THE MISPRICING OF CALLABLE U.S. TREASURY BONDS: A NOTE

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INTRODUCTION

The embedded option implicit in callable U.S. Treasury bonds has recently been the focus of research with conflicting results. Starting with Longstaff (1992), a number of researchers have examined the pricing behavior of callable Treasury bonds and document an apparent puzzle: Market prices for these bonds often imply negative values for the implicit call and/or put options, a result at odds with one of the most fundamental propositions of finance. Moreover, the negative values frequently exceed the spread-related costs of an arbitrage strategy designed to exploit the mispriced callable bond.

In contrast, Jordan, Jordan, and Jorgensen (1995) and Jordan, Jordan, and Kuipers (1998) find little or no evidence of profitable arbitrage opportunities involving misvalued implicit options. They suggest that what seems to be a puzzle is only the result of tax effects associated with the cash flow replication techniques used in previous studies. They argue that these techniques may lead to the appearance of a negative option value when the true value is positive.

This note reexamines the tax disadvantage argument as a potential explanation of the callable bond puzzle. It suggests that while a no-arbitrage boundary condition implied by the presence of the embedded option is often violated, tax effects previously cited as an explanation for the

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phenomenon cannot fully explain the magnitude and the frequency of the violations.

CALLABLE BOND PRICES AND THE BOUNDARY CONDITION

Treasury callable bonds are regular bonds which can be called at par at the discretion of the government on any coupon date during the last five years of their lives with four months notice. Thus, a long position in a callable Treasury bond can be considered the same as a portfolio consisting of a long position in an equivalent (with respect to the coupon rate) noncallable bond with the same maturity and a short position in a call option. The call option gives the U.S. Treasury the right to redeem the callable bond at par on any of the ten coupon payment dates during the five-year period prior to the final maturity date of the bond. The callable bond can also be viewed as a portfolio of an equivalent noncallable bond which matures on the callable bond's next call date plus a short position in a put option. This put option gives the U.S. Treasury the right to extend the maturity of the equivalent noncallable bond. Thus, given the non-negativity of option values, the price of the callable bond has to be lower than the prices of the two equivalent noncallable issues maturing either on the callable bond's final maturity or next call date. Furthermore, as Jordan et al. (1995) suggest, the callable bond price has to be lower than the value of an equivalent noncallable bond maturing on any of the callable bond's intermediate call dates.[1] Thus,

$$B_c(t, T) \leqq B_{nc}(t, T_i), i = 1, \ldots, 11 \tag{1}$$

where t is the current date, T is the date of the original maturity, T_i denotes either one of the callable bond's call dates or final maturity, ($T_{11} = T$), $B_c(t, T)$ denotes the value of the callable bond, and $B_{nc}(t, T_i)$ denotes the value of an equivalent noncallable bond which matures either on the same date as the callable bond or on one of its call dates. If the price of the callable bond exceeds the value of any of the noncallable issues in eq. (1), then the callable bond is overpriced. Thus, condition (1) implies the following boundary condition:

[1]Jordan et al. (1995) consider each callable bond a portfolio of an equivalent noncallable bond which matures on any of the callable bond's intermediate call dates and a short position in an option whose value is a combination of a put and a call. However, as Bliss and Ronn (1997) suggest, that approach is a useful, though purely conceptual, exercise which gives rise to multiple pricing bounds, but not multiple options. In reality, there is only an American-style call option (strictly speaking a Bermuda option) that can be exercised prior to maturity.

$$B_c(t, T) \leqq \min_i \{B_{nc}(t, T_i)\}, i = 1, \ldots, 11 \quad (2)$$

$\text{Min}_i \{B_{nc}(t, T_i)\}$ will be referred to as the minimum value noncallable hereafter. The maturity date of the minimum value noncallable is a function of the term structure of interest rates and the level of the bond's coupon rate. However, one would expect that in the majority of the cases the minimum value noncallable matures either on the first call date or on the final maturity date of the callable bond. This depends on whether the callable bond currently sells at a premium or at a discount, respectively. If it sells around par, it is possible for the minimum value noncallable to mature on one of the intermediate call dates.

