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Liquidity, Reconstitution, and the Value of U.S. Treasury Strips

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ABSTRACT

An apparent pricing anomaly exists in the market for U.S. Treasury strips: zero-coupon strips created from principal payments typically trade at significantly higher prices than otherwise identical zero-coupon strips created from coupon payments. In addition to documenting this phenomenon, this study demonstrates that differences in liquidity and differences in reconstitution characteristics explain much of this price variation.

U.S. TREASURY STRIPS ARE zero-coupon bonds created from either the principal or individual coupons of U.S. Treasury bonds. If the maturity date and face value are identical, the cash flows for a strip derived from a principal payment are identical to the cash flows for a strip derived from a coupon payment. However, the two instruments almost always trade at significantly different prices. For a recent sample (5/31/91), the mean percentage difference in price is greater than 1.2%, with some differences greater than 2.7%. This is an apparent anomaly, since securities with identical cash flows should trade at the same price. Although coupon strips and principal strips have identical cash flows at maturity, closer inspection reveals two differences: the two instruments have different degrees of liquidity and different reconstitution characteristics.

Previous studies have documented the effect of liquidity on prices in other markets. Amihud and Mendelson (1986, 1989) find that common stocks with differences in liquidity have significantly different risk-adjusted rates of return. Silber (1991) studies restricted stock offerings and documents substantial price discounts on these illiquid securities vis-à-vis identical stocks that trade in the open market.[1] In a study of U.S. Treasury bills and Treasury bonds with remaining maturities of less than six months, Amihud and Mendelson (1991) find that differences in liquidity contribute to differences in prices between matched pairs of bills and bonds of the same

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[1] Restricted stock offerings are private placements that are not registered with the Securities and Exchange Commission (SEC). Such offerings cannot subsequently be traded in the open market except under conditions specified by SEC's Rule 144.

maturity. Corporate debt markets also exhibit liquidity effects. Fisher (1959) found that the excess yield on risky bonds relative to default-free bonds is inversely related to the market size of the risky bonds. The extra liquidity in larger markets reduces the return demanded by investors.

The results in this study confirm the importance of liquidity. The difference in prices between coupon strips and principal strips is strongly related to the difference in liquidity. In addition, differences in reconstitution characteristics also contribute to significant price differences.

The remainder of the paper is organized as follows. Section I describes institutional features of the market for U.S. Treasury strips; in particular, differences in liquidity and reconstitution features are identified as potential causes of price differences. The magnitudes of the price differences are documented and discussed in Section II. Empirical tests are conducted in Section III to determine if liquidity and/or reconstruction effects can explain the observed price differences. Section IV is a brief summary.

I. The Market for U.S. Treasury Strip Bonds

A. Institutional Features

In 1982, Merrill Lynch created the first default-free zero-coupon instruments by stripping and selling separately the coupons and principal payments from U.S. Treasury bonds.[2] Three years later, the U.S. Treasury initiated the STRIPS program (Separate Trading of Registered Interest and Principal of Securities). The STRIPS program allows bond dealers to "strip" Treasury notes and bonds with maturities greater than or equal to ten years issued after February of 1985. The total face value of a packet of bonds to be stripped must be such that the stripped coupon instruments each have a face value of $1,000 or an integer multiple of $1,000. The newly created zero-coupon instruments are recorded as book-entry securities by the Federal Reserve.

For investors with specific future cash requirements, strips have advantages relative to conventional long-term bonds. With a fixed payment at maturity and no intermediate payments, strips allow an investor to lock in a rate of return that is independent of any subsequent changes in market interest rates. This guaranteed future value is ideal for insurance companies and pension funds, which often hold strips with maturities matching future liabilities. Individual investors, such as those saving for their own retirement or for their children's college expenses, also buy strips of the desired maturities. By the end of 1988, 23% of all eligible bonds had been stripped, with a market value in excess $50 billion (see Shapiro and Johnson (1990)).

Most stripping is motivated by the desire of investors to match future liabilities with a zero-coupon asset. There is also another, though less com-

[2] For more details on features in the market for U.S. Treasury strips, see Shapiro and Johnson (1990) and Klaffky and Kopprash (1990).

mon, motive for stripping. Despite the size and activity of the market, the separately traded coupons and principal components of a bond occasionally have a greater aggregate price than the whole bond. In these instances, it is profitable for dealers to buy the bond, strip the coupons and principal, and sell the stripped instruments separately.[3]

Livingston and Gregory (1989) develop a model in which profitable stripping occurs in response to changes in the term structure. In their model, the differential tax treatment between coupon-bearing bonds and zero-coupon instruments causes investor demand for the two types of instruments to vary as the term structure shifts. In this context, stripping serves to increase the supply of zero-coupon instruments and to decrease the supply of coupon-bearing bonds in response to demand shifts.

In the U.S. tax code, coupon strips and principal strips are each treated as original discount issues for tax purposes, with imputed interest taxed as it accrues. This has not always been the case for international investors. Prior to Japan's tax reform, (effective January 1, 1989 for individuals and April 1, 1989 for corporations) capital gains appreciation in principal strips was untaxed (see Ishi (1989)). Capital gains appreciation in coupon strips, however, was considered interest income, and was only partially sheltered from taxation. Stigum (1990) states that one of the reasons that the Treasury initially distinguished between coupon and principal strips was to appeal to Japanese investors who desired to shelter the appreciation in principal strips. Under the new Japanese tax law all income resulting from the disposition of securities receives the same tax treatment (see Odden (1989)).

Given identical tax treatments, there are no differences between the instruments with respect to either tax-clientele effects or tax-option effects. Since coupon strips and principal strips of the same maturity have identical pretax and aftertax cash flows, the securities should trade at the same price. However, the prices of the two instruments are usually different. For the sample of 225 matched maturity principal and coupon strips, only seven have equal bid prices, only eight have equal ask prices, and only seven have both equal bid prices and equal ask prices.

Other than relatively short-term reverse repurchase agreements, it is not possible to short sell these securities, which precludes arbitrage. However, if the prices of a coupon strip and a principal strip of the same maturity differ, then the lowest priced strip is clearly dominant. This leads to an intriguing question: why do the prices differ?

Although the contractual cash flows are identical, coupon strips and principal strips are not perfect substitutes. They differ with respect to two features:

[3] Data from a recent sample, 2/25/91, are examined to determine whether profitable stripping opportunities are common (see Section III for a detailed description of the data). The profit from stripping (buying a whole bond and selling separately the coupons and principal) is defined as the sum of the bid prices of appropriate stripped securities less the ask price of the whole bond; the profit is also reduced by commissions. For the 42 bonds in this sample, only one could be stripped profitably.

(1) principal strips play a special role in the reconstitution of a bond, and (2) the liquidity in the market for coupon strips differs from that of principal strips.

B. Reconstitution Effects

Beginning in May of 1987 the Treasury allowed investors to "reconstitute" a previously stripped bond. To reconstitute a bond, an investor would purchase a series of single coupon strips with maturities corresponding to each of the original payment dates. It is important to note that the coupon strips used in reconstituting a bond are not required to have been derived from the original bond; they may have been derived from any bonds that have coupon payments occurring on the desired dates.

The investor must also purchase principal strips with the desired maturity. Unlike the coupon components, U.S. Treasury regulations require that these must have been derived from the original bond that is being reconstituted; i.e., the investor is not allowed to substitute an equal dollar value of coupon strips maturing in ten years. Therefore, principal strips and coupon strips are not perfect substitutes. The reconstituted portfolio is recorded as a packet of individual bonds in the book-entry system of the Federal Reserve.[4]

There are two major reasons why reconstitution may occur. Occasionally, the sum of prices for the separately traded strips is less than the price of the whole bond. In these cases, it is profitable for a dealer to reconstitute the bond from the strips and sell the reconstituted bond.[5] The Livingston and Gregory (1989) model implies that profitable reconstitution opportunities will occur in response to term structure changes as the relative demands for coupon-bearing bonds and zero-coupon instruments change. Reconstitution will decrease the supply of zero-coupon instruments and increase the supply of coupon-bearing instruments in response to this change in demand.

Second, Stigum (1990, p. 696) notes that stripping and reconstitution often occur as a result of requests from retail customers. For example, one customer may wish a zero-coupon bond maturing in 30 years and another customer may wish a series of zero-coupon bonds maturing in years 20 to 30. In this case, the dealer might strip a 30-year bond and sell the stripped instruments to the two customers. Rather than either holding the remaining strips in inventory or searching for additional customers to purchase the

[4] The packet size depends on the bond's coupon rate and varies substantially for different coupon rates. The minimum packet size of 20 bonds occurs for a 10% coupon; this produces 20 principal strips and one coupon strip. The maximum packet size of 1600 bonds occurs for a 9.875% coupon; this produces 1600 principal strips and 79 coupon strips.

[5] A procedure similar to that described in footnote 3 is conducted for reconstituting (buying the appropriate individual strips and selling the bond as a whole). The profit is defined as the bid price of the bond less the sum of ask prices for the appropriate strips; it is also adjusted for commissions. For the 42 bonds in this sample, 26 could be reconstituted profitably. For these situations, the average profit is $0.30 on a $100 par, with a maximum profit of $1.10. It is not clear that the transactions could be executed simultaneously, hence the reconstitution may not be riskless. However, the magnitude of the profits suggest that the reconstitution feature may be valuable.

strips, the dealer might purchase enough additional strips to reconstitute the strips as a package of shorter maturity bonds. The dealer would then sell these reconstituted bonds.

C. Liquidity Effects

Informal conversations with bond dealers suggest that liquidity differences also cause differences in the prices of principal and coupon strips of the same maturity. How, then, do liquidity differences between coupon strips and principal strips arise?

Consider the hypothetical issuance of $10,000,000,000 of 30-year bonds in February, 1988; each bond has a face value of $1,000 and a coupon rate of 10%, payable semiannually. This creates the potential for 10,000,000 principal strips maturing in February of 2018 and 500,000 coupon strips maturing in February of 2018, each with a face value of $1,000. In this case, the potential market for principal strips maturing in February of 2018 is substantially larger than the market for coupon strips maturing on the same date. While all bonds in the issue may not be stripped, the ratio between the actual number of principal strips and coupon strips from this bond issue is always 20 to 1.

The potential size of the market for coupons changes as time passes. For example, suppose that $10,000,000,000 of 30-year 10% bonds subsequently are issued in February of 1989. The potential total market for coupon strips maturing in February of 2018 doubles to 1,000,000 coupon strips, but the market for principal strips maturing on February of 2018 is unchanged. As time passes, the potential market for coupon strips may actually exceed that for principal strips.

II. Price Differences Between Principal Strips and Coupon Strips

A. Data

Regular quarterly auctions of new Treasury bonds are held in February, May, August, and November of each year. The auctions are held in the first week of the month, with the newly issued bonds dated the 15th. Since the potential volume of strips remains unchanged except for auction months, price data are collected from the *Wall Street Journal* in these months. The data for the last trading day of the month are collected. The first sample is collected for August 31, 1989; the sixth and final sample is collected for November 29, 1991.[6] Data for the volume of the issues that have actually

[6] Prior to June 30, 1990, Bloomberg Financial Markets provided data to the *Wall Street Journal*; after this date, Bear, Stearns & Co. via Street Software Technology, Inc. provided the data. The phenomenon of different prices between principal and coupon strips of the same maturity is present in data from both sources, although the bid-ask spreads for the Bloomberg data are much larger than those of the Bear, Stearns & Co. data. For reasons of consistency, only data from the most recent source are used in this study; results for the earlier period are available from the authors.

been stripped are collected from *The Monthly Statement of the Public Debt*, which is published by the U.S. Treasury Department.

The total sample contains 225 matched maturity pairs of principal strips and coupon strips.[7] As reported in Table I, each sample has at least 33 pairs, with the largest sample containing 42 pairs. The maturities range from approximately 3.7 years to just under 30 years.

There are two potential sources of noise in the data. First, strip trading volumes are not as heavy as for conventional Treasury instruments, so it is possible that the quotes are asynchronous. Second, the quotes may not reflect prices at which actual trades of realistic magnitudes could occur; in fact, the quotes may be more like advertisements than actual prices. Even though potential problems exist with the data, it is improbable that they can explain either the direction or magnitude of the observed price differences that are documented in the next section.

B. Differences in Prices of Principal and Coupon Strips

Let P_{P_τ} and P_{C_τ} denote the respective ask prices of principal strips and coupon strips with maturity τ. Ask prices are used since they represent prices at which an investor could purchase the instruments.[8] As shown in Table I, only seven of the 225 principal strips have bid and ask prices identical to those of the corresponding coupon strip. In fact, P_{P_τ}, the price of the principal strip, is greater than P_{C_τ}, the price of the coupon strip, in 180 of the 225 total pairs. A nonparametric binomial test is conducted for the following null hypothesis: there is an equal probability that the principal strip price will be either greater or less than the coupon strip price. The results are presented in Table I. The null hypothesis is rejected for the entire sample and for five of the six individual samples.

The percentage difference in price, $\%\Delta P_\tau$, is defined as $(P_{P_\tau} - P_{C_\tau})/P_{C_\tau}$. The mean difference for the entire sample is 0.86%; see Table I. This difference is significantly greater than zero at the 5% level for each subsample and for the sample as a whole. Thus, the difference in price is statistically significant using either a parametric or nonparametric test.

Not only is the price difference statistically significant, but the size of this difference is economically significant. Consider the situation in which an investor currently owns one of the instruments. The investor could switch, selling the security at the bid price and buying the other at the ask price. Stigum (1990, p. 650) reports typical commissions of 1/256 dollar per \$100 face value in the market for Treasury notes and bonds. Using these transactions costs, the "switching" profits are computed. For 136 of the 225 pairs, it would be profitable to switch from a principal to a coupon strip, even after

[7] Bid and ask prices are sometimes reported for principal strips that correspond to original bonds that have no net stripping. Since there may never have been trading in these instruments, these observations are deleted.

[8] The major tests of the study have also been replicated using bid prices and prices defined as the average of the bid and ask prices. The results are similar to those reported for ask prices. The complete results are available from the authors.

Table I

Comparison of Principal Strip Prices with Coupon Strip Prices of the Same Maturity

The prices of principal strips and coupon strips of the same maturity are compared. P_{P_τ} and P_{C_τ} denote the ask prices of principal strips and coupon strips of maturity τ, respectively. The profit from a switch from a principal strip to a coupon strip is defined as the principal bid price less the coupon ask price and is adjusted for commissions; this is the net change in wealth from such a switch. For those pairs with positive profits from switching, the percentage profit is defined as the net profit divided by the bid price. For an additional 19 pairs in the entire sample, it would be profitable to switch from coupon strips to principal strips.

Date of Sample	No. of Pairs	No. of Pairs with Same Ask Price	No. of Pairs with Same Bid Price	No. of Pairs with Same Ask and Bid Prices	No. of Pairs with $P_{P_\tau} > P_{C_\tau}$	Mean of $(P_{P_\tau} - P_{C_\tau})/P_{C_\tau}$	No. with Positive Profit by Switching from Principal to Coupon	Mean % Profit in Positive Switches from Principal to Coupon
11/29/91	42	1	1	1	19	0.0031*	9	0.0087
8/30/91	39	2	2	2	32*	0.0079*	19	0.0088
5/31/91	38	0	0	0	35*	0.0120*	31	0.0092
2/28/91	37	3	2	2	33*	0.0100*	29	0.0068
11/30/90	36	1	1	1	33*	0.0080*	24	0.0055
8/31/91	33	1	1	1	28*	0.0116*	24	0.0092
Total	225	8	7	7	180*	0.0086*	136	0.0080

*Significant at the 5% level using either a two-tailed t-test or a binomial test.

including costs due to commissions and the bid-ask spread.[9] For these profitable switches, the average profit for a \$100 face value security is \$0.19, with a maximum profit of \$0.68. Prices of zero-coupon instruments decline as maturity increases, causing the percentage improvement, defined as the profit divided by the price of the principal strip, to increase with maturity. Several bond positions actually can be improved by over 2.3%; i.e., a principal strip can be replaced with a coupon strip, generating extra cash equal to 2.3% of the principal strip price. These results show that price differences between principal and coupon strips are statistically and economically significant.

III. Tests of Liquidity and Reconstitution Effects

As indicated in Section I, differences in liquidity and reconstitution features may cause price differences between principal and coupon strips of the same maturity. In the first part of this section, factors related to liquidity and reconstitution are identified. In the second part these factors are tested to determine whether they are also related to price differences. In the third part of this section, a model to explain price differences is developed and tested.

A. Factors Related to Differences in Liquidity and Reconstitution

Four factors are hypothesized to affect liquidity. The first, $W_{i\tau}$, is the total actual volume of the market for security i ($i = C$ denotes a coupon strip and $i = P$ denotes a principal strip) with maturity τ. For principal strips, this is simply the net amount of the original issue maturing on that date that has been stripped. For coupon strips, it is the net total dollar payments of all coupons from stripped bonds that are payable on that date.

The second measure is $V_{i\tau}$, the total potential volume of the market for security i with maturity τ. For principal strips, this is simply the amount of the original issue maturing on that date. For coupon strips, it is the total dollar payments of all coupons from strippable bonds that are payable on that date.

The third liquidity factor is the packet size required to use the instrument in either stripping or reconstitution. For principal strips of maturity τ, this packet size, $A_{P\tau}$, is defined as the packet size associated with the coupon rate of the bond from which the principal is derived. The stripping of many different bond issues may generate coupon strips maturing at time τ. Therefore, the packet size of a coupon strip maturing at time τ, $A_{C\tau}$, is defined as the minimum packet size of all strippable bonds which make coupon payments on that date. An issue may be more difficult to strip, and hence less liquid, if its packet size is relatively large. On the other hand, large packet sizes imply greater infusions of liquidity each time there is a stripping.

[9] For an additional 19 pairs, it would be profitable to switch from a coupon strip to a principal strip.

The fourth measure of liquidity is the percentage bid-ask spread, $S_{i\tau}$, and is defined as the difference in the bid and ask prices divided by the ask price. Larger spreads are often associated with less liquidity.[10]

Liquidity is valuable only if there is some nonzero probability of trading an instrument prior to maturity. It is reasonable that this probability would be greater the longer the life of the instrument. Therefore, maturity is included as an explanatory factor.

Several of the factors affecting liquidity also affect reconstitution. The value of using strips for reconstitution should increase with maturity, since there will be a longer period during which reconstitution may become desirable. Impediments to reconstitution, such as large packet sizes required to undertake reconstitution, or a large bid-ask spread, should decrease the reconstitution value. Panel A of Table II presents sample statistics for the liquidity and reconstitution factors: bid-ask spread, stripped volume, potential volume, and packet size.

There is another institutional feature that may affect the value of reconstitution. Principal strips may be used to reconstitute only a unique bond issue, but coupon strips may be used to reconstitute any bond with a coupon payment on that date. To account for this feature, let $N_{C\tau}$ denote the number of issues for which a coupon strip may be used in reconstitution.

B. Price Differentials and Liquidity / Reconstitution Factors

The percentage difference in strip price is denoted by $\%\Delta P_\tau$ and is defined as $(P_{P\tau} - P_{C\tau})/P_{C\tau}$. $\%\Delta P_\tau$ should be positively related to: (1) the percentage difference in actual volume, $\%\Delta W_\tau$ (defined as $(W_{P\tau} - W_{C\tau})/W_{C\tau}$); and (2) the percentage difference in potential volume difference, $\%\Delta V_\tau$ (defined as $(V_{P\tau} - V_{C\tau})/V_{C\tau}$). $\%\Delta P_\tau$ should be negatively related to: (1) the percentage difference in spread, $\%\Delta S_\tau$ (defined as $(S_{P\tau} - S_{C\tau})/S_{C\tau}$); and (2) the number of issues for which a coupon strip is eligible for reconstitution, $N_{C\tau}$. The relationships of $\%\Delta P_\tau$ to maturity, τ, and the percentage difference in packet size, $\%\Delta A_\tau$ (defined as $(A_{P\tau} - A_{C\tau})/A_{C\tau}$) may be of either sign.

Panel B of Table II reports the simple correlation between $\%\Delta P_\tau$ and the proposed variables. As hypothesized, $\%\Delta P_\tau$ is positively correlated with $\%\Delta W_\tau$ and $\%\Delta V_\tau$, which are both measures of liquidity. Also as hypothesized, $\%\Delta P_\tau$ is negatively correlated with $N_{C\tau}$.

$\%\Delta P_\tau$ is positively correlated with τ and negatively correlated with $\%\Delta A_\tau$, but there is no a priori reason to predict any particular sign.

[10] The percentage bid-ask spread increases as maturity increases. The simple correlation between percentage spread and maturity is 0.96 for coupon strips and 0.97 for principal strips. If percentage spread is considered a measure of liquidity, then these results indicate that longer term strips are less liquid than short-term strips. This is consistent with conventional wisdom, which states that many investors do not actively trade the long-term strips, but instead lock them away in portfolios. However, the focus of this study is not on the differences in liquidity between instruments of different maturity, but is on the effect of liquidity on instruments of identical maturity.

Table II

Price Differences and Liquidity / Reconstitution Effects

Panel A presents descriptive statistics for the coupon strip and principal strip pairs. Spreads are in dollars per \$100 face value. Volumes and packet sizes are expressed in units of millions of dollars of face value. Panel B presents the correlations of the percent difference in principal strip and coupon strip ask prices, $\%\Delta P_\tau$, with the percent differences in the corresponding proposed explanatory variables. $\%\Delta W_\tau$ is the percent difference in actual volumes, $\%\Delta V_\tau$ is the percent difference in potential volumes, $\%\Delta A_\tau$ is the percent difference in packet sizes, $\%\Delta S_\tau$ is the percent difference in the spreads, $N_{C\tau}$ is the number of issues for which a coupon strip is eligible for reconstitution, and τ is maturity.

Panel A: Descriptive Statistics

Date of Sample	No. of Pairs	Mean Bid-Ask Spread for Principal Strips	Mean Bid-Ask Spread for Coupon Strips	Mean Actual Volume of Stripped Principals	Mean Actual Volume of Stripped Coupons	Mean Potential Volume of Stripped Principals	Mean Potential Volume of Stripped Coupons	Mean Packet Size of Principals	Mean Packet Size of Stripped Coupons
11/29/91	42	0.1019	0.1004	2946.55	2102.74	11,546.55	6413.10	807.50	67.55
8/30/91	39	0.1026	0.1010	3109.85	2102.02	11,511.10	6305.85	810.13	88.54
5/31/91	38	0.0987	0.0970	3034.13	1958.12	11,516.32	5933.62	810.39	122.87
2/28/91	37	0.1056	0.1014	2981.76	1905.15	11,504.35	5683.94	823.65	124.97
11/30/90	36	0.1007	0.0955	2876.94	1804.79	11,515.22	5378.52	802.08	84.00
8/31/90	33	0.0975	0.0928	3007.61	1701.12	11,351.73	5108.77	811.97	85.24
Total	225	0.1013	0.0982	2993.25	1939.12	11,494.77	5836.79	810.89	95.20

Panel B. Correlations of $\%\Delta P_\tau$ with Proposed Explanatory Variables

	$\%\Delta W_\tau$	$\%\Delta V_\tau$	$\%\Delta A_\tau$	$\%\Delta S_\tau$	$N_{C\tau}$	τ
Sign of predicted relationship	+	+	+ or −	−	−	+ or −
Actual correlation with $\%\Delta P_\tau$	0.61*	0.62*	−0.36*	0.07	−0.75*	0.72*

*Significant at the 5% level.

Contrary to predictions, $\%\Delta P_\tau$ is positively correlated with $\%\Delta S_\tau$; however, this correlation is not statistically significant at even a 10% level. Analysis of the spreads reveals that the coupon and principal spreads differ for 66 observations. As with the entire sample, the correlation between $\%\Delta P_\tau$ and $\%\Delta S_\tau$ is not significant for these observations.

However, there is an interesting phenomenon associated with the 66 pairs that have different bid-ask spreads. For these observations, the mean difference in ask prices between principal strips and coupon strips is $0.168 (based on $100 dollar face value); the mean difference in bid prices is $0.157. Although these means are not statistically different using a *t*-test, they are different in a nonparametric signs test: 44 of the 66 pairs with different spreads have larger differences in ask prices than in bid prices. So even though the bid and ask prices of principal strips are usually larger than the respective bid and ask prices of coupon strips, the differences in ask prices account for most of the differences in spreads (when there are differences in spread).

There are two potential explanations for this phenomenon.[11] First, it may be due to reconstitution. Principal strips are particularly valuable if reconstitution is desired, since only principal strips from the original issue may be used in reconstitution. In contrast, any coupon maturing on the appropriate dates may be used, no matter its origin. Informal conversations with dealers indicate that when they want to reconstitute a particular bond issue they typically increase their ask price for the principal strip. In other words, they are not eager to sell the principal strip, and so they quote a high price.

Second, dealers sometimes will quote an ask price even when they don't hold any of the underlying security in inventory (a "short offer"). If the security is in short supply, then in the case of principals, the dealer would have to strip a particular bond in order to fill the order. To provide a coupon strip, the dealer could strip any of the bonds with the same payment month, as long as the bonds have equal or greater maturities. This can induce a higher ask price for principals, since consummating the transaction requires the purchase and stripping of a particular bond.

C. A Model of Liquidity and Reconstitution Effects

In this section, a model to determine separately liquidity and reconstitution effects is proposed and tested. It is assumed that the observed price of a

[11] A third explanation may be the presence of market segmentation. Institutions, such as insurance companies and pension funds, are major purchasers of strips. As Stigum (1990, p. 696) notes, these institutions tend to buy strips in large blocks, which may only be available as principal strips. Smaller investors, such as individuals purchasing strips for a retirement account, may end up holding the coupon strips. In addition to segmentation via institutional vs. smaller investors, there may also be an international dimension. Conversations with bond traders suggest that Japanese investors are usually active in only the market for principal strips, and that they tend to trade in large blocks. This higher demand for principal strips may drive up the price of principal strips, without regard to measures of liquidity such as bid-ask spread. In other words, the liquidity effect may be overshadowed by a clientele effect.

security can be modeled by the following equation:

$$P_{i\tau} = P_{0\tau} L_{i\tau} R_{i\tau}, \qquad \text{for} \quad i \in \{P, C\} \tag{1}$$

where $P_{0\tau}$ denotes the price of a generic, nonreconstitutable, zero-coupon instrument with perfect liquidity. $L_{i\tau}$ denotes the liquidity effect and is equal to one for a perfectly liquid asset; it should be less than one for an instrument which is not perfectly liquid. $R_{i\tau}$ denotes the reconstitution effect and is equal to one for a nonreconstitutable asset. $R_{i\tau}$ should be greater than one for reconstitutable assets. Although this may not be the correct functional form, it is consistent with the ideas that reductions in liquidity decrease value and that the ability to reconstitute adds value.

The effect of liquidity should be negligible for an instrument with a very short time until maturity while reductions in liquidity should have a greater impact on securities with longer maturities. The following functional form of liquidity is proposed:

$$L_{i\tau} = (\tau + 1)^{b_0 + \frac{b_1}{W_{i\tau}} + \frac{b_2}{V_{i\tau}} + b_3 A_{i\tau} + b_4 S_{i\tau}}, \qquad \text{for} \quad i \in \{P, C\} \tag{2}$$

where b_0, b_1, b_2, b_3, and b_4 are constants. Although no formal proof can be given for this particular functional form, it is consistent with economic intuition; i.e., reductions in liquidity reduce the value of a security, and value is reduced more for instruments of longer maturity.

The value of reconstitution should also increase with maturity. A similar functional form is proposed for the reconstitution effect:

$$R_{i\tau} = (\tau + 1)^{b_5 + b_6 A_{i\tau} + b_7 S_{i\tau} + b_8 N_{i\tau} + b_9 D_{i\tau}}, \qquad \text{for} \quad i \in \{P, C\} \tag{3}$$

where b_5, b_6, b_7, b_8, and b_9 are constants. $D_{i\tau}$ is a dummy variable that takes on the value of one for a principal strip ($i = P$) and a value of zero for a coupon strip. This dummy variable is added to reflect the unique role that a principal strip plays in the reconstitution process.

Equations (1), (2), and (3) imply the following testable relationship:

$$\begin{aligned}\frac{\ln(P_{P\tau}/P_{C\tau})}{\ln(1+\tau)} &= \sum_{t=2}^{6} a_t T_t + b_1\left(\frac{1}{W_{P\tau}} - \frac{1}{W_{C\tau}}\right) + b_2\left(\frac{1}{V_{P\tau}} - \frac{1}{V_{C\tau}}\right) \\ &\quad + (b_3 + b_6)(A_{P\tau} - A_{C\tau}) + (b_4 + b_7)(S_{P\tau} - S_{C\tau}) \\ &\quad + b_8(1 - N_{C\tau}) + b_9 D_{P\tau} + \epsilon_\tau,\end{aligned} \tag{4}$$

where the T_i are dummies for the sample dates, a_i and b_i are coefficients, and ϵ_τ is an error term.

A correction for heteroscedasticity is applied; see Judge, Hill, Griffiths, and Lee (1982) for details and Amihud and Mendelson (1991) for a recent example of an application.

The results are presented in Table III. With an adjusted R^2 of 0.57, the model has a high degree of explanatory power. By way of comparison, the model used by Silber (1991) to explain liquidity effects in restricted stock

Table III

Regression Results for the Liquidity / Reconstitution Model:

$$\frac{\ln(P_{P\tau}/P_{C\tau})}{\ln(1+\tau)} = \sum_{t=2}^{6} a_t T_t + b_1\left(\frac{1}{W_{P\tau}} - \frac{1}{W_{C\tau}}\right) + b_2\left(\frac{1}{V_{P\tau}} - \frac{1}{V_{C\tau}}\right) + (b_3+b_6)(A_{P\tau} - A_{C\tau}) + (b_4+b_7)(S_{P\tau} - S_{C\tau}) + b_8(1 - N_{C\tau}) + b_9 D_{P\tau} + \epsilon_\tau$$

The first row in the table indicates the predicted signs of the coefficients; the second row presents the estimated coefficients. $i = P$ for principal strips, $i = C$ for coupon strips and τ = maturity. $P_{i\tau}$ = ask price, $T_t = 1$ for sample date t, $W_{i\tau}$ = actual volume, $V_{i\tau}$ = potential volume, $A_{i\tau}$ = packet size, $S_{i\tau}$ = bid-ask spread, $D_{P\tau} = 1$ for principal strips, $N_{C\tau}$ = number of issues for which a coupon strip is eligible for reconstitution. For clarity of presentation, the estimated dummy coefficients for the sample dates are not reported. They are typically positive and significant. Complete results are available from the authors. The third row presents the estimated parameters when only the dummy coefficients and the two significant explanatory variables are included. "n.i." indicates that the variable is not included in the regression.

Independent Variables			$(1/W_{P\tau})$ − $(1/W_{C\tau})$	$(1/V_{P\tau})$ − $(1/V_{C\tau})$	$A_{P\tau} - A_{C\tau}$	$S_{P\tau} - S_{C\tau}$	$1 - N_{C\tau}$	$D_{P\tau}$
Predicted Sign			−	−	+ or −	−	+	+
Regression Statistics			Estimated Coefficients of Independent Variables (t-statistic)					
No. Obs.	F	Adj. R^2						
225	32.86*	0.57	2.21[b] (1.98)*	−0.379 (−1.29)	0.284[a] (1.38)	−0.072 (−0.70)	0.267[b] (10.89)*	3.69[b] (7.09)*
225	40.61*	0.57	0.623[b] (0.75)	n.i. n.i.	n.i. n.i.	n.i. n.i.	0.277[b] (13.82)*	3.96[b] (10.43)*

*Significant at the 5% level.

[a] For clarity of presentation, the reported coefficient for $(A_{P\tau} - A_{C\tau})$ is multiplied by 10^6.

[b] For clarity of presentation, the reported coefficients for $(1/W_{P\tau} - 1/W_{C\tau})$, $D_{P\tau}$, and $(1 - N_{C\tau})$ are multiplied by 10^3.

offerings has an R^2 of 0.29.

The two coefficients that are associated solely with the reconstitution effects (b_8 and b_9) are significant and of the predicted sign. Therefore, the unique role of the principal strip in reconstitution, as measured by b_9, is significant. The number of opportunities to reconstitute, as measured by b_8, is also significant.

It is impossible to distinguish separately the role of packet size and spread with respect to liquidity and reconstitution effects; however, neither coefficient is significant.

The two coefficients associated only with liquidity effects (b_1 and b_2) are ambiguous. The estimated coefficient of b_2 is of the correct sign but is insignificant, while the estimated coefficient of b_1 is significant but of the wrong sign. However, b_1 is not significant when the other insignificant variables in the regression are deleted, as shown in the last row of Table III.

IV. Conclusions

An apparent pricing anomaly exists in the market for U.S. Treasury strips: principal strips consistently sell at higher prices than coupon strips of the same maturity. The price differences are not only statistically significant, but are large enough to be economically meaningful. The robustness of this conclusion must be tempered to the extent that the data may not be perfectly reliable.

Principal strips and coupon strips are not perfect substitutes, but differ with respect to reconstitution procedures and liquidity. Empirical tests indicate that there is a positive premium due to the ability to reconstitute. The degree of ease with which reconstitution is possible also adds value to the security. Reconstitution effects are related to maturity, with reconstitution more valuable for instruments of longer maturity.

The empirical results with respect to liquidity effects are somewhat mixed. The univariate tests indicate a positive value associated with liquidity, while the multivariate model provides no evidence of a liquidity effect. It should be noted that conclusions based on the model are actually dependent on the joint hypothesis that the selected variables and the functional form of the model are correct. If the functional form is incorrect, then the results are uninterpretable.

Finally, there is an interesting phenomenon with respect to the relative differentials of bid prices and ask prices. For those pairs of strips with different bid-ask spreads, it is typically the differences in ask prices that cause the spread differences. Not only are ask and bid prices of principal strips usually greater than the respective ask and bid prices of coupon strips, but differences in ask prices are frequently greater than the respective differences in bid prices.

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