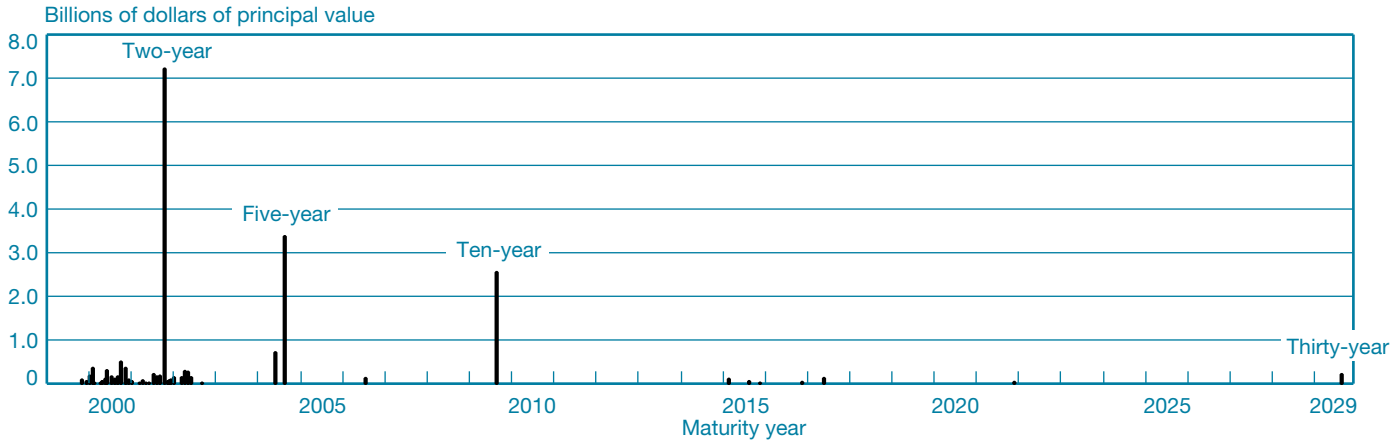
Chart 1

Interdealer Trading of Treasury Notes and Bonds on October 6, 1999




Note: On-the-run issues are labeled with term to maturity.

## 2. Liquidity and Asset Pricing

Asset pricing models commonly assume that markets are competitive and frictionless. Continuous time versions of such markets are perfectly liquid: an investor can purchase or sell as much as he or she wants at any time, instantaneously and at equilibrium prices. Real markets, however, are not perfectly liquid. An investor has to pay for the service of immediate order execution (in the form of a spread between the offer price at which he or she can buy and the bid price at which he or she can sell);[2] the investor faces wider spreads on larger orders; and, if the investor chooses to search for a more favorable transaction price, he or she must bear the costs of search and the risks of delay.[3]

Securities traded in markets where bid-ask spreads are narrow and relatively insensitive to the size of a transaction, where an acceptable counterparty can be located quickly and at low cost, and where prices are not volatile are said to be more liquid than securities traded in markets where spreads are both wider and more sensitive to transaction size, where search is costly and time-consuming, and where prices are volatile. For example, short-term Treasury securities are more liquid than longer term Treasury debt,[4] bills are more liquid than short-term notes and bonds,[5] larger issues are more liquid than smaller issues,[6] on-the-run securities are more liquid than seasoned obligations,[7] and—more generally—liquidity declines with the age of a security.[8]

Financial analysts concerned with minimizing capital costs have begun to pay more attention to liquidity in the wake of a series of papers establishing a connection between liquidity and asset pricing.[9] Amihud and Mendelson (1986) show that the return on common stock listed on the New York Stock Exchange is, *inter alia*, an increasing function of the bid-ask spread on the stock. Silber (1991) observes that companies issue unregistered stock (that cannot be resold in open market transactions for two years and that is relatively illiquid during that interval) at an average discount of more than 30 percent relative to the price of registered, but otherwise identical, stock. Several authors—including Garbade (1984), Amihud and Mendelson (1991a), and Kamara (1994)—point out the connection between (a) the yield spread between short-term Treasury notes and Treasury bills and (b) the superior liquidity of bills compared with notes. Warga (1992) examines the premium return on seasoned Treasury notes and bonds compared with on-the-run issues,[10] and Boudoukh and Whitelaw (1991, 1993) discuss the premium pricing of "benchmark" bonds in the Japanese government bond market. All of the papers conclude that liquidity is an important determinant of asset pricing and that more liquid issues have higher prices and lower returns.[11]

## 3. Liquidity and Treasury Debt Management

Minimizing the cost of funding the federal debt is a leading objective of Treasury debt management policy.[12] Since liquidity is an important determinant of borrowing costs, one could imagine a funding program designed to maximize the liquidity

of the securities issued. In the most extreme form, the Treasury Department could finance any current deficit, and refinance maturing debt, with frequent sales of large quantities of short-term bills. This would concentrate Treasury indebtedness in the most liquid sector of the market: large, short-maturity, and unseasoned discount obligations.

However, borrowing costs are affected by factors other than the liquidity of the securities issued. Most prominently, issuing exclusively in a narrow maturity sector might distort the shape of the yield curve and lead to more than minimal overall funding costs, and the Treasury has historically chosen to issue at a variety of short, intermediate, and long maturities.[13] This policy has ancillary benefits: it provides market participants with regular new issues of benchmark securities whose yields reflect the cost of credit for a default-proof borrower at a variety of maturities,[14] and it facilitates budget planning because it enhances the predictability of interest expenses during a fiscal year and over longer intervals.

Issuing securities at maturities beyond the money market sector undoubtedly reduces to some extent the liquidity of the Treasury market. Longer maturity debt is inherently less liquid than short-term debt, and a note or bond becomes more illiquid with the passage of time—as it migrates from on-the-run to off-the-run status.[15] Additionally, issuing longer term debt results in a greater number of issues and a smaller average size per issue, further reducing liquidity. These adverse consequences, however, are outweighed by the advantages of diffusing issuance across the curve.

## Innovations in Debt Management

Financing the federal debt by issuing securities at a variety of maturities means that the Treasury has to choose the maturities at which it will issue, the amount to be issued at each maturity, and the frequency of issue—for example, weekly, monthly, or quarterly. The Treasury's choices have changed from time to time in light of evolving market conditions, the size of the deficit, and refinancing requirements.

The Treasury has adjusted its funding program several times during the past fifteen years with the explicit objective of minimizing borrowing costs. It canceled the twenty-year bond in April 1986,[16] the four-year note in December 1990,[17] and the seven-year note in May 1993,[18] and it increased the frequency of issuing five-year notes from quarterly to monthly in December 1990.[19]

Although the Treasury has, from time to time, adjusted its funding program for strategic reasons, it has not usually varied the size of individual offerings tactically—that is, in response to short-run changes in investor demand for particular maturities. For example, it has not attempted to benefit systematically from an unusually strong demand for bills maturing at the end of a calendar month, quarter, or year; for bills maturing immediately before a tax payment date; or for bills deliverable on a futures contract.[20] Instead, it has maintained fairly steady issue sizes and regular terms.[21] One consequence of this policy is the tendency for exceptionally large bill issues—including cash management issues and bills first issued as fifty-two-week bills and then reopened as twenty-six-week bills and again as thirteen-week bills—to trade at yields higher than those on nearby bills with smaller outstanding issue sizes.[22]

## Debt Management Practices Intended to Reduce Borrowing Costs by Enhancing Liquidity

Some features of Treasury debt management practices have been adopted with the specific objective of reducing borrowing costs by enhancing the liquidity of Treasury securities. The most prominent example is the modification of the fifty-two-week bill cycle initiated in late 1979.

Up to and including the issuance, on October 16, 1979, of the bill maturing October 14, 1980, fifty-two-week bills were issued (once every four weeks) on a Tuesday and matured on a Tuesday.[23] As a result, fifty-two-week bills were not fungible with subsequent issues of twenty-six-week and thirteen-week bills, which matured on Thursdays.[24] On November 1, 1979, the Treasury announced that fifty-two-week bills would henceforth mature on a Thursday and that they would be fungible with subsequent issues of twenty-six-week bills and thirteen-week bills with the same maturity date.[25] The Treasury stated that the change would "reduce the number of separate bills outstanding . . . and *improve liquidity* [emphasis added] for the fifty-two-week bills."[26]

Similarly, the Treasury has taken advantage of opportunities to reopen outstanding notes and bonds in lieu of issuing new securities. The most important and frequent examples are reopenings of the most recently auctioned ten-year note and thirty-year bond.[27] Table 1 shows new issues and reopenings of those securities over the past decade.

Additionally, the Treasury has reopened an old five-year note in a shorter term cycle on three occasions:

- in May 1988, the 8 1/2 percent note of May 15, 1991 (issued as a five-year note on March 5, 1986), was reopened as a three-year note;

Table 1

## Ten-Year Note and Thirty-Year Bond Offerings in the Quarterly Financing Auctions: 1990-99

| Year | Month | Ten-Year Note | Thirty-Year Bond |
|---|---|---|---|
| 1990 | Feb. | 8 1/2% of Feb. 15, 2000 | 8 1/2% of Feb. 15, 2020 |
| | May | 8 7/8% of May 15, 2000 | 8 3/4% of May 15, 2020 |
| | Aug. | 8 3/4% of Aug. 15, 2000 | 8 3/4% of Aug. 15, 2020 |
| | Nov. | 8 1/2% of Nov. 15, 2000 | **8 3/4% of Aug. 15, 2020** |
| 1991 | Feb. | 7 3/4% of Feb. 15, 2001 | 7 7/8% of Feb. 15, 2021 |
| | May | 8% of May 15, 2001 | 8 1/8% of May 15, 2021 |
| | Aug. | 7 7/8% of Aug. 15, 2001 | 8 1/8% of Aug. 15, 2021 |
| | Nov. | 7 1/2% of Nov. 15, 2001 | 8% of Nov. 15, 2021 |
| 1992 | Feb. | **7 1/2% of Nov. 15, 2001** | **8% of Nov. 15, 2021** |
| | May | 7 1/2% of May 15, 2002 | **8% of Nov. 15, 2021** |
| | Aug. | 6 3/8% of Aug. 15, 2002 | 7 1/4% of Aug. 15, 2022 |
| | Nov. | **6 3/8% of Aug. 15, 2002** | 7 5/8% of Nov. 15, 2022 |
| 1993 | Feb. | 6 1/4% of Feb. 15, 2003 | 7 1/8% of Feb. 15, 2023 |
| | May | **6 1/4% of Feb. 15, 2003** | **7 1/8% of Feb. 15, 2023** |
| | Aug. | 5 3/4% of Aug. 15, 2003 | 6 1/4% of Aug. 15, 2023 |
| | Nov. | **5 3/4% of Aug. 15, 2003** | Not offered |
| 1994 | Feb. | 5 7/8% of Feb. 15, 2004 | **6 1/4% of Aug. 15, 2023** |
| | May | 7 1/4% of May 15, 2004 | Not offered |
| | Aug. | 7 1/4% of Aug. 15, 2004 | 7 1/2% of Nov. 15, 2024[a] |
| | Nov. | 7 7/8% of Nov. 15, 2004 | Not offered |
| 1995 | Feb. | 7 1/2% of Feb. 15, 2005 | 7 5/8% of Feb. 15, 2025 |
| | May | 6 1/2% of May 15, 2005 | Not offered |
| | Aug. | 6 1/2% of Aug. 15, 2005 | 6 7/8% of Aug. 15, 2025 |
| | Nov. | 5 7/8% of Nov. 15, 2005 | Not offered |
| 1996 | Feb. | 5 5/8% of Feb. 15, 2006 | 6% of Feb. 15, 2026 |
| | May | 6 7/8% of May 15, 2006 | Not offered |
| | Aug. | **7% of July 15, 2006**[b] | 6 3/4% of Aug. 15, 2026 |
| | Nov. | **6 1/2% of Oct. 15, 2006**[c] | 6 1/4% of Nov. 15, 2026 |
| 1997 | Feb. | 6 1/4% of Feb. 15, 2007 | 6 5/8% of Feb. 15, 2027 |
| | May | 6 5/8% of May 15, 2007 | Not offered |
| | Aug. | 6 1/8% of Aug. 15, 2007 | 6 3/8% of Aug. 15, 2027 |
| | Nov. | **6 1/8% of Aug. 15, 2007** | 6 1/8% of Nov. 15, 2027 |
| 1998 | Feb. | 5 1/2% of Feb. 15, 2008 | **6 1/8% of Nov. 15, 2027** |
| | May | 5 5/8% of May 15, 2008 | Not offered |
| | Aug. | **5 5/8% of May 15, 2008** | 5 1/2% of Aug. 15, 2028 |
| | Nov. | 4 3/4% of Nov. 15, 2008 | 5 1/4% of Nov. 15, 2028 |
| 1999 | Feb. | **4 3/4% of Nov. 15, 2008** | 5 1/4% of Feb. 15, 2029 |
| | May | 5 1/2% of May 15, 2009 | Not offered |
| | Aug. | 6% of Aug. 15, 2009 | 6 1/8% of Aug. 15, 2029 |
| | Nov. | **6% of Aug. 15, 2009** | Not offered |

Note: Reopenings are in bold type.

[a]30-1/4-year bond; see endnote 21.
[b]Reopening of a ten-year note first offered in July 1996.
[c]Reopening of a ten-year note first offered in October 1996.

- in October 1994, the 6 7/8 percent note of October 31, 1996 (issued as a five-year note on October 31, 1991), was reopened as a two-year note; and
- in February 1996, the 5 1/8 percent note of February 28, 1998 (issued as a five-year note on March 1, 1993), was reopened as a two-year note.

The Treasury also stated that it was prepared to reopen an old five-year note in the two-year note auctions in April, July, September, and October 1995.[28]

During 1998, the Treasury altered its debt management practices on two occasions to maintain the liquidity of Treasury securities. In early March, it announced that contrary to past practice, it would offer a larger face amount of twenty-six-week bills than thirteen-week bills in the auctions to be held on Monday, March 9. The change was in response to strong demand for twenty-six-week bills from foreign central banks and the desire to ensure that sufficient bills reached the hands of domestic investors. The Deputy Assistant Secretary for Federal Finance characterized the change as "an effort to *maintain liquidity* [emphasis added] in the market."[29] The Treasury continued to offer unequal amounts of thirteen-week and twenty-six-week bills until the auction of Monday, September 21, 1998.

In May 1998, the Treasury announced that the three-year note cycle would be eliminated and that those notes would be replaced in the quarterly financings by five-year notes.[30] The action was taken in response to substantial budget surpluses and to avoid reducing the issuance sizes of two-, five-, and ten-year notes and thirty-year bonds (out of concern that smaller issues would be less liquid). The Assistant Secretary for Financial Markets remarked, "We chose to concentrate on having fewer, larger, issues."[31]

## How Some Initiatives to Reduce Borrowing Costs May Have Adversely Affected the Liquidity of Conventional Notes and Bonds

The Treasury has shown great sensitivity to the importance of maintaining and enhancing the liquidity of Treasury securities. Nevertheless, some Treasury initiatives intended to reduce borrowing costs may have adversely affected liquidity. These initiatives reflect the principle, noted in the beginning of this section, that liquidity is only one factor affecting borrowing costs and that, in some cases, it can be outweighed by other considerations.[32]

On two occasions, the Treasury introduced novel securities intended to appeal to investors with specialized interests. Between 1984 and 1986, it sold a total of four foreign-targeted

Treasury notes,[33] and in January 1997 it introduced inflation-indexed securities. (Table 2 provides details on the inflation-indexed securities offerings.) Both programs were undertaken with the intention of reducing borrowing costs by issuing securities tailored to exploit specific market niches.[34] However, both programs also led to the issuance of securities that turned out to be materially less liquid than conventional Treasury issues,[35] and both led to the reduced issuance of conventional notes and bonds, thus reducing the liquidity of the markets for those securities.[36]

### *The STRIPS Program*

Similar comments apply to the STRIPS program, introduced in early 1985, that provided for the separation of the interest and principal payments on a note or bond into single-payment, or "zero-coupon," obligations.

The new obligations were patterned on private sector zero-coupon custodial receipts that had appeared in August 1982.[37] The statement announcing the STRIPS program indicated that "zero-coupon securities . . . have become very popular for those who wish to avoid reinvestment risk or seek greater certainty in matching the maturities of their assets and liabilities. They have been particularly attractive investments for individual retirement accounts and pension funds." The statement noted that the private receipts had "broadened the market for Treasury securities" and produced "significant savings in financing costs."[38] In addition, the statement noted that "STRIPS will greatly reduce . . . financing costs . . . and facilitate further expansion of the zero-coupon market. The savings made possible by STRIPS will be reflected in the competitive bidding for Treasury securities."[39] At the same time, however, stripping led to the creation of relatively less liquid single-payment interest component STRIPS and principal component STRIPS, and may have reduced the liquidity of underlying notes and bonds by reducing the outstanding supplies of those securities.[40]

*Innovations that mitigated the STRIPS program's impact on conventional note and bond liquidity.* Two subsequent modifications to the STRIPS program mitigated whatever adverse impact that program may have had on the liquidity of the Treasury market.

Effective July 29, 1985, all interest component STRIPS payable on a common date were assigned a common CUSIP number and became fungible with each other. Under the original program, interest component STRIPS payable on a common date had different CUSIPs (and, therefore, were not fungible) if they were derived from securities with different CUSIPs. The statement announcing the change noted that it would "further *increase the liquidity* [emphasis added] of the STRIPS program . . . thereby reducing transactions costs and at the same time broadening the marketability of STRIPS."[41]

The second modification became effective May 1, 1987, and provided that principal component STRIPS could be "reconstituted" with interest component STRIPS into the notes or bonds from which they were derived. The statement announcing the change observed that the new facility would "*enhance the . . . liquidity* [emphasis added] . . . of Treasury securities."[42]

*Remaining limitations on the fungibility of all STRIPS maturing on a common date.* Although the STRIPS program has, since July 1985, provided for fungibility of interest component STRIPS maturing on a common date, it has not provided for comparable fungibility of principal component STRIPS derived from different coupon-bearing securities maturing on the same date, or of interest component STRIPS and principal component STRIPS maturing on a common date.

As illustrated in Table 3, this has resulted in numerous cases of pairs of STRIPS—and four cases of triplets of STRIPS—trading at different prices and yields, even though they mature on the same future date.[43] It is not unreasonable to assume that fragmentation of trading in STRIPS with identical payment characteristics has led to higher transaction costs and lower liquidity than would otherwise be the case.[44]

TABLE 2
### Offerings of Inflation-Indexed Securities

| Auction Date | Description | Issue Size and Date |
|---|---|---|
| Jan. 29, 1997 | 3 3/8% of Jan. 15, 2007 | $7.7 billion on Feb. 6, 1997 |
| Apr. 8, 1997 | **3 3/8% of Jan. 15, 2007** | $8.4 billion on Apr. 15, 1997 |
| July 9, 1997 | 3 5/8% of July 15, 2002 | $8.4 billion on July 15, 1997 |
| Oct. 8, 1997 | **3 5/8% of July 15, 2002** | $8.4 billion on Oct. 15, 1997 |
| Jan. 8, 1998 | 3 5/8% of Jan. 15, 2008 | $8.4 billion on Jan. 15, 1998 |
| Apr. 8, 1998 | 3 5/8% of Apr. 15, 2028 | $8.4 billion on Apr. 15, 1998 |
| July 8, 1998 | **3 5/8% of Apr. 15, 2028** | $8.4 billion on July 15, 1998 |
| Oct. 7, 1998 | **3 5/8% of Jan. 15, 2008** | $8.4 billion on Oct. 15, 1998 |
| Jan. 6, 1999 | 3 7/8% of Jan. 15, 2009 | $8.5 billion on Jan. 15, 1999 |
| Apr. 7, 1999 | 3 7/8% of Apr. 15, 2029 | $7.4 billion on Apr. 15, 1999 |
| July 7, 1999 | **3 7/8% of Jan. 15, 2009** | $7.4 billion on July 15, 1999 |
| Oct. 6, 1999 | **3 7/8% of Apr. 15, 2029** | $7.4 billion on Oct. 15, 1999 |

Note: Reopenings are in bold type.

Table 3

### Yields on July 22, 1999, on Nonfungible STRIPS Maturing on the Same Date

| Maturity Date | Interest Component STRIPS (Percent) | Note Principal Component STRIPS (Percent) | Bond Principal Component STRIPS (Percent) |
|---|---|---|---|
| Feb. 15, 2004 | 5.80 | 5.69 | N.A. |
| May 15 | 5.82 | 5.75 | N.A. |
| Aug. 15 | 5.79 | 5.78 | N.A. |
| Nov. 15 | 5.86 | 5.81 | 5.89 |
| Feb. 15, 2005 | 5.91 | 5.84 | N.A. |
| May 15 | 5.93 | 5.83 | 5.95 |
| Aug. 15 | 5.95 | 5.86 | 5.97 |
| Nov. 15 | 5.93 | 5.86 | N.A. |
| Feb. 15, 2006 | 5.96 | 5.86 | 5.91 |
| May 15 | 5.97 | N.A. | N.A. |
| Aug. 15 | 5.99 | N.A. | N.A. |
| Nov. 15 | 5.96 | N.A. | N.A. |
| Feb. 15, 2007 | 6.02 | N.A. | N.A. |
| May 15 | 6.03 | N.A. | N.A. |
| Aug. 15 | 6.03 | N.A. | N.A. |
| Nov. 15 | 6.00 | N.A. | N.A. |
| Feb. 15, 2008 | 6.09 | N.A. | N.A. |
| May 15 | 6.11 | N.A. | N.A. |
| Aug. 15 | 6.12 | N.A. | N.A. |
| Nov. 15 | 6.13 | N.A. | N.A. |
| Feb. 15, 2009 | 6.14 | N.A. | N.A. |
| May 15 | 6.16 | N.A. | N.A. |
| Aug. 15 | 6.16 | N.A. | N.A. |
| Nov. 15 | 6.17 | N.A. | 6.27[a] |
| Feb. 15, 2010 | 6.19 | N.A. | N.A. |
| May 15 | 6.20 | N.A. | N.A. |
| Aug. 15 | 6.21 | N.A. | N.A. |
| Nov. 15 | 6.22 | N.A. | N.A. |

[a] Callable.

## 4. A Proposal to Reduce Heterogeneity in the STRIPS Market

Our first proposal is to reduce the fragmentation and enhance the liquidity of trading in STRIPS by eliminating distinctions among principal component STRIPS derived from different coupon-bearing securities maturing on the same date as well as eliminating the distinction between principal component STRIPS and interest component STRIPS paying on the same date. In particular, we propose that all STRIPS maturing on a common date should be fungible with each other and should be assigned a common CUSIP number.

Chart 2 shows STRIP yields on October 6, 1999. The dispersion of yields on STRIPS maturing on common dates is evident. By eliminating distinctions among STRIPS other than maturity date, the proposal would collapse STRIP yields onto a single curve of yield as a function of time to payment, and would thereby enhance the integration of the STRIPS market.

Because notes and bonds can be stripped quickly and at little cost, and because STRIPS can be similarly reconstituted into notes and bonds, arbitrage keeps the price of a note or bond very nearly equal to the sum of the prices of its component STRIPS.[45] Our proposal to reduce heterogeneity in the STRIPS market would thus result in very nearly identical market prices for identical cash flow streams—regardless of whether the cash flows are derived from portfolios of notes and bonds or from portfolios of STRIPS promising to make the same future payments—and would thereby enhance the integration of the market for notes and bonds as well as the integration of that market with the STRIPS market.

## Recent Characteristics of Note and Bond Market Integration

The implication of our proposal for the integration of the market for notes and bonds is especially significant in light of evidence that the internal cohesion of that market deteriorated in the fall of 1998 and has not subsequently recovered.

Chart 2

### Yields on Interest and Principal STRIPS on October 6, 1999

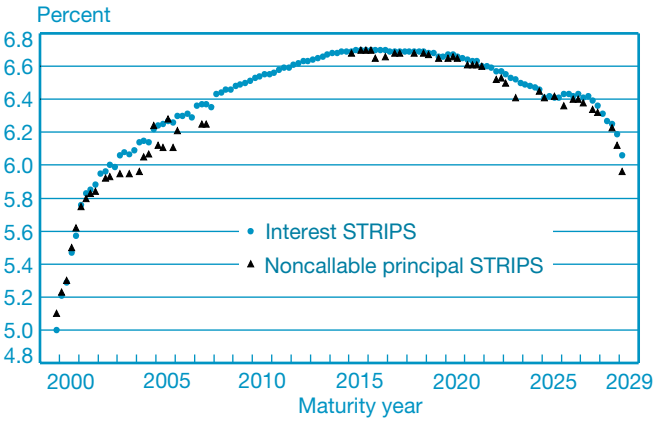


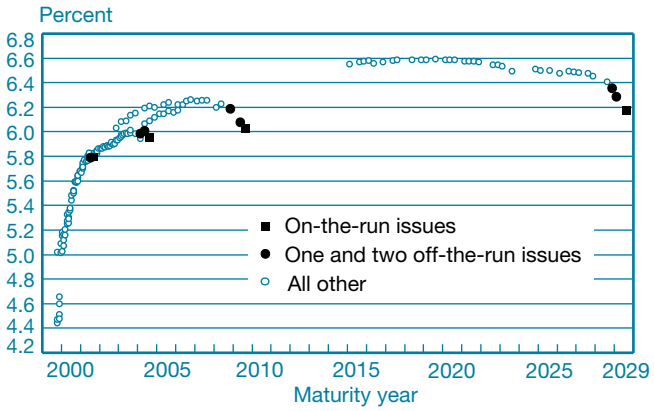
Chart 3 shows yields on coupon-bearing securities on October 6, 1999, as a function of time to maturity. There is no reason to expect the yields to lie on a curve because yield can vary with coupon rate as well as with time to maturity.

However, we might expect, at least to a first approximation, that the market prices the individual payments on notes and bonds from a common "spot," or single-payment, yield curve, so that the price of a portfolio of cash flows does not depend on the particular notes and bonds used to construct the portfolio. To examine this proposition, a cubic spline approximation to a spot yield curve pricing the underlying cash flows was fitted to the note and bond prices observed on October 6, 1999,[46] and the predicted prices were converted to yields. The median absolute difference between model yields and market yields was 1.9 basis points. This is a measure of the dispersion of the difference between the market values of the notes and bonds and the aggregate present values of the constituent future payments discounted with the fitted spot yield curve.

Chart 4 shows similar measures over the interval from July 1, 1993, to October 6, 1999. The increase in the median absolute difference in the fall of 1998 and the absence of any subsequent reversal are both evident. Since our proposal would result in very nearly identical market prices for identical cash flows, it would greatly reduce the median absolute difference between market yields and the yields computed from a spot yield curve fitted to yields on STRIPS. Therefore, it would help to reverse the increase in yield dispersion in the note and bond market.

Chart 3

Yields on Notes and Noncallable Bonds on October 6, 1999




## Elasticity in the Supply of Individual Notes and Bonds

A second significant implication of our proposal is that when there is unusually strong demand for a security, market participants could use the reconstitution facility to create more of the security than the Treasury Department originally issued. The proposal would not permit market participants to alter the Treasury's *aggregate* liabilities on any future date, including both interest liabilities and principal liabilities, but it would allow market participants to alter the packaging of the liabilities. For example, as illustrated in Box A, the market could convert a higher coupon security into STRIPS and a lower coupon security.

Box A

### Conversion of a Higher Coupon Security into a Lower Coupon Security and STRIPS

Here we describe how a market participant could convert $1.6 million principal value of the 11 5/8 percent bond of November 15, 2004, into (a) $1.6 million principal value of the 7 7/8 percent note of November 15, 2004, and (b) a portfolio of STRIPS, with a face amount of $30,000 each, payable every six months until and including May 15, 2004.

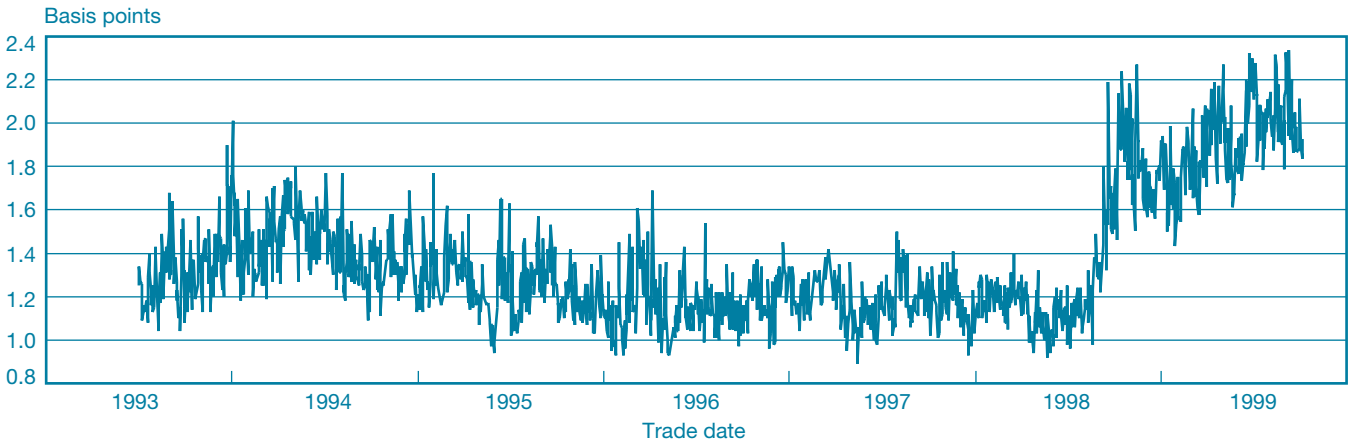
Following the interest payment on November 15, 1999, $1,600,000 principal amount of the 11 5/8 percent bond of November 15, 2004, promised to pay $93,000 interest every six months from May 15, 2000, to November 15, 2004, inclusive, and to repay principal of $1,600,000 at maturity. Assuming that all STRIPS maturing on the same date are fungible, $1,600,000 principal amount of the 11 5/8 percent bond could be stripped into nine STRIPS with a face amount of $93,000 each, payable every six months from May 15, 2000, to May 15, 2004, inclusive, and a tenth STRIP with a face amount of $1,693,000, payable on November 15, 2004.

Also following the interest payment on November 15, 1999, $1,600,000 principal amount of the 7 7/8 percent note of November 15, 2004, promised to pay $63,000 interest every six months from May 15, 2000, to November 15, 2004, inclusive, and to repay principal of $1,600,000 at maturity.

It follows that $1,600,000 principal amount of the 7 7/8 percent note could be reconstituted from the STRIPS derived from the 11 5/8 percent bond and that ten STRIPS, with a face amount of $30,000 each, payable every six months from May 15, 2000, to November 15, 2004, inclusive, would remain outstanding.

Chart 4

Median Absolute Difference between Market Yields and Model Yields, July 1, 1993, to October 6, 1999

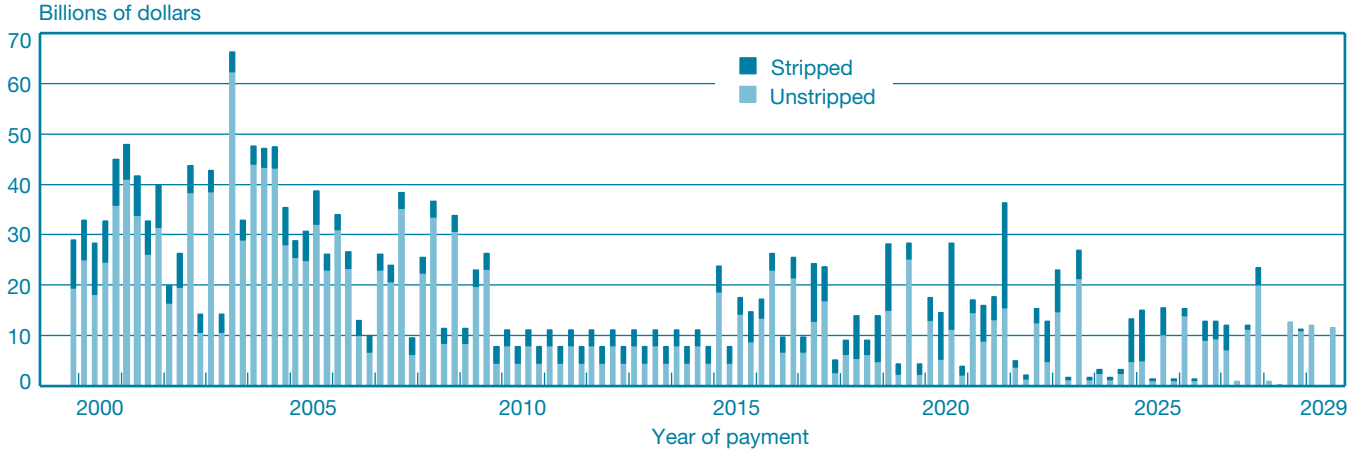



The decision of market participants to buy and strip a relatively inexpensive security, add or remove some STRIPS, and then reconstitute and sell a relatively expensive security is not undesirable because (as described above) it would keep the prices and yields of outstanding notes and bonds in line with each other. In particular, it would provide a mechanism for expanding the supply of a security that is "on special" in the financing market for specific collateral[47] and that is consequently expensive in the cash market.[48] It would also provide a "relief valve," not unlike the delivery options specified in futures contracts,[49] and would limit the prospect of squeezes and corners.[50]

Chart 5 illustrates (on a cash flow basis) how much noncallable Treasury debt with mid-quarter maturities has been stripped and how much more could be stripped. Table 4 shows (on a principal basis) the outstanding amounts and the maximum additional amounts that could be created by reconstituting STRIPS derived from other securities. The amounts are substantial, suggesting that "uncapping" the reconstitution feature could have a material impact on relative

Chart 5

Principal and Interest Liabilities Resulting from Treasury Notes and Noncallable Bonds Maturing in Midquarter, as of October 6, 1999



issue supplies and prices. However, as shown in Table 4, the potential addition to supply would be smaller the more distant a security's maturity date because there are fewer other cash flows available to expand the supply of a longer dated bond. In particular, the supply of the bond with the most distant maturity date would be limited to the amount issued.

## Tax Implications

Conversion of higher coupon notes and bonds into STRIPS and lower coupon notes and bonds, as illustrated in Box A, could lead to lower Treasury tax receipts on interest income. Assessing the magnitude of this effect is beyond the scope of

Table 4

### Principal Amount Outstanding (PAO) and Maximum Additional Amount (MAA) that Could Be Reconstituted from the Principal and Interest Liabilities in Chart 5

| Original Term (Years) | Coupon Rate (Percent) | Maturity Date | PAO (Billions of Dollars) | MAA (Billions of Dollars) | MAA as a Percentage of PAO |
|---|---|---|---|---|---|
| Ten | 7.875 | Nov. 15, 1999 | 10.77 | 17.13 | 159.0 |
| Ten | 8.500 | Feb. 15, 2000 | 10.67 | 20.94 | 196.3 |
| Ten | 8.875 | May 15, 2000 | 10.50 | 16.61 | 158.2 |
| Ten | 8.750 | Aug. 15, 2000 | 11.08 | 20.45 | 184.5 |
| Ten | 8.500 | Nov. 15, 2000 | 11.52 | 31.55 | 273.9 |
| Three | 5.750 | Nov. 15, 2000 | 16.04 | 27.61 | 172.2 |
| Ten | 7.750 | Feb. 15, 2001 | 11.31 | 34.92 | 308.6 |
| Three | 5.375 | Feb. 15, 2001 | 15.37 | 31.40 | 204.3 |
| Ten | 8.000 | May 15, 2001 | 12.40 | 27.66 | 223.1 |
| Three | 5.625 | May 15, 2001 | 12.87 | 27.65 | 214.8 |
| Ten | 7.875 | Aug. 15, 2001 | 12.34 | 19.25 | 156.0 |
| Ten | 7.500 | Nov. 15, 2001 | 24.23 | 14.10 | 58.2 |
| Ten | 7.500 | May 15, 2002 | 11.71 | 13.67 | 116.7 |
| Ten | 6.375 | Aug. 15, 2002 | 23.86 | 18.65 | 78.2 |
| Ten | 6.250 | Feb. 15, 2003 | 23.56 | 17.95 | 76.2 |
| Ten | 5.750 | Aug. 15, 2003 | 28.01 | 36.50 | 130.3 |
| Five | 5.250 | Aug. 15, 2003 | 19.85 | 44.82 | 225.8 |
| Five | 4.250 | Nov. 15, 2003 | 18.63 | 13.50 | 72.5 |
| Ten | 5.875 | Feb. 15, 2004 | 12.96 | 33.27 | 256.8 |
| Five | 4.750 | Feb. 15, 2004 | 17.82 | 28.66 | 160.8 |
| Ten | 7.250 | May 15, 2004 | 14.44 | 31.07 | 215.1 |
| Five | 5.250 | May 15, 2004 | 18.93 | 27.03 | 142.8 |
| Ten | 7.250 | Aug. 15, 2004 | 13.35 | 32.43 | 243.0 |
| Five | 6.000 | Aug. 15, 2004 | 18.09 | 27.97 | 154.6 |
| Twenty | 11.625 | Nov. 15, 2004 | 8.30 | 25.20 | 303.5 |
| Ten | 7.875 | Nov. 15, 2004 | 14.37 | 19.73 | 137.3 |
| Ten | 7.500 | Feb. 15, 2005 | 13.84 | 13.94 | 100.7 |
| Twenty | 12.000 | May 15, 2005 | 4.26 | 24.72 | 580.2 |
| Ten | 6.500 | May 15, 2005 | 14.74 | 15.02 | 101.9 |
| Twenty | 10.750 | Aug. 15, 2005 | 9.27 | 27.49 | 296.5 |
| Ten | 6.500 | Aug. 15, 2005 | 15.00 | 22.51 | 150.0 |
| Ten | 5.875 | Nov. 15, 2005 | 15.21 | 10.24 | 67.3 |
| Twenty | 9.375 | Feb. 15, 2006 | 4.76 | 27.83 | 585.2 |
| Ten | 5.625 | Feb. 15, 2006 | 15.51 | 17.67 | 113.9 |
| Ten | 6.875 | May 15, 2006 | 16.02 | 9.66 | 60.3 |
| Ten | 6.250 | Feb. 15, 2007 | 13.10 | 12.39 | 94.5 |
| Ten | 6.625 | May 15, 2007 | 13.96 | 9.22 | 66.1 |
| Ten | 6.125 | Aug. 15, 2007 | 25.64 | 11.63 | 45.4 |
| Ten | 5.500 | Feb. 15, 2008 | 13.58 | 11.31 | 83.2 |
| Ten | 5.625 | May 15, 2008 | 27.19 | 8.52 | 31.3 |
| Ten | 4.750 | Nov. 15, 2008 | 25.08 | 7.98 | 31.8 |
| Ten | 5.500 | May 15, 2009 | 14.79 | 7.55 | 51.1 |
| Ten | 6.000 | Aug. 15, 2009 | 14.76 | 10.85 | 73.5 |
| Thirty | 11.250 | Feb. 15, 2015 | 12.67 | 9.91 | 78.2 |
| Thirty | 10.625 | Aug. 15, 2015 | 7.15 | 9.57 | 133.9 |
| Thirty | 9.875 | Nov. 15, 2015 | 6.90 | 7.07 | 102.5 |
| Thirty | 9.250 | Feb. 15, 2016 | 7.27 | 9.32 | 128.2 |
| Thirty | 7.250 | May 15, 2016 | 18.82 | 6.50 | 34.5 |
| Thirty | 7.500 | Nov. 15, 2016 | 18.86 | 5.81 | 30.8 |
| Thirty | 8.750 | May 15, 2017 | 18.19 | 5.02 | 27.6 |
| Thirty | 8.875 | Aug. 15, 2017 | 14.02 | 8.74 | 62.3 |
| Thirty | 9.125 | May 15, 2018 | 8.71 | 4.63 | 53.1 |
| Thirty | 9.000 | Nov. 15, 2018 | 9.03 | 4.24 | 46.9 |
| Thirty | 8.875 | Feb. 15, 2019 | 19.25 | 7.92 | 41.1 |
| Thirty | 8.125 | Aug. 15, 2019 | 20.21 | 7.16 | 35.4 |
| Thirty | 8.500 | Feb. 15, 2020 | 10.23 | 6.73 | 65.8 |
| Thirty | 8.750 | May 15, 2020 | 10.16 | 3.82 | 37.6 |
| Thirty | 8.750 | Aug. 15, 2020 | 21.42 | 5.82 | 27.2 |
| Thirty | 7.875 | Feb. 15, 2021 | 11.11 | 5.43 | 48.8 |
| Thirty | 8.125 | May 15, 2021 | 11.96 | 3.36 | 28.1 |
| Thirty | 8.125 | Aug. 15, 2021 | 12.16 | 4.94 | 40.7 |
| Thirty | 8.000 | Nov. 15, 2021 | 32.80 | 2.10 | 6.4 |
| Thirty | 7.250 | Aug. 15, 2022 | 10.35 | 4.60 | 44.5 |
| Thirty | 7.625 | Nov. 15, 2022 | 10.70 | 1.72 | 16.0 |
| Thirty | 7.125 | Feb. 15, 2023 | 18.37 | 3.97 | 21.6 |
| Thirty | 6.250 | Aug. 15, 2023 | 22.91 | 3.30 | 14.4 |
| Thirty | 7.500 | Nov. 15, 2024 | 11.47 | 1.30 | 11.3 |
| Thirty | 6.750 | Aug. 15, 2026 | 10.89 | 1.71 | 15.7 |
| Thirty | 6.500 | Nov. 15, 2026 | 11.49 | 0.95 | 8.2 |
| Thirty | 6.625 | Feb. 15, 2027 | 10.46 | 1.37 | 13.1 |
| Thirty | 6.375 | Aug. 15, 2027 | 10.74 | 1.04 | 9.7 |
| Thirty | 6.125 | Nov. 15, 2027 | 22.52 | 0.28 | 1.2 |
| Thirty | 5.500 | Aug. 15, 2028 | 11.78 | 0.73 | 6.2 |
| Thirty | 5.250 | Nov. 15, 2028 | 10.95 | 0.00 | 0.0 |
| Thirty | 5.250 | Feb. 15, 2029 | 11.35 | 0.33 | 2.9 |
| Thirty | 6.125 | Aug. 15, 2029 | 11.18 | 0.00 | 0.0 |

this paper. However, we observe that what is important is the *net* effect on Treasury tax revenues, including

- forgone taxes on interest income from the higher coupon securities converted into lower coupon securities and STRIPS;
- increased taxes on the interest income from the lower coupon securities created by conversion;
- increased taxes on the annual accretions of discount on the STRIPS created by conversion; and
- the tax consequences of any capital gains or losses associated with the sale (for conversion) and conversion of higher coupon securities into lower coupon securities and STRIPS.

Among other things, the magnitudes of these tax effects depend on the tax brackets of the investors who sell and convert higher coupon debt and the tax brackets of the investors who acquire the lower coupon debt and STRIPS created by conversion.[51]

### Capping the Amount of a Note or Bond That Can Be Reconstituted

To limit any prospective loss of Treasury tax revenue, it would not be unreasonable to "cap" the amount of a note or bond that could be reconstituted. The cap could be set at the original issue size of the security (including any reopenings), less the currently outstanding stock of the security, plus an additional amount that could vary from security to security. The additional amount could, for example, be relatively generous for an issue priced substantially above its principal value and smaller for an issue priced at a material discount. Similarly, it could vary over time as market yields rise and fall.

Such a cap would not materially vitiate any of the benefits of the proposal related to fungibility and liquidity. However, it would allow the possibility of a note or bond becoming more expensive than the sum of the prices of the STRIPS that can be derived from the security. This would happen if reconstitution had expanded the supply of the security to its original issuance size plus the additional amount prescribed by the Treasury, so that no additional supplies could be created through further reconstitution in spite of the economic incentive.

## 5. A Proposal to Reduce Maturity Date Heterogeneity

The proposal presented in the preceding section was premised on the notion that fragmentation of trading in STRIPS with identical payment characteristics degrades liquidity, reduces the attractiveness of Treasury securities, and increases the cost of funding the federal debt.[52] Liquidity can also be degraded by fragmentation of trading in securities with heterogeneous payment characteristics. We observed in Section 3 that the Treasury Department has reduced the heterogeneity and enhanced the liquidity of its debt during the past twenty years by integrating fifty-two-week bills with twenty-six-week and thirteen-week bills; by reopening outstanding notes and bonds whenever possible; and—as illustrated in Table 5—by pruning selected offerings, including three-year, four-year, and seven-year notes as well as twenty-year bonds.[53]

Currently, bills mature on Thursdays, two-year notes mature at month-end, and five- and ten-year notes and thirty-year bonds mature at midquarter. Further simplification would be welcome.

Table 5
Number of New Treasury Securities Offerings, Excluding Reopenings

| | Fiscal Year | | |
|---|---|---|---|
| Offering | Oct. 1, 1984-Sept. 30, 1985 | Oct. 1, 1991-Sept. 30, 1992 | Oct. 1, 1998-Sept. 30, 1999 |
| Bills | | | |
| Cash management | 0 | 0 | 6 |
| Twenty-six-week | 39 | 38 | 40 |
| Fifty-two-week | 13 | 13 | 13 |
| Subtotal | 52 | 51 | 59 |
| Conventional notes and bonds | | | |
| Two-year | 13 | 12 | 12 |
| Three-year | 4 | 4 | 0 |
| Four-year | 4 | 0 | 0 |
| Five-year | 4 | 12 | 4 |
| Seven-year | 4 | 4 | 0 |
| Ten-year | 4 | 3 | 3 |
| Twenty-year | 3 | 0 | 0 |
| Thirty-year | 3 | 2 | 3 |
| Subtotal | 39 | 37 | 22 |
| Foreign-targeted notes | | | |
| Four-year | 1 | 0 | 0 |
| Five-year | 2 | 0 | 0 |
| Ten-year | 0 | 0 | 0 |
| Subtotal | 3 | 0 | 0 |
| Inflation-indexed notes and bonds | | | |
| Five-year | 0 | 0 | 0 |
| Ten-year | 0 | 0 | 1 |
| Thirty-year | 0 | 0 | 1 |
| Subtotal | 0 | 0 | 2 |
| Total | 94 | 88 | 83 |

One possibility is to alter the maturity of two-year notes to midmonth. In combination with our proposal to reduce heterogeneity in the STRIPS market, this would increase the integration of two-year notes maturing in the middle of the second month of each quarter with old five- and ten-year notes and thirty-year bonds maturing on the same dates. In some cases, it may be possible to reopen a seasoned security in the two-year note auction in the second month of a quarter.[54] However, unless the frequency of two-year issuance is reduced to once a quarter, the reduction in heterogeneity would be limited because there would still be cycles of two-year notes maturing in the middle of the first month and the third month of each quarter.

Alternatively, the Treasury could integrate the two-year debt program with the bill program, paralleling the change from monthly offerings of one-year bills to quad-weekly offerings of fifty-two-week bills maturing on Thursday.[55] In particular, the Treasury could replace its monthly offerings of two-year notes with quad-weekly offerings of 104-week bills. The cycle of 104-week bills could be timed so that the maturity dates of the bills fall midway between the maturity dates of subsequent offerings of fifty-two-week bills.[56]

## Integrating Bills with Notes and Bonds

Closer integration of the two-year debt program with either the bill program or the longer term note and bond program would reduce fragmentation and enhance liquidity, but the benefits of integrating bills with notes and bonds are potentially far greater.

Chart 6 shows that outstanding supplies of bills and short-term notes and bonds are of roughly similar magnitude.

However, bills are priced quite differently from coupon-bearing securities maturing only a few days earlier or later, or even on the same day. This is illustrated by the yield spreads of 20 to 30 basis points between bills and short-term notes and bonds shown in Chart 7. The greater value (lower yield) of bills is commonly attributed to the greater liquidity of those securities compared with notes and bonds of a similar maturity.[57] Closer integration of the two classes of securities could materially enhance the liquidity (and market value) of the notes and bonds. The prospect of improved liquidity and higher prices in the market for short-term coupon-bearing securities would, in turn, enhance the liquidity and value of intermediate-term securities and consequently lower the cost of funding the federal debt.

However, integrating bills and coupon-bearing securities more closely would appear to require that coupon payments be changed from intervals of six calendar months to intervals of 182 days. This would create unusual maturity sequences—five- and ten-year notes and thirty-year bonds would mature every 91 days, rather than every three calendar months—and would constitute a significant departure from present practice. In short, while two-year debt can be integrated with bills (by converting monthly issues of two-year notes to quad-weekly issuances of 104-week bills) or with longer term notes and bonds (by converting two-year notes to midmonth maturities), directly integrating bills and coupon-bearing securities may be impractical.

In view of the substantial benefits that would follow from closer integration, it is worth examining an indirect approach to integrating the bill program with the note and bond program. The next section describes how the markets for bills and coupon-bearing securities could be more closely

Chart 6

Monthly Bill, Note, and Bond Maturities, as of October 6, 1999

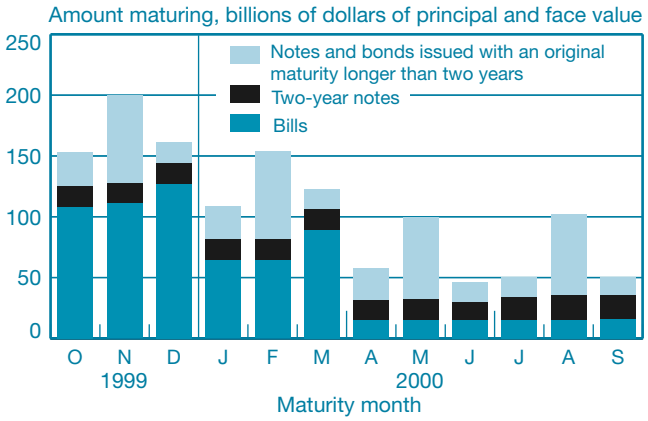
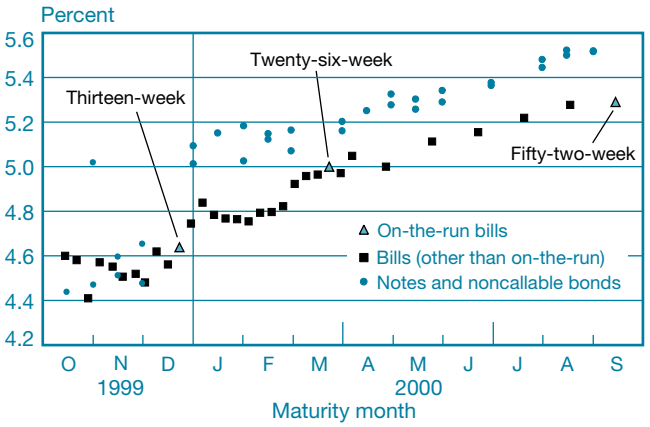



Chart 7

Yields on Treasury Bills, Notes, and Noncallable Bonds on October 6, 1999



integrated—without departing from present issuance practices—as an ancillary consequence of a facility designed to enhance further the liquidity of the markets for notes, bonds, and STRIPS.

## 6. A Third, More Adventurous Proposal to Enhance Liquidity

The contrast between yields on bills and yields on short-term notes and bonds shows that Treasury securities with similar payment characteristics but in different classes may be priced quite differently by market participants. Minor differences in security characteristics can also lead to anomalous yield structures within a security class.

For example, on July 22, 1999, Treasury bills maturing on September 23, September 30, and October 7, 1999, were offered at yields of 4.48 percent, 4.43 percent, and 4.51 percent, respectively. The 5-basis-point decline in yield from the September 23 bill to the September 30 bill and the relatively sharp 8-basis-point increase in yield from the September 30 bill to the October 7 bill are notable for a maturity sector where the bill yield curve generally had a mildly positive slope (Table 6).[58]

On the same date, interest component STRIPS maturing on August 15 and November 15, 2006, and on February 15, 2007, were offered at yields of 5.99 percent, 5.96 percent, and 6.02 percent, respectively. The 3-basis-point decline in yield from the August 2006 obligation to the November 2006 obligation and the more-than-offsetting 6-basis-point increase in yield from the November 2006 obligation to the February 2007 obligation are notable in a market where the yield curve for interest component STRIPS maturing between 2005 and 2010 was moderately positively sloped (Table 3).

The proposal outlined in Section 4 would enhance the liquidity of the Treasury market by making STRIPS with *identical* maturities *perfect* substitutes. Liquidity can be further enhanced by improving the substitutability of single-payment securities (including both STRIPS *and* Treasury bills) with similar, but not identical, maturities. In particular, while the Treasury cannot—and, indeed, should not—make STRIPS maturing in August and November 2006 and in February 2007 perfect substitutes for each other (in the sense of ensuring that they always trade at fixed yield spreads), it can make the securities better substitutes by permitting some elasticity in relative supplies that would reduce the prospect of more extreme variations in the relationships among the yields on the three securities.

Table 6
Treasury Bill Yields on July 22, 1999

| Maturity Date | Discount Rate (Percent) | Yield (Percent) |
|---|---|---|
| July 29, 1999 | 3.96 | 4.02 |
| Aug. 5 | 4.24 | 4.31 |
| Aug.12 | 4.33 | 4.40 |
| Aug. 19 | 4.33 | 4.40 |
| Aug. 26 | 4.32 | 4.40 |
| Sept. 2 | 4.39 | 4.47 |
| Sept. 9 | 4.38 | 4.47 |
| Sept. 16 | 4.37 | 4.46 |
| Sept. 23 | 4.39 | 4.48 |
| Sept. 30 | 4.33 | 4.43 |
| Oct. 7 | 4.41 | 4.51 |
| Oct. 14 | 4.44 | 4.55 |
| Oct. 21 | 4.46 | 4.57 |
| Oct. 28 | 4.47 | 4.59 |
| Nov. 4 | 4.50 | 4.62 |
| Nov. 12 | 4.51 | 4.64 |
| Nov. 18 | 4.50 | 4.63 |
| Nov. 26 | 4.50 | 4.64 |
| Dec. 2 | 4.51 | 4.65 |
| Dec. 9 | 4.54 | 4.69 |
| Dec. 16 | 4.55 | 4.70 |
| Dec. 23 | 4.56 | 4.71 |
| Dec. 30 | 4.50 | 4.66 |
| Jan. 6, 2000 | 4.44 | 4.60 |
| Jan. 13 | 4.44 | 4.60 |
| Jan. 20 | 4.46 | 4.63 |
| Jan. 27 | 4.51 | 4.68 |
| Feb. 3 | 4.41 | 4.57 |
| Mar. 2 | 4.51 | 4.68 |
| Mar. 30 | 4.51 | 4.69 |
| Apr. 27 | 4.54 | 4.73 |
| May 25 | 4.59 | 4.80 |
| June 22 | 4.66 | 4.88 |
| July 20 | 4.71 | 4.95 |

### The Proposal

Our third proposal is for an "exchange facility" that would allow market participants to exchange—with the Treasury—two single-payment securities (with very similar maturities and with face values of $1,000 each) for a single-payment security with an intermediate maturity and a $2,000 face value, and vice versa.

Suppose, for example, that a November 2006 STRIP is expensive relative to the August 2006 and February 2007 STRIPS—as was the case with interest component STRIPS on July 22, 1999 (Table 3). Market participants could then

exchange $1,000 face amount of each of the less expensive STRIPS for $2,000 face amount of the more expensive November 2006 STRIPS. Conversely, if the November 2006 STRIPS were relatively cheap, market participants could exchange $2,000 face amount of that security for $1,000 face amount each of the August 2006 and February 2007 STRIPS.

As described in more detail below, the exchange facility would bound very short-range irregularities in the structure of yields on single-payment securities, but it should be structured to avoid influencing the overall level and shape of the yield curve. To preclude any effects on the curve, we suggest that the Treasury impose a fee on exchanges and limit exchanges to "nearby" securities.[59]

### *An Exchange Fee*

We suggest that the Treasury impose a fee—specified in terms of yield and amounting to perhaps 2 or 3 basis points—on an exchange of single-payment securities. For purposes of computing the fee in dollar terms, the shorter and longer securities involved in an exchange would be valued at prevailing market yields. The intermediate security would be valued at the average, or interpolated, yield on the shorter and longer securities, plus or minus the prescribed fee.

Suppose, for example, that the exchange fee is set at 2 1/2 basis points. For illustrative purposes, let us use the yields on interest component STRIPS on July 22, 1999, from Table 3 and a settlement date of July 23, 1999. Since the average yield on the August 2006 and February 2007 STRIPS was 6.005 percent (6.005 percent is the average of 5.99 percent and 6.02 percent), a market participant could exchange $1,000 face amount of each of those STRIPS (priced at their respective market yields) for $2,000 face amount of November 2006 STRIPS priced at a yield of 5.98 percent (5.98 percent = 6.005 percent, less the 2-1/2-basis-point exchange fee). As shown in Box B, this would result in a cash payment to the Treasury of $2.27.

Alternatively, a market participant could exchange $2,000 face amount of November 2006 STRIPS priced at a yield of 6.03 percent (6.03 percent = 6.005 percent, plus the 2-1/2-basis-point exchange fee) for $1,000 face amount of August 2006 STRIPS and the same face amount of February 2007 STRIPS (priced at their respective market yields). As shown in Box C, this would result in a cash payment to the Treasury of $2.34.[60]

Appendix A discusses whether the size of the cash payment to the Treasury resulting from an exchange is sensitive to the yields used to value the obligations exchanged. We conclude that the size of the payment is relatively insensitive to modest variations in both the *levels* of the yields and the *difference between the yields* on the shorter and longer securities involved in the exchange. It does not appear that the Treasury, or its agent, would have to maintain unreasonably close contact with evolving market conditions to price an exchange with acceptable accuracy. Thus, it would not be impractical for the Treasury to announce a schedule of yields on single-payment securities at the end of the day and to receive requests for

Box B

### Exchange of Shorter and Longer Maturity STRIPS for an Intermediate-Maturity STRIP

Consider the exchange of

- $1,000 face amount of STRIPS maturing August 15, 2006, quoted on July 22, 1999, at a yield of 5.99 percent for settlement on July 23, 1999, and
- $1,000 face amount of STRIPS maturing February 15, 2007, quoted on July 22, 1999, at a yield of 6.02 percent for settlement on July 23, 1999,

for

- $2,000 face amount of STRIPS maturing November 15, 2006.

The shorter obligation has an invoice price of 65.90911 percent of face value,[a] and the longer obligation has an invoice price of 63.85172 percent of face value.[b] For purposes of the exchange, the intermediate obligation is valued at a yield of 5.98 percent (5.98 percent = 1/2 of 5.99 percent and 6.02 percent, minus 2 1/2 basis points) or at an invoice price of 64.99385 percent of face value.[c]

The net funds due the Treasury at the time of the exchange on July 23, 1999, are $2.2687, computed as

- 64.99385 percent of $2,000 for the intermediate obligation, less
- 65.90911 percent of $1,000 credit for the shorter obligation, less
- 63.85172 percent of $1,000 credit for the longer obligation.

[a] $65.90911 = 100(1+\frac{1}{2}.0599)^{-(14+(23/181))}$, where the obligation has 23 days plus 14 full semiannual periods remaining to maturity, and where there are 181 days in the semiannual interval from February 15, 1999, to August 15, 1999.

[b] $63.85172 = 100(1+\frac{1}{2}.0602)^{-(15+(23/181))}$, where the obligation has 23 days plus 15 full semiannual periods remaining to maturity.

[c] $64.99385 = 100(1+\frac{1}{2}.0598)^{-(14+(115/184))}$, where the obligation has 115 days plus 14 full semiannual periods remaining to maturity, and where there are 184 days in the semiannual interval from May 15, 1999, to November 15, 1999.

exchanges pursuant to that schedule up to the opening of the market the following morning.

The proposed exchange facility would bound very short-range irregularities in the structure of yields on single-payment securities such as those described in the introduction to this section. The market yield on a single-payment security could never differ by more than the exchange fee from the average of the market yields on a pair of shorter and longer term single-payment securities for which it can be exchanged. Thus, for example, the market yield on a November 2006 STRIP would have to be in the interval of 5.98 percent to 6.03 percent if the market yields on the August 2006 and February 2007 STRIPS were 5.99 percent and 6.02 percent, respectively.

Box C

## Exchange of an Intermediate-Maturity STRIP for Shorter and Longer Maturity STRIPS

Consider the exchange of

- $2,000 face amount of STRIPS maturing November 15, 2006,

for

- $1,000 face amount of STRIPS maturing August 15, 2006, quoted on July 22, 1999, at a yield of 5.99 percent for settlement on July 23, 1999, and
- $1,000 face amount of STRIPS maturing February 15, 2007, quoted on July 22, 1999, at a yield of 6.02 percent for settlement on July 23, 1999.

The shorter obligation has an invoice price of 65.90911 percent of face value,[a] and the longer obligation has an invoice price of 63.85172 percent of face value.[b] For purposes of the exchange, the intermediate obligation is valued at a yield of 6.03 percent (6.03 percent = 1/2 of 5.99 percent and 6.02 percent, plus 2 1/2 basis points) or at an invoice price of 64.76355 percent of face value.[c]

The net funds due the Treasury at the time of the exchange on July 23, 1999, are $2.3373, computed as

- 65.90911 percent of $1,000 for the shorter obligation, plus
- 63.85172 percent of $1,000 for the longer obligation, less
- 64.76355 percent of $2,000 credit for the intermediate obligation.

[a] $65.90911 = 100(1+\frac{1}{2}.0599)^{-(14+(23/181))}$, where the obligation has 23 days plus 14 full semiannual periods remaining to maturity, and where there are 181 days in the semiannual interval from February 15, 1999, to August 15, 1999.

[b] $63.85172 = 100(1+\frac{1}{2}.0602)^{-(15+(23/181))}$, where the obligation has 23 days plus 15 full semiannual periods remaining to maturity.

[c] $64.76355 = 100(1+\frac{1}{2}.0603)^{-(14+(115/184))}$, where the obligation has 115 days plus 14 full semiannual periods remaining to maturity, and where there are 184 days in the semiannual interval from May 15, 1999, to November 15, 1999.

### *Limiting Exchanges to "Nearby" Securities*

To preclude the possibility that the exchange facility will do more than bound short-range irregularities in the structure of yields on single-payment securities, the difference between the maturities of the longer and shorter securities that can be exchanged for an intermediate-maturity security should be limited, possibly as suggested in Table 7. Appendix B discusses in more detail the implications of the limitations in Table 7 for the shape of the yield curve.[61]

### *Other Limitations*

In addition to limitations like those in Table 7, it may be desirable to limit the maximum increase or decrease in the amount payable on a given date to prevent the development of large variations in rollover financing requirements. This cap would be similar to the cap on reconstitution discussed in Section 4, but here it would limit the increase or decrease in aggregate Treasury liabilities payable on a given date, rather than the principal amount of a note or bond that can be created by reconstituting STRIPS derived from other securities.

Table 7

## Suggested Limitations on Exchanges of Single-Payment Securities

| If the intermediate-maturity security in a proposed exchange has a remaining term to maturity of . . . | . . . Then the difference between the maturities of the shorter and longer securities that can be exchanged for the intermediate-maturity security should be no more than . . . |
|---|---|
| Less than thirteen weeks | Two weeks |
| Less than twenty-six weeks | Four weeks |
| Less than fifty-two weeks | Six weeks |
| Less than two years | Four months |
| More than two years | Six months |

To facilitate the Treasury's planning for rollover financings, it may also be desirable to prohibit exchanges that involve any security with less than a month or six weeks remaining to maturity.

## Benefits of the Proposal

We believe that the proposed exchange facility would enhance the liquidity of STRIPS and off-the-run Treasury notes and bonds and would increase the integration of the bill market with the markets for short-term STRIPS and coupon-bearing securities.

### *Liquidity Enhancement*

The proposal would improve the substitutability of substantially similar single-payment securities by limiting the range of relative variation of yields on securities with very nearly identical payment characteristics. This can have important consequences for the liquidity of Treasury securities.

For example, a dealer could satisfy a customer's interest in purchasing $10 million face amount of a STRIP that the dealer did not already own by selling the STRIP short and then hedging the risk of loss on the short sale (to no more than twice the exchange fee) by purchasing $5 million each of a somewhat shorter STRIP and a somewhat longer STRIP.[62] We believe that limiting basis risk on hedged short sales will lead to a more liquid STRIPS market with narrower bid-ask spreads. Similar comments apply to the markets for notes and bonds because those securities are linked to STRIPS through stripping and reconstitution.

### *Market Integration*

The proposal would also lead to a sharp reduction in the yield spread between STRIPS and bills as well as between short-term coupon-bearing securities and bills.

Large spreads between yields on STRIPS and yields on bills of a similar maturity cannot persist if—as illustrated in Box D—market participants can exchange (for a modest fee) $2,000 face amount of a STRIP maturing on November 15, 1999, for $1,000 face amount of a bill maturing on November 12 and $1,000 face amount of a bill maturing on November 18, 1999. The exchange facility would greatly enhance the integration of the relatively illiquid markets for short-term STRIPS and coupon-bearing securities with the much more liquid bill market. In particular, the spread between the yield on a short-term note or bond and the yield on a bill with a similar maturity would be limited to no more than the prescribed exchange fee (2 1/2 basis points in the prior example). The prospect of improved liquidity and higher prices in the markets for short-term coupon-bearing securities would, in turn, enhance the

Box D

### Exchange of an Intermediate-Maturity STRIP for Shorter and Longer Bills

Consider the exchange of

- $2,000 face amount of STRIPS maturing November 15, 1999,

for

- $1,000 face amount of bills maturing November 12, 1999, quoted on July 22, 1999, at a discount rate of 4.51 percent for settlement on July 23, 1999, and
- $1,000 face amount of bills maturing November 18, 1999, quoted on July 22, 1999, at a discount rate of 4.50 percent for settlement on July 23, 1999.

The shorter bill has a yield of 4.638 percent and an invoice price of 98.59689 percent of face value,[a] and the longer bill has a yield of 4.631 percent and an invoice price of 98.52500 percent of face value.[b] For purposes of the exchange, the intermediate STRIP is valued at a yield of 4.660 percent (4.660 percent = 1/2 of 4.638 percent and 4.631 percent, plus 2 1/2 basis points) or at an invoice price of 98.53322 percent of face value.[c]

The net funds due the Treasury at the time of the exchange on July 23, 1999, are $.1583, computed as

- 98.59689 percent of $1,000 for the shorter bill, plus
- 98.52500 percent of $1,000 for the longer bill, less
- 98.55303 percent of $2,000 credit for the intermediate STRIP.

[a] $98.59689 = 100 - \frac{112}{360}\,4.51$, where the bill has 112 days remaining to maturity. The yield is the value of R that satisfies the equation $98.59689 = 100(1+\frac{112}{365}\,R)^{-1}$, or R = .04638.

[b] $98.52500 = 100 - \frac{118}{360}\,4.50$, where the bill has 118 days remaining to maturity. The yield is the value of R that satisfies the equation $98.52500 = 100(1+\frac{118}{365}\,R)^{-1}$, or R = .04631.

[c] $98.55303 = 100(1+\frac{115}{365}\,.04660)^{-1}$, where the STRIP has 115 days remaining to maturity. Note that, for consistency, here we relate the yield and invoice price of the STRIP using the same equation used to relate the yield and invoice price of a bill with less than 183 days remaining to maturity.

liquidity and value of intermediate-term securities and consequently lower the cost of funding the federal debt.

Enhanced integration of the markets for short-term STRIPS and bills would not necessarily lead to exchanges of STRIPS for bills on a wholesale basis. Since positions in short-term STRIPS could be priced and hedged more reliably with bills of a comparable maturity, the superior liquidity of the bill market would spill over into the STRIPS market, making STRIPS more valuable and reducing the economic incentive for any actual exchange.[63] Phrased another way, the stated willingness of the Treasury to exchange bills for STRIPS at a modest fee would itself limit the incidence of such exchanges.

### *Other Benefits*

The proposed exchange facility would allow market conditions to influence, within limits prescribed by the Treasury, the amount of Treasury debt maturing on different dates. In contrast to present debt management practices, the amount payable on a particularly desirable date, such as the end of a calendar quarter, could expand in response to market demand, while the amounts payable on nearby dates contract dollar-for-dollar.

Our proposal can be viewed as a market-driven substitute for tactical variations in primary market offerings in response to unusually strong investor demand for particular maturities. It is analogous to the philosophy that motivated the 1985 decision by the Treasury to facilitate bond stripping rather than to issue zero-coupon securities itself:

> The investment community will be better able [than the Treasury] to offer zero-coupon instruments that meet particular needs in a timely manner. The market for zero-coupon securities is a rapidly changing one. The demand varies substantially for particular maturities and with changes in interest rates and in the needs of various investor classes. . . . This changing demand for zeros will be best accommodated by the STRIPS program of making a broad range of maturities eligible for stripping but *leaving it to the market to decide* [emphasis added] when and how much of an issue it will separate and market as zero-coupon instruments.[64]

As a related matter, by partially endogenizing the face amount of single-payment securities maturing on a particular date, the exchange facility—taken in conjunction with the proposal in Section 4 and the existing provision for reconstituting STRIPS into coupon-bearing securities—would provide another mechanism for expanding the supply of a security on special in the financing market for specific collateral. Additionally, the supply of a new, on-the-run security could increase beyond the original issuance amount in response to demand for the security, and then contract as the security migrated from on-the-run to off-the-run status.

And last, but not least, the revenue generated by the exchange fee would directly benefit the Treasury's objective of minimizing the cost of funding the federal debt.

## A Precedent for the Proposal

The proposed exchange facility is novel, but it is not without precedent. Each foreign-targeted Treasury note sold in the mid-1980s (see endnote 33) was exchangeable (throughout its life) for an equal principal amount of a conventional note with the same coupon rate and maturity date.[65] (Conventional notes that were issued in exchange for foreign-targeted notes increased the amount outstanding of a note that was originally sold contemporaneously with the foreign-targeted note.) Depending on when an exchange was made, a market participant electing to exchange a foreign-targeted note made a cash payment to the Treasury Department or received a cash payment from the Treasury. The payment accounted for the difference in value between annual payment of interest on the foreign-targeted note and semiannual payment of interest on the conventional note.

Thus, it is not unprecedented for the Treasury to issue additional amounts of an outstanding security, in exchange for a different security, in a transaction that results in a change in the timing of its future liabilities (but leaves the aggregate quantity of liabilities unchanged) and that involves a cash payment to account for the present value of the change in the timing of the future liabilities.[66]

## A Trial

We are not unaware that the proposed exchange facility may be viewed by some as a risky policy initiative. Therefore, we suggest the possibility of a limited trial.

The Treasury could adopt the facility but limit the facility's initial availability to bills and STRIPS with less than one year to maturity. If the program is deemed useful and in the public interest, it could be extended to securities with longer maturities. If, however, experience indicates that the program is ineffective or has unforeseen adverse consequences, the program could be terminated. The subsequent passage of time and redemption of debt would eradicate its effects within a year.[67]

## 7. Conclusion

The starting point for this paper is the belief that the reduction of limitations on the fungibility and substitutability of Treasury securities can enhance liquidity and lead to higher prices for those securities.[68]

We discussed three ways to expand the fungibility of identical cash flows and the substitutability of nearly identical liabilities. The fungibility of identical cash flows can be enhanced by allowing market participants who reconstitute STRIPS to substitute interest payments and principal payments due on the same date. Aligning the maturity dates of two-year debt with either the maturity dates of bills or the maturity dates of longer term debt would also reduce heterogeneity and enhance fungibility. Our third proposal, to establish an exchange facility, would directly enhance the substitutability of Treasury securities with nearly identical cash flows.

The market environment created by traders executing arbitrage and relative value transactions in light of expanded opportunities for reconstitution and exchange would complement efforts to maintain liquidity through buybacks of old issues and expanded offerings of new issues. The enhanced liquidity and market integration associated with improved substitutability and fungibility would increase demand and reduce the cost of funding the debt. Allowing the supply of a security to expand beyond its original issuance size would provide for some elasticity in the supply of on-the-run securities and reduce the risk of a squeeze. More generally, greater liquidity and market integration, reduced scarcity risk, and elasticity in the supply of on-the-run debt would help ensure the continued attractiveness of Treasury securities for investing, trading, and hedging in an era of surpluses.

## Appendix A: Sensitivity of the Cash Payment on an Exchange to the Yields on the Shorter and Longer Securities

In this appendix, we examine whether the size of the cash payment to the Treasury Department resulting from an exchange like the one proposed in Section 6 is sensitive to the yields used to value the obligations exchanged. In particular, do small changes in the yields on the shorter and longer securities result in very different cash payments, so that the Treasury, or its agent, would have to maintain close contact with evolving market conditions to price an exchange with reasonable accuracy?

Box A1 examines the same exchange as the one in Box B in the text, but prices the shorter and longer STRIPS (and hence the intermediate STRIP) at yields that are 10 basis points *lower* than the yields in Box B. The cash payment to the Treasury is $2.29, an amount that differs by less than 1 percent from the $2.27 payment calculated in Box B.

Box A2 also examines the same exchange as the one in Box B, but it uses a yield for pricing the shorter STRIP that is 5 basis points *lower* than the yield in Box B and uses a yield for pricing the longer STRIP that is 5 basis points *higher* than the yield in Box B. The cash payment to the Treasury is $2.34, an amount that differs by a bit more than 3 percent from the $2.27 payment calculated in Box B.

We conclude that the payment to the Treasury is relatively insensitive to moderate variations in (a) the levels of the yields and (b) the difference between the yields on the securities involved in the exchange.

Box A1

### Exchange of Shorter and Longer Maturity STRIPS for an Intermediate-Maturity STRIP When the Level of Yields Is 10 Basis Points Lower

Consider the exchange of

- $1,000 face amount of STRIPS maturing August 15, 2006, priced at a yield of 5.89 percent for settlement on July 23, 1999, and
- $1,000 face amount of STRIPS maturing February 15, 2007, priced at a yield of 5.92 percent for settlement on July 23, 1999,

for

- $2,000 face amount of STRIPS maturing November 15, 2006.

The shorter obligation has an invoice price of 66.36279 percent of face value,[a] and the longer obligation has an invoice price of 64.32239 percent of face value.[b] For purposes of the exchange, the intermediate obligation is valued at a yield of 5.88 percent (5.88 percent = 1/2 of 5.89 percent and 5.92 percent, minus 2 1/2 basis points) or at an invoice price of 65.45708 percent of face value.[c]

The net funds due the Treasury at the time of the exchange on July 23, 1999, are $2.2898, computed as

- 65.45708 percent of $2,000 for the intermediate obligation, less
- 66.36279 percent of $1,000 credit for the shorter obligation, less
- 64.32239 percent of $1,000 credit for the longer obligation.

[a] $66.36279 = 100(1+\frac{1}{2}.0589)^{-(14+(23/181))}$, where the obligation has 23 days plus 14 full semiannual periods remaining to maturity, and where there are 181 days in the semiannual interval from February 15, 1999, to August 15, 1999.

[b] $64.32239 = 100(1+\frac{1}{2}.0592)^{-(15+(23/181))}$, where the obligation has 23 days plus 15 full semiannual periods remaining to maturity.

[c] $65.45708 = 100(1+\frac{1}{2}.0588)^{-(14+(115/184))}$, where the obligation has 115 days plus 14 full semiannual periods remaining to maturity, and where there are 184 days in the semiannual interval from May 15, 1999, to November 15, 1999.

Box A2

## Exchange of Shorter and Longer Maturity STRIPS for an Intermediate-Maturity STRIP When the Difference between the Yields on the Longer and Shorter STRIPS Is 10 Basis Points Higher

Consider the exchange of

- $1,000 face amount of STRIPS maturing August 15, 2006, priced at a yield of 5.94 percent for settlement on July 23, 1999, and
- $1,000 face amount of STRIPS maturing February 15, 2007, priced at a yield of 6.07 percent for settlement on July 23, 1999,

for

- $2,000 face amount of STRIPS maturing November 15, 2006.

The shorter obligation has an invoice price of 66.13553 percent of face value,[a] and the longer obligation has an invoice price of 63.61776 percent of face value.[b] For purposes of the exchange, the intermediate obligation is valued at a yield of 5.98 percent (5.98 percent = 1/2 of 5.94 percent and 6.07 percent, minus 2 1/2 basis points) or at an invoice price of 64.99385 percent of face value.[c]

The net funds due the Treasury at the time of the exchange on July 23, 1999, are $2.3441, computed as

- 64.99385 percent of $2,000 for the intermediate obligation, less
- 66.13553 percent of $1,000 credit for the shorter obligation, less
- 63.61776 percent of $1,000 credit for the longer obligation.

[a] $66.13553 = 100(1+\frac{1}{2}.0594)^{-(14+(23/181))}$, where the obligation has 23 days plus 14 full semiannual periods remaining to maturity, and where there are 181 days in the semiannual interval from February 15, 1999, to August 15, 1999.

[b] $63.61776 = 100(1+\frac{1}{2}.0607)^{-(15+(23/181))}$, where the obligation has 23 days plus 15 full semiannual periods remaining to maturity.

[c] $64.99385 = 100(1+\frac{1}{2}.0598)^{-(14+(115/184))}$, where the obligation has 115 days plus 14 full semiannual periods remaining to maturity, and where there are 184 days in the semiannual interval from May 15, 1999, to November 15, 1999.

## Appendix B: Implications of the Exchange Facility for the Shape of the Yield Curve

We observed in Section 6 that the proposed exchange facility would bound short-range irregularities in the structure of yields on single-payment securities. The yield on a single-payment security could never differ by more than the prescribed exchange fee from the average of the yields on a pair of shorter and longer term single-payment securities for which it can be exchanged.

To preclude the possibility that the exchange facility might affect the overall shape of the yield curve, we suggested that the difference between the maturities of the longer and shorter securities that can be exchanged for an intermediate-maturity security should be limited, as shown in Table 7. The limitations are important because if market participants can, without limitation, exchange short-term securities (such as one-year STRIPS) and long-term securities (such as twenty-five-year STRIPS) for intermediate-term securities (such as thirteen-year STRIPS) and vice versa—at an exchange fee of, for example, 2 or 3 basis points—then (in an equilibrium in which positive amounts of short-, intermediate-, and long-term STRIPS remain outstanding) the STRIPS yield curve would have to be very close to a straight (but not necessarily flat) line.

The limitations in Table 7 will not preclude indirect exchanges of much longer and much shorter securities for an intermediate-maturity security, but such indirect exchanges will be prohibitively expensive. We show in this appendix how two STRIPS maturing a year apart could be exchanged for an intermediate-maturity STRIP maturing in more than two years by combining three exchanges permitted by Table 7, and we also show that the triplet of exchanges is equivalent to a direct exchange for a fee four times larger than the fee prescribed for an exchange that falls within the limitations in Table 7. We conclude that the rapidly escalating costs of more dispersed indirect exchanges will, as a practical matter, preclude such exchanges and that the exchange facility can be structured to avoid affecting the overall shape of the yield curve.

### Combining Three Exchanges to Effect an Exchange That Cannot Be Done Directly

Suppose that the fee on an exchange that falls within the limitations in Table 7 is 2 1/2 basis points. Using the yields on interest component STRIPS on July 22, 1999, from Table 3, we demonstrate how a market participant could indirectly effect an exchange of $1,000 face amount of STRIPS maturing May 15, 2006, and $1,000 face amount of STRIPS maturing a year later, on May 15, 2007, for $2,000 face amount of STRIPS maturing November 15, 2006, for a fee of about 10 basis points. (Note that this exchange cannot be done directly for a fee of 2 1/2 basis points because the difference in the maturities of the shorter and longer STRIPS exceeds the limitations in Table 7.)

*Exchange 1.* Consider first the exchange of

- $1,000 face amount of STRIPS maturing May 15, 2006, quoted on July 22, 1999, at a yield of 5.97 percent for settlement on July 23, 1999, and
- $1,000 face amount of STRIPS maturing November 15, 2006, quoted on July 22, 1999, at a yield of 5.96 percent for settlement on July 23, 1999,

for

- $2,000 face amount of STRIPS maturing August 15, 2006.

The shorter obligation has an invoice price of 66.98146 percent of face value,[69] and the longer obligation has an invoice price of 65.08622 percent of face value.[70] For purposes of the exchange, the intermediate obligation is valued at a yield of 5.940 percent (5.940 percent = 1/2 of 5.97 percent and 5.96 percent, minus 2 1/2 basis points) or at an invoice price of 66.13553 percent of face value.[71]

The net funds due the Treasury at the time of the exchange on July 23, 1999, are $2.0338, computed as

- 66.13553 percent of $2,000 for the intermediate obligation, less
- 66.98146 percent of $1,000 credit for the shorter obligation, less
- 65.08622 percent of $1,000 credit for the longer obligation.

*Exchange 2.* Consider next the exchange of

- $1,000 face amount of STRIPS maturing November 15, 2006, quoted on July 22, 1999, at a yield of 5.96 percent for settlement on July 23, 1999, and
- $1,000 face amount of STRIPS maturing May 15, 2007, quoted on July 22, 1999, at a yield of 6.03 percent for settlement on July 23, 1999,

for

- $2,000 face amount of STRIPS maturing February 15, 2007.

The shorter obligation has an invoice price of 65.08622 percent of face value,[72] and the longer obligation has an invoice price of 62.86808 percent of face value.[73] For purposes of the exchange, the intermediate obligation is valued at a yield of 5.970 percent (5.970 percent = 1/2 of 5.96 percent and 6.03 percent, minus 2 1/2 basis points) or at an invoice price of 64.08659 percent of face value.[74]

The net funds due the Treasury at the time of the exchange are $2.1888, computed as

- 64.08659 percent of $2,000 for the intermediate obligation, less
- 65.08622 percent of $1,000 credit for the shorter obligation, less
- 62.86808 percent of $1,000 credit for the longer obligation.

*Exchange 3.* Finally, consider the exchange of

- $2,000 face amount of STRIPS maturing August 15, 2006, quoted on July 22, 1999, at a yield of 5.99 percent for settlement on July 23, 1999, and
- $2,000 face amount of STRIPS maturing February 15, 2007, quoted on July 22, 1999, at a yield of 6.02 percent for settlement on July 23, 1999,

for

- $4,000 face amount of STRIPS maturing November 15, 2006.

From the calculations in Box B in the text, the net funds due the Treasury at the time of the exchange are $4.5374 ($4.5374 = 2 times $2.2687).

*Summary.* The net effect of the three exchanges is an exchange of

- $1,000 face amount of STRIPS maturing May 15, 2006, quoted on July 22, 1999, at a yield of 5.97 percent for settlement on July 23, 1999, and
- $1,000 face amount of STRIPS maturing May 15, 2007, quoted on July 22, 1999, at a yield of 6.03 percent for settlement on July 23, 1999,

for

- $2,000 face amount of STRIPS maturing November 15, 2006.

The total payment due the Treasury at the time of the composite exchange is $8.7600, computed as

- $2.0338 for $1,000 face amount of the May 2006 STRIP and $1,000 face amount of the November 2006 STRIP exchanged for $2,000 face amount of the August 2006 STRIP,
- $2.1888 for $1,000 face amount of the November 2006 STRIP and $1,000 face amount of the May 2007 STRIP exchanged for $2,000 face amount of the February 2007 STRIP, and
- $4.5374 for $2,000 face amount of the August 2006 STRIP and $2,000 face amount of the February 2007 STRIP exchanged for $4,000 face amount of the November 2006 STRIP.

The box on the next page shows that this combination of exchanges is essentially equivalent to a direct exchange of $1,000 face amount of the May 2006 STRIP and $1,000 face amount of the May 2007 STRIP for $2,000 face amount of the November 2006 STRIP at an exchange fee of 10 basis points, or four times the 2-1/2-basis-point fee for an exchange that falls within the limitations in Table 7.

The foregoing calculation implies that the proposed exchange facility would bound the yield on a single-payment security maturing in more than two years to a range of about 10 basis points around the average yield on a pair of single-payment securities maturing six months earlier and six months later. Similar calculations show that if the shorter and longer securities mature eighteen months apart, then the range around the average yield is about ± 22 1/2 basis points. If the shorter and longer securities mature two years apart, the range around the average yield is about ± 40 basis points. If the securities mature three years apart, the range is about ± 90 basis points, and if they mature four years apart, the range is about ± 160 basis points.[75]

These bands are so wide that it is unlikely that the curvature of the yield curve will be large enough to induce market participants to undertake indirect exchanges of securities maturing more than six months apart for an intermediate-term security maturing in more than two years, and hence it is unlikely that the proposed exchange facility will have any effect on the overall shape of the yield curve beyond two years. Since the limitations in Table 7 shrink with the maturity of the intermediate security in an exchange, similar conclusions apply to the front end of the curve as well.

If, on further examination, the bounds on the curvature of the yield curve described above appear to be too tight, the bounds can be expanded by raising the exchange fee. For example, raising the fee from 2 1/2 basis points to 3 1/2 basis points would expand the band on the yield on a single-payment security around the average yield on a pair of single-payment securities maturing six months earlier and six months later from 10 basis points to 14 basis points. Similarly, the band around the average yield on a pair of single-payment securities maturing one year earlier and one year later would expand from 40 basis points to 56 basis points.

### Exchange of Shorter and Longer Maturity STRIPS for an Intermediate-Maturity STRIP When the Exchange Fee Is 10 Basis Points

Consider the exchange of

- $1,000 face amount of STRIPS maturing May 15, 2006, quoted on July 22, 1999, at a yield of 5.97 percent for settlement on July 23, 1999, and
- $1,000 face amount of STRIPS maturing May 15, 2007, quoted on July 22, 1999, at a yield of 6.03 percent for settlement on July 23, 1999,

for

- $2,000 face amount of STRIPS maturing November 15, 2006,

when the fee for the exchange is 10 basis points. The shorter obligation has an invoice price of 66.98146 percent of face value,[a] and the longer obligation has an invoice price of 62.86808 percent of face value.[b] For purposes of the exchange, the intermediate obligation is valued at a yield of 5.90 percent (5.90 percent = 1/2 of 5.97 percent and 6.03 percent, minus 10 basis points) or at an invoice price of 65.36415 percent of face value.[c]

The net funds due the Treasury at the time of the exchange on July 23, 1999, are $8.7876, computed as

- 65.36415 percent of $2,000 for the intermediate obligation, less
- 66.98146 percent of $1,000 credit for the shorter obligation, less
- 62.86808 percent of $1,000 credit for the longer obligation.

[a] $66.98146 = 100(1+\frac{1}{2}.0597)^{-(13+(115/184))}$, where the obligation has 115 days plus 13 full semiannual periods remaining to maturity, and where there are 184 days in the semiannual interval from May 15, 1999, to November 15, 1999.

[b] $62.86808 = 100(1+\frac{1}{2}.0603)^{-(15+(115/184))}$, where the obligation has 115 days plus 15 full semiannual periods remaining to maturity.

[c] $65.36415 = 100(1+\frac{1}{2}.0590)^{-(14+(115/184))}$, where the obligation has 115 days plus 14 full semiannual periods remaining to maturity.

## Endnotes

1. See *Wall Street Journal* (1999b) and *New York Times* (1999b).

2. See Demsetz (1968) and Tanner and Kochin (1971).

3. See Stigler (1961), Garbade and Silber (1976), Lippman and McCall (1986), and Amihud, Mendelson, and Lauterbach (1997).

4. See Tanner and Kochin (1971), Garbade and Silber (1976), Garbade and Rosey (1977), and Elton and Green (1998).

5. See Garbade (1984), Amihud and Mendelson (1991a), Kamara (1994), and Elton and Green (1998).

6. See Tanner and Kochin (1971), Garbade and Silber (1976), Garbade and Rosey (1977), Sarig and Warga (1989), and Warga (1992).

7. See Garbade and Silber (1976), Garbade and Rosey (1977), Sarig and Warga (1989), Warga (1992), and Elton and Green (1998).

8. See Warga (1992) and Elton and Green (1998).

9. See, generally, Amihud and Mendelson (1991b).

10. See also Sarig and Warga (1989).

11. More recently, Elton and Green (1998) suggested that the effect of liquidity on the price of a Treasury security is not as large as previously reported and is restricted to longer maturity bonds with high trading volume. However, these authors measured the liquidity of an issue by the volume of trading in the interdealer market, rather than by the cost of transacting in the public market. Although the transaction costs of trading, for example, a six-month-old ten-year note are certainly higher than those of trading an on-the-run ten-year note, the ratio of transaction costs is not nearly as large as the reciprocal of the ratio of the volume of trading in the two notes. Dealers are willing to make fairly liquid markets for relatively infrequent transactions in an old ten-year note because order flow and transaction prices in the highly liquid and actively traded on-the-run ten-year note provide information on the value of the off-the-run note. In addition, the dealers can hedge much of their risk with the on-the-run note. (Price and yield changes for an on-the-run note or bond are very highly correlated with price and yield changes for other notes and bonds of a similar maturity and coupon rate. Amihud, Mendelson, and Lauterbach [1997] present evidence on the existence of liquidity spillovers across securities with highly correlated returns.) Thus, there may not be any simple relationship between the cost of liquidity for a particular Treasury security and the volume of trading in the security.

12. In 1996, the Secretary of the Treasury remarked, "the Treasury Department has through its history focused on the most cost-effective ways to finance the federal debt" (*Treasury News* 1996). The Assistant Secretary for Financial Markets recently characterized "lowest cost financing" as one of the three main goals of Treasury debt management (Sachs 1999). (He described the other two as ensuring that adequate cash balances are available at all times and promoting efficient capital markets.)

13. The Assistant Secretary for Financial Markets recently described "financing across the yield curve" as one of five principles of Treasury debt management, observing that "a balanced maturity structure enables us to appeal to the broadest range of investors and mitigates refunding risks" (Sachs 1999). (The other four principles are maintenance of the credit-risk-free status of Treasury debt, predictable issuance schedules, maintenance of market liquidity, and unitary financing of all federal government programs.)

The sensitivity of the Treasury Department to the effect of its debt management program on the shape of the yield curve is illustrated by the May 1993 statement of the Acting Assistant Secretary for Domestic Finance that the shift to greater issuance of securities with maturities of less than three years, the elimination of the seven-year note, and the change from quarterly to semiannual issuance of thirty-year bonds "wasn't intended to manipulate long-term interest rates" (*Wall Street Journal* 1993).

14. Fleming (2000) discusses the benchmark role of Treasury debt. See also *Wall Street Journal* (1999a), which describes changes in market practices that followed the appearance of a substantial liquidity premium in on-the-run Treasury securities in the fall of 1998.

15. The *net* effect of the passage of time (after an issue is no longer on the run) on the liquidity of intermediate- and long-term securities is unclear. We are unaware of any empirical assessment of the liquidity of, say, a note that has been outstanding for eight years but has only two years remaining to maturity relative to the liquidity of a note that has been outstanding for only two years but has eight years remaining to maturity.

16. In deciding to cancel the twenty-year bond, the Treasury Department concluded that "it would be more cost-effective for the Treasury to issue larger amounts of ten- and thirty-year securities rather than twenty-year issues" (Federal Reserve Bank of New York 1986; *Wall Street Journal* 1986). The Treasury yield curve had exhibited a persistent hump between the ten-year sector and the thirty-year sector, and the Treasury decided it should stop paying the higher interest rates required to issue near the hump. One market

*Note 16 continued*
participant also commented that "the twenty-year issue seemed to be a bond without a natural home," and that it was "too long for investors who sought to reduce the risk of falling prices when interest rates rise, but too short for other investors and speculators who want to earn the highest possible profits by correctly guessing changes in interest rates" (*New York Times* 1986).

17. The four-year note was canceled when the Treasury decided to reduce its reliance on bills and increase its use of intermediate-term debt. Contemporaneously, the Treasury moved the more popular five-year note cycle from quarterly to monthly (*Treasury News* 1990).

18. Before 1993, the yield curve had not inverted significantly for any material length of time since the early 1980s. The Treasury Department canceled the seven-year note after concluding that it could realize long-term savings by shifting to short-term issues (*Wall Street Journal* 1993; *New York Times* 1993). In 1996, the Secretary of the Treasury observed that the decision to cancel the seven-year note cycle "was initially looked on with some skepticism, but . . . since has won considerable praise and is saving the taxpayers $7 billion" (*Treasury News* 1996).

19. In May 1998, the Treasury reduced the frequency of issuing five-year notes for reasons noted in the text at endnote 30.

20. Premium pricing of bills deliverable on a futures contract or maturing at the end of a calendar period or immediately before a tax payment date is discussed in Garbade (1985b), Simpson and Ireland (1985), Park and Reinganum (1986), and Ogden (1987). See also *New York Times* (1999a), which describes unusually strong demand for bills maturing after the end of 1999.

In the course of the 1979 Treasury Department/Federal Reserve study of futures contracts on Treasury securities, the Commodities Futures Trading Commission and officers of commodity exchanges that sponsored trading in futures contracts on Treasury securities asked, "why, in situations where a potential shortage of deliverable supply against a futures contract [on three-month bills] appeared to be creating a strong demand for the part of this supply that was about to be offered in a cash auction, would the Treasury not want to expand the size of the auction and take advantage of what would likely be a relatively low borrowing cost?" (U.S. Department of the Treasury and Federal Reserve System 1979, vol. 2, pp. 83-4). For reasons discussed in the study (vol. 2, pp. 84-91), the study concluded that "having the Treasury . . . act directly to modify potential squeezes on the deliverable supply of three-month bills . . . through a Treasury increase in the size of the new bill auction . . . is not acceptable. While there may be occasions when the Treasury should add to the share of its marketable debt represented by three-month bills, such actions ought to be taken only as needed to implement the Treasury's general debt management objectives; they should not be initiated to help resolve the particular needs of the commodity exchanges" (U.S. Department of the Treasury and Federal Reserve System 1979, vol. 1, p. 26).

21. However, the Treasury Department has reacted to unusual market situations at least three times since 1990.

The first time was the reopening of the 6 3/8 percent note of August 15, 2002 (originally issued as a ten-year note in August 1992), in the ten-year note auction in November 1992. In its announcement, the Treasury stated that the reopening was intended to "alleviate an acute, protracted shortage of [the] security" (U.S. Department of the Treasury 1992).

The second time was the offering of a 30 1/4-year bond (the 7 1/2 percent bond of November 15, 2024) in the August 1994 quarterly financing. The four preceding issues of thirty-year bonds had increased the supply of STRIPS maturing in February and August (see Table 1), and the unusual 30-1/4-year maturity was chosen to accommodate market demand for STRIPS maturing in May and November.

The third time was the decision to offer more twenty-six-week bills than thirteen-week bills in the weekly auctions from Monday, March 9, 1998, to Monday, September 14, 1998, as a result of unusually strong foreign central bank demand for twenty-six-week bills. See *Wall Street Journal* (1998a).

22. Simon (1991, 1994).

23. This fifty-two-week bill cycle was adopted in the summer of 1972, when the Treasury switched from the previous practice (adopted in August 1963) of monthly auctions of one-year bills issued at the end of a month and maturing at the end of a month—similar to the current two-year note cycle (*Treasury Bulletin*, July 1963, p. A-1; September 1963, pp. A-4 and A-5; September 1972, p. II).

24. Twenty-six-week bills were first auctioned in December 1958 and, from inception, were fungible with subsequent issues of thirteen-week bills (*Treasury Bulletin*, December 1958, p. A-2; January 1959, p. A-2).

25. The first bill issued under the new procedure was the 359-day bill issued on Tuesday, November 13, 1979, to mature Thursday, November 6, 1980. That bill was issued on a Tuesday to refinance an old fifty-two-week bill maturing on the same date. The last 359-day bill was issued on Tuesday, October 14, 1980—to mature on

Thursday, October 8, 1981—to refinance the last of the fifty-two-week bills with a Tuesday maturity date. The first fifty-two-week bill with a Thursday issuance date as well as a Thursday maturity date was the November 5, 1981, bill issued on November 6, 1980 (*Treasury Bulletin*, June 1980, p. 28; June 1981, p. 33).

In June 1981, the Chicago Mercantile Exchange amended the delivery provisions on its thirteen-week Treasury bill futures contract to provide that, beginning with the contract settling in June 1983, the deliverable bill would be an old fifty-two-week bill with thirteen weeks remaining to maturity (Chicago Mercantile Exchange 1981). The change reduced the likelihood of a squeeze or corner in the bill contract—an issue discussed in U.S. Department of the Treasury and Federal Reserve System (1979, vol. 1, pp. 13-4, and vol. 2, pp. 66-72). See also Commodity Futures Trading Commission (1981, pt. 3, pp. 56-61) for an analysis of Treasury bill prices before the June 1979 settlement of the thirteen-week bill contract on the Chicago Mercantile Exchange.

26. *Treasury Bulletin* (November 1979, p. VII).

27. On one occasion, the Treasury Department reopened a thirty-year bond that was not the most recently issued bond in the series. In the February 1988 quarterly financing, the Treasury reopened the 8 3/4 percent bond of May 15, 2017, that had been issued on May 15, 1987, and that had twenty-nine and one quarter years remaining to maturity. The most recently auctioned thirty-year bond at the time of the February 1988 financing was the 8 7/8 percent bond of August 15, 2017, that had been issued on August 17, 1987, and reissued on November 16, 1987.

28. Notes and bonds issued before July 1984 could not be reopened after that date because of changes in the treatment of market discount and the 30 percent foreign withholding tax mandated by the Tax Reform Act of 1984 (*Treasury News* 1985b). On several occasions—including the auctions of five-year notes in May and November 1988 and in May 1989 and the auction of ten-year notes in August 1991—the Treasury was consequently unable to reopen an old bond in a note auction. To minimize the possibility of confusion, the Treasury announced before each auction that, regardless of auction results, it would not issue the new note with the same coupon rate as the coupon rate on the old bond with the same maturity date. See, for example, U.S. Department of the Treasury (1991), which notes that "if, under Treasury's usual auction procedures, the auction of ten-year notes results in the same interest rate as on the outstanding 8 percent bonds of August 15, 2001, the new notes will be issued with either a 7 7/8 percent or an 8 1/8 percent coupon."

29. *Wall Street Journal* (1998a).

30. The monthly cycle of five-year notes was canceled at the same time.

31. *New York Times* (1998). The Assistant Secretary for Financial Markets observed that the Treasury decided to stop issuing three-year notes because the continuing issues of two-year notes and five-year notes would offer similar investment opportunities, and because the ten-year note and thirty-year bond series "provide a critical service to overall capital markets that would be hard for anybody else to fill." See also *Wall Street Journal* (1998b), which notes that "drastically reducing the . . . amount of [Treasury] securities sold [in a single auction] . . . would likely hurt liquidity in the issues."

32. This characterization is consistent with the recent statement of the Assistant Secretary for Financial Markets that minimizing borrowing costs is one of three goals of Treasury debt management, while maintenance of market liquidity is one of five guiding principles (Sachs 1999).

33. The four issues were the foreign-targeted 11 3/8 percent four-year note of September 30, 1988 (issued October 31, 1984), the foreign-targeted 11 percent five-year note of February 15, 1990 (issued December 3, 1984), the foreign-targeted 9 7/8 percent five-year note of August 15, 1990 (issued June 4, 1985), and the foreign-targeted 8 7/8 percent ten-year note of February 15, 1996 (issued February 18, 1986).

34. Foreign-targeted notes were sold only to United States aliens or foreign branches of United States financial institutions. See, for example, U.S. Department of the Treasury (1984). The notes were intended to appeal to nonresident aliens and foreign corporations that did not care to own Treasury securities in a conventionally registered form.

In announcing the intent of the Treasury to issue inflation-indexed securities, the Secretary of the Treasury cited the potential contribution of the new asset class to reducing the cost of funding the federal debt, and noted the belief of the Department that the securities would be most attractive to individuals saving for their retirement or other long-term purposes (*Treasury News* 1996).

35. The limited liquidity of the foreign-targeted notes was mitigated by the convertibility of each of the notes into a conventional note with the same coupon rate and maturity date. See, for example, U.S. Department of the Treasury (1984). See also Garbade (1985a).

*Note 35 continued*

Market participants made active use of the conversion option. For example, in February 1986, the Treasury issued $1 billion of the foreign-targeted 8 7/8 percent ten-year note of February 15, 1996, and $7.5 billion of the conventional 8 7/8 percent note maturing on the same date (*Treasury Bulletin*, Spring 1986, p. 28). By March 31, 1986, $217 million of the foreign-targeted note had been converted into the conventional note (*Treasury Bulletin*, Spring 1986, p. 23). By the end of 1986, the outstanding amount of the foreign-targeted note was down to $188 million (*Treasury Bulletin*, Winter 1987, p. 28), and by the end of 1995 the outstanding amount of the foreign-targeted note was only $125 million (*Treasury Bulletin*, March 1996, p. 35).

36. Only $4 billion of foreign-targeted notes was issued, and all of the notes were issued at a time of large budget deficits, so the impact on the liquidity of other Treasury securities was likely mininal. In contrast, more than $97 billion of inflation-indexed securities has been issued through the end of 1999, at a time of significant surpluses and substantial net redemptions of conventional Treasury debt.

37. The first private sector receipt programs included Certificates of Accrual on Treasury Securities (CATS), introduced by Salomon Brothers Inc.; Treasury Investment Growth Receipts (TIGRs), introduced by Merrill Lynch White Weld Capital Markets Group; and Zero Coupon Treasury Obligations, introduced by Lehman Government Securities, Inc. These "private-label" programs were later joined by Treasury Receipts (TRs), a generic, or open, receipt program initially sponsored by Goldman, Sachs & Company and the First Boston Corporation (*New York Times* 1984).

38. *Treasury News* (1985a).

39. The Treasury Department modified its issuance practices to enhance stripping-based auction demand for ten-year notes and thirty-year bonds by issuing the securities with a full first coupon (and positive accrued interest) when the issuance date did not fall on a semiannual anniversary date. The first securities issued with positive accrued interest were the 9 1/2 percent note of November 15, 1995, and the 9 7/8 percent bond of November 15, 2015, sold in the November 1985 quarterly financing. Both securities were issued on November 29, 1985, but both were dated November 15, 1985. The modification was important because the STRIPS program provided that a security could not be stripped if it had an unpaid short or long first coupon. (This restriction delayed stripping a twenty-year bond until the bond paid its first coupon. For example, the 10 3/4 percent bond of August 15, 2005, was issued on July 2, 1985, but did not become eligible for the STRIPS program until a few days after it paid its long first coupon on February 15, 1986.)

To accommodate market demand for long-term STRIPS and further enhance stripping-based demand for new issues of thirty-year bonds, the Treasury also eliminated the call option that had been embedded in those bonds (*Treasury News* 1985a).

40. However, STRIPS proved to be far more liquid than private sector custodial receipts because private sector receipts payable on a common date were fragmented by sponsor and series and because the receipts were not direct obligations of the U.S. government and were not eligible for book-entry accounts at Federal Reserve banks.

41. *Treasury News* (1985c).

42. *Treasury News* (1987). Reconstitution would have been much more difficult in the absence of the provision for fungibility of interest component STRIPS maturing on a common date.

43. Daves and Ehrhardt (1993) examine why interest component STRIPS and principal component STRIPS maturing on the same date trade at different yields.

44. Grieves and Sunner (1999) emphasize the importance of fungibility of STRIPS maturing on a common date for market liquidity.

45. Transaction costs incurred in purchasing and selling STRIPS and coupon-bearing securities prevent arbitrage from keeping the price of a note or bond *exactly* equal to the sum of the prices of its component STRIPS.

46. Fleming (2000) describes the methodology in detail.

47. Duffie (1996), Keane (1996), and Jordan and Jordan (1997) describe and characterize the financing market for specific collateral.

48. It would, therefore, supplement the mid-1998 changes in the management of the System Open Market Account intended to "enhance liquidity in the financing market" (Fisher 1998).

49. Delivery options on futures contracts are discussed in Paul, Kahl, and Tomek (1981, pp. 110-2), Commodity Futures Trading Commission (1981, pp. 98-117), Kilcollin (1982), Garbade and Silber (1983), Gay and Manaster (1984, 1986), Kane and Marcus (1986), Arak and Goodman (1987), Kamara and Siegel (1987), Boyle (1989), and Manaster (1992).

50. The potential contribution of eliminating distinctions among STRIPS maturing on a common date to alleviating squeezes is examined in U.S. Department of the Treasury, Securities and Exchange Commission, and Board of Governors of the Federal Reserve System (1992, pp. B11-B16).

51. A similar issue arises in the context of the Treasury Department's proposal to repurchase off-the-run securities (see endnote 1). To the extent the Treasury elects to repurchase securities with high coupon rates trading at prices in excess of principal value (to maintain issuance of new debt with current coupon rates and prices close to principal value), tax revenues on interest income could decline. However, as with the conversion of high coupon debt into low coupon debt that could result from our proposal, the magnitude of any such effect will depend on the tax brackets of the investors selling the high coupon debt and those of the investors buying the new (current coupon) debt, as well as any offsetting tax revenues derived from capital gains on the sale of the high coupon debt.

52. The Treasury recognized explicitly that fragmentation of trading in interest component STRIPS with identical payment characteristics degrades liquidity and reduces the attractiveness of those STRIPS; in mid-1985, it acted to eliminate that fragmentation. See text at endnote 41.

53. Eliminating seven-year notes also eliminated an odd cycle of notes maturing in the middle of the first month of each quarter.

54. This would be similar to the reopenings described in the text at endnote 28.

55. As noted in endnote 25 and in the text at endnotes 23, 24, and 25, the integration of one-year bills with twenty-six-week and thirteen-week bills was accomplished in two separate steps, in 1972 and in 1979-80.

56. For example, on January 22, 1998, the Treasury could have issued a 104-week bill maturing on January 20, 2000. That bill would have matured midway between the maturity dates of two subsequent issues of fifty-two-week bills: the January 6, 2000, bill (issued on January 7, 1999) and the February 3, 2000, bill (issued on February 4, 1999).

57. See Garbade (1984), Amihud and Mendelson (1991a), and Kamara (1994).

58. The September 30 bill was an end-of-quarter bill as well as an end-of-month bill. Garbade (1985b), Park and Reinganum (1986), and Ogden (1987) discuss the premium pricing of such bills.

59. Left in the simple form described in the above paragraph, the exchange facility would result in an equilibrium whereby the price of any single-payment security would be equal to the average price of a pair of shorter and longer term single-payment securities. If positive amounts of single-payment securities of all maturities remained outstanding, the price of a single-payment security would be a linear function of its time to maturity.

60. The payment to the Treasury Department is slightly larger for the exchange of the intermediate STRIP for the shorter and longer STRIPS, because the price of a STRIP is a convex function of both its yield and its time to maturity.

61. In the absence of limitations like those prescribed in Table 7, the exchange facility would result in an equilibrium whereby the yield on any single-payment security could not differ from the average of the yields on a pair of shorter and longer term single-payment securities by more than the exchange fee. If positive amounts of single-payment securities of all maturities remained outstanding, the yield on a single-payment security would very nearly be a linear function of its time to maturity. This issue is discussed further in Appendix B.

62. The maximum loss of twice the exchange fee would occur if the dealer sold the intermediate STRIP short at a yield close to the average yield on the shorter and longer STRIPS *plus* the fee, and then liquidated the hedged short position when the yield on the intermediate STRIP was close to the average yield on the shorter and longer STRIPS *minus* the fee. The smaller the difference between (a) the yield at which the intermediate STRIP is sold short and (b) the average yield on the shorter and longer STRIPS, the smaller the maximum loss.

63. Liquidity spillovers are discussed in Amihud, Mendelson, and Lauterbach (1997, pp. 378-80). See also the related analysis in Amihud and Mendelson (1996, pp. 1455-64).

64. *Treasury News* (1985a).

65. See endnote 35 for an example of the use of the exchange option by market participants.

66. The exchange facility may also be analogized to a "tap," or continuing, offering of new securities (in this case, single-payment securities), where payment is made largely with other securities—rather than with cash only.

67. The authors are grateful to Yakov Amihud for suggesting such a trial.

68. Liquidity (and security prices) can also be enhanced by improving the microstructure of a market. See, for example, Amihud, Mendelson, and Lauterbach (1997). Amihud and Mendelson (1996) suggest that an issuer should have a property right to determine the market or markets in which its securities are traded as a way to incentivize the innovation of liquidity-enhancing market microstructures.

69. Calculated as $66.98146 = 100(1+\frac{1}{2}.0597)^{-(13+(115/184))}$, where the obligation has 115 days plus 13 full semiannual periods remaining to maturity, and where there are 184 days in the semiannual interval from May 15, 1999 to November 15, 1999.

70. Calculated as $65.08622 = 100(1+\frac{1}{2}.0596)^{-(14+(115/184))}$, where the obligation has 115 days plus 14 full semiannual periods remaining to maturity.

71. Calculated as $66.13553 = 100(1+\frac{1}{2}.0594)^{-(14+(23/181))}$, where the obligation has 23 days plus 14 full semiannual periods remaining to maturity, and where there are 181 days in the semiannual interval from February 15, 1999, to August 15, 1999.

72. Calculated as $65.08622 = 100(1+\frac{1}{2}.0596)^{-(14+(115/184))}$, where the obligation has 115 days plus 13 full semiannual periods remaining to maturity, and where there are 184 days in the semiannual interval from May 15, 1999, to November 15, 1999.

73. Calculated as $62.86808 = 100(1+\frac{1}{2}.0603)^{-(15+(115/184))}$, where the obligation has 115 days plus 15 full semiannual periods remaining to maturity.

74. Calculated as $64.08659 = 100(1+\frac{1}{2}.0597)^{-(15+(23/181))}$, where the obligation has 23 days plus 15 full semiannual periods remaining to maturity, and where there are 181 days in the semiannual interval from February 15, 1999, to August 15, 1999.

75. It can be shown that the magnitude of the range is twice the exchange fee times the square of the number of half-years between the maturities of the shorter and longer STRIPS. For example, if the fee is 2 1/2 basis points and the shorter and longer STRIPS mature two years apart, the magnitude of the range is 80 basis points (80 = 2 times 2 1/2 times $4^2$, where two years is equivalent to four half-years).

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