PREVIOUS STUDIES

Differences in the reported frequency of mispriced callable bonds or negative implied option values in previous studies are the result of different interpretations of conditions (1) and (2). If the callable bond is compared to a noncallable other than the minimum value one, results may indicate no violation; however, one cannot preclude violations of the boundary condition and, thus, the existence of a mispriced callable bond. Studies supporting the existence of the puzzle have examined either the first call date or the bond's final maturity date (or both). Since these dates are likely to coincide with the maturity of the minimum value noncallable, the studies are able to document the pricing anomaly and the negative option values associated with it. The values of the implied options in these studies are calculated by subtracting the price of the callable bond from the value of a portfolio which exactly matches the cash flows of the equivalent noncallable issue. The portfolio is constructed by either combining a noncallable Treasury bond and a coupon STRIPS as in Longstaff (1992) and Edleson, Fehr, and Mason (1993), or with a portfolio of coupon STRIPS (all-STRIPS approach) as in Carayannopoulos (1995). STRIPS are Treasury obligations created by stripping and selling separately each coupon and principal obligation from existing Treasury issues of ten or more years of maturity.

Jordan et al. (1995) reexamined the issue and provide a plausible explanation for what seems to be a pricing anomaly. They suggest that the inclusion of STRIPS in the replication techniques of previous studies biases downward the value of the equivalent portfolio since STRIPS have a tax disadvantage when compared to other Treasury issues selling at a discount. Therefore, what appears to be a negative implied option value is the result of the replicating portfolio having a lower value compared to an otherwise equivalent noncallable Treasury bond. Using only Treasury bonds (and no STRIPS) in the replicating portfolio and considering the final maturity date or any of the ten call dates of the callable bonds for which a replicating portfolio can be constructed, they find little or no evidence of profitable arbitrage opportunities involving misvalued callable bonds in more than 4000 cases examined. However, this absence of any significant violations has more to do with the fact that Jordan et al. (1995) compare callable bonds to equivalent noncallables issues which mature mostly on intermediate call dates, rather than the absence of mispriced callable bonds. As discussed earlier, these maturity dates are most likely different from the maturity of the minimum value noncallable. Thus, the reported absence of any significant violations does not necessarily preclude the mispricing of the corresponding callable bonds. Jordan et al. (1998), using the all-STRIPS approach, examine all 11 pricing bounds implied by condition (1) and report a violation frequency much lower than previously reported. However, the reported frequency of violations is misleading with respect to the frequency of mispriced callable bonds since it treats the 11 pricing bounds in eq. (1) as independent. For example, if only 1 of the 11 bounds implied by condition (1) is violated, Jordan et al. (1998) report the incident as only a 9% violation frequency. However, even if only 1 of the 11 bounds is violated, this should be reported as an instance of an overpriced callable bond as determined by condition (2).

Bliss and Ronn (1997) make a similar argument and provide a thorough comparison of previous results. They suggest that, if differences in reporting are accounted for, the frequency of mispriced callable bonds in the Jordan et al. (1998) article is even higher than the one reported in the Carayannopoulos (1995) study, which uses the same cash flow replication technique and a greatly overlapping testing period. Furthermore, using a completely different methodology, which allows them to test a much larger sample of bond prices not only for overpriced but also for underpriced callable bonds, Bliss and Ronn (1997) show that the frequency of mispriced callable bonds is time varying.

Differences in reporting aside, one question still remaining is whether tax effects can be used as an explanation for the callable U.S. Treasury bond puzzle. This is the focus of the remainder of this study.

VIOLATIONS OF THE BOUNDARY CONDITION

Before proceeding with the examination of the tax effects argument, and given the differential source of bond data in this study compared to previous studies, violations of condition (2) are examined. The study covers monthly closing callable bond prices for the period from July 1990 to March 1994. The process involves calculating the value of the 11 noncallable bonds suggested in condition (2), choosing the one with the minimum value, and then comparing its price to the price of the callable bond.[2] When the price of the callable bond exceeds the value of the minimum value noncallable, a violation occurs. The values of the noncallable bonds are calculated using the all-STRIPS method employed in the Carayannopoulos (1995) and Jordan et al. (1998) studies. The method involves constructing a portfolio of STRIPS which exactly replicates the cash flows of the noncallable that is being replicated.[3] Therefore, given the identical cash flows, the value of the noncallable should be the same as the value of the replicating STRIPS portfolio. Bid and ask monthly closing STRIPS prices are collected from *The Wall Street Journal,* which has been publishing them since mid-1989. Prior to July 1990, quotations in *The Wall Street Journal* were obtained from the Bloomberg system. Since July 1990, quotations are provided by Bear Stearns. To maintain consistency, only quotations provided by the latter company are included in the study.[4]

Monthly closing prices for the 23 callable Treasury bonds outstanding during the aforementioned period are obtained from the University of Wisconsin-Milwaukee fixed income data base. This data base contains detailed pricing information (bid prices only) on the individual bonds that make up the Lehman Brothers Bond Indexes. The flower bonds—4.250 August 1992, 4.000 February 1993, and 4.125 May 1994—are excluded from the sample. In total, 988 observations are included in the sample, 45 for each bond except the 7.5 August 1993 and 7.00 May 1998 bonds, which were called by the Treasury before their actual maturity dates. The 7.5 August 1993 was called in February 1992, which, in turn, suggests that a call notice was given in October 1991. However, prices for this bond stopped appearing in *The Wall Street Journal* as of August 1991. For consistency, price comparisons for the particular issue are performed

[2]The number of noncallables considered is less than 11 if the callable bond has less than five years to maturity left. In such case, if the length of the period between the current valuation time and the next coupon payment date is more than four months, the next coupon payment date is set as the first possible call date. Otherwise, the first possible call date is set to coincide with the coupon payment date following the next one. This takes care of the four months call notice which has to be given by the Treasury.

[3]Only STRIPS derived from coupons are used in the construction of the replicating portfolio. It has been shown in the past that STRIPS derived from principal contain liquidity effects and, as a result, their prices are, in general, different from the prices of their equivalent coupon counterparts. For a discussion and explanation of these differences, see Daves and Ehrhardt (1993) and Carayannopoulos (1996).

[4]STRIPS prices provided by the Bloomberg system are characterized by much larger bid–ask spreads.

TABLE I

Violations of the Boundary Condition Implied by Callable U.S. Treasury Bond Prices (Bid–Ask Spread Adjusted)

Callable Bond Price as Percentage of Face Value	*Total Observations*	*Violations*	*Mean*	*Maximum*	*75%*	*Median*	*25%*
>120	463	16	0.51	1.53	0.80	0.43	0.15
(115, 120]	57	—	—	—	—	—	—
(110, 115]	73	3	0.22	0.35	—	0.27	—
(105, 110]	136	22	0.55	2.00	0.93	0.41	0.08
(100, 105]	151	76	0.74	2.53	1.10	0.51	0.27
100	4	1	0.69	—	—	—	—
[95, 100)	72	71	0.86	2.34	1.34	0.78	0.43
[90, 95)	29	29	0.73	1.49	0.98	0.61	0.35
[85, 90)	3	3	0.56	0.78		0.68	
Total	988	221	0.73	2.53	1.12	0.57	0.31

Notes: A violation occurs when the bid price of the callable bond exceeds the ask value of the minimum value noncallable. The minimum value noncallable is the bond with the minimum value among all noncallable bonds that have the same coupon rate as the callable bond and mature on one of the callable bond's call dates or its final maturity. The noncallables are constructed with a portfolio of STRIPS. Violations are reported in dollars, and a $100 par value per bond is assumed.

up to the end of July 1991, and, thus, the 13 observations. The 7.00 May 1998 was called in May 1993, which suggests a call notice was given in January 1993. Thus, price comparisons are performed up to the end of December 1992, which results in 30 observations for this particular issue.

Results, based on a $100 bond par value and adjusted for the bid–ask spread, are presented in Table I. Overall, 221 violations (22.37% of the sample) are documented. The mean violation is $0.73 and the maximum violation is $2.53. Fifty percent of the violations exceed $0.57, while 25% of them are greater than $1.12. As Table I demonstrates, the majority of the violations occur when the callable bond is selling at a discount. Almost 100% of the observations (103 of 104) violate the boundary condition. Violations are also considerable for callable bonds with prices between 100% and 105% of par value. In such cases, 76 violations (or 50.33% of the sample) are reported. The frequency of the violations reduces significantly for callable bonds selling at more than 105% of par value. For prices between 105% and 110% of par value, 22 violations (or 16.18% of the sample) are reported, while for prices above 110% of par value, only 19 violations (or 3.20% of the sample) occur.

Implied negative option values are not reported in Table I. However, negative implied call values occur 19.13% of the time (189 of 988 observations). With discount callable bond prices, negative call values are implied 99.04% of the time (103 of 104 observations), while with par or premium callable bond prices, negative implied call values occur only 9.73% of the time (86 of 884 observations). In contrast, negative put values are implied only 5.47% of the time. For premium bonds (when the put option is out of the money), 44 violations are documented in a sample of 884 prices. Only 7 put violations (of 104 observations) are found for discount bonds. As expected, violations for intermediate call dates are almost nonexistent. The results with respect to the call and put violations frequencies are similar to the ones reported by Carayannopoulos (1995) and Jordan et al. (1998).[5]

TAX EFFECTS AND THE CALLABLE U.S. TREASURY BOND PUZZLE

Jordan et al. (1995) develop the theoretical argument that what seems to be a puzzle is nothing else but the result of the cash flow replication technique used in the previous studies. STRIPS and discount bonds are taxed the same way with an important distinction: For both, the discount from par is amortized and the implicit interest accrues each year. However, for the discount bond, payment of tax on the accrued interest can be deferred until the bond is sold or matures. Taxes must be paid on the STRIPS each year. STRIPS, therefore, have a significant tax disadvantage which is discounted in their prices. As a result, their inclusion in the replicating portfolio might decrease the value of the portfolio compared to an otherwise equivalent coupon bond. Thus, what appears to be an implied negative option value is the result of comparing the value of the callable bond to the depressed value of the replicating portfolio.

[5]The original article by Carayannopoulos reverses the frequency of implied negative call and put option values. Subsequently, the error was corrected (see *The Journal of Futures Markets*, January 1997, erratum). Jordan et al. (1998) suggest that this error led Carayannopoulos to the conclusion that negative implied option prices are predominant in low coupon callable issues while they are absent from higher coupon ones. Rather, they suggest, the appearance of negative implied option values is related to discount-premium status. While the issue is rather unimportant and it is difficult to differentiate between low-high coupon vs. premium-discount effects, it should be noted that there is strong evidence in Jordan et al.'s (1998) results that the pricing behavior of low coupon callable bonds is significantly different than that of higher coupon issues. An examination of Tables IV and V in their article suggests that in what they call a premium class there are 4989 low coupon callable bond observations of which 25.5% (or 1270) imply negative call values. In the same class, there are 692 observations of higher coupon callable bonds of which only 2.75% (or 19) imply negative call options. Adjusted for the bid–ask spread, negative implied call option values appear 19.7% and 0% of the time, respectively. In what they call a super-premium class, of 1576 observations of lower coupon callable bonds, 5.2% of negative implied call values are found (3.3% spread adjusted), while of 14,227 observations associated with higher coupon callable bonds, no negative call option values are found. Unfortunately, there are no observations of higher coupon bonds in what they call discount and deep-discount classes, and a direct comparison is impossible in this case.

This explanation seems very plausible, especially given the results reported earlier in this note which suggest that violations of the boundary condition, and, thus, negative implied option values, occur mostly for callables which are selling at a discount. When the bond is selling at a discount, the minimum value noncallable is usually the one which has a maturity equal to the callable bond's original maturity, and the violation suggests a negative implied call value. When the bond is selling at a discount, since it is out of the money, the call option has a small value. The greater the degree of discount of the callable bond, the closer to zero the value of the implied call option. As a result, since the embedded call option has a very low value, it cannot offset the tax disadvantage of the STRIPS portfolio and the result is what appears to be a negative call value.

However, while the tax disadvantage argument could explain the appearance of violations in cases where the callable bond is selling at a discount, it would not provide an explanation for the violations documented when the callable bond is selling at par or at a premium. Results in Table I suggest that 50.33% of the time violations occur for callable bonds selling at a price between 100% and 105% of par value, while 16.18% of the time violations occur for bonds selling between 105% and 110% of par value.

One caveat of the theoretical argument in the Jordan et al. (1995) study is that it is based on a marginal tax rate of 30% on all incomes including coupon, long-term, and short-term capital gains. Considering the fact that tax-exempt investors are the dominant players in the market, it is difficult to believe that the 30% bracket represents investors' marginal tax rate for all Treasury bonds. Furthermore, stripping and reconstitution allowed in the U.S. Treasury bond market should eliminate a lot of price discrepancies due to differential tax treatment of the underlying securities to the extent that bid–ask margins allow.

Indeed, if tax effects exist, they should be present when STRIPS are used to replicate noncallable bonds as well. Jordan et al. (1998) empirically examine the performance of the all-STRIPS replication technique by comparing 132,641 daily differences between noncallable Treasury issues and equivalent STRIPS portfolios for the period from 1990 to 1994. They find that 61% of the time the value of the bond exceeds the value of the equivalent STRIPS portfolio, and, on average, bond price exceeds the value of the equivalent STRIPS portfolio by $0.11. When the sample is limited to discount bonds, 78% of the time the value of the bond exceeds that of the STRIPS portfolio, and, on average, bond price exceeds the value of the STRIPS portfolio by $0.19. Given the size of the sample, they suggest that these results are indicative of a tax disadvantage of STRIPS especially with respect to discount bonds, and they use it to explain the appearance of the negative implied call options.

However, absent from the Jordan et al. (1998) paper is a direct comparison of the pricing behavior of callable and noncallable Treasury bonds with respect to the STRIPS replicating portfolio and a discussion as to whether tax (or other) effects are large enough to explain the magnitude and the frequency of the mispricing of callable U.S. Treasury bonds.[6]

Monthly prices of all noncallable Treasury bonds outstanding during the period from July 1990 to March 1994 are compared to the value of an equivalent STRIPS portfolio. These prices are also extracted from the University of Wisconsin-Milwaukee fixed income data base. The only issues excluded from the sample are bonds with special tax status (flower bonds) and newly issued securities which are known to trade at higher prices. Amihud and Mendelson (1991) show that newly issued Treasuries trade at prices higher than equivalent Treasuries that were issued some time earlier. Carayannopoulos (1996) suggests that it takes approximately three months for prices of newly issued Treasuries with maturities of 3, 5, and 30 years to become comparable to prices of other seasoned issues, while the seasoning process for 10-year newly issued Treasuries lasts approximately 20 months. Thus, newly issued Treasuries of 3, 5, and 30 year maturities with less than 3 months since issued and 10-year issues with less than 20 months since issued are excluded from the sample.

The result is 4525 pairs of matched noncallable bonds and equivalent STRIPS portfolio prices. Results are reported as bond price minus STRIPS portfolio price. Results in Table II, based on a comparison of bid prices, suggest differences in the pricing behavior when premium and discount bonds are viewed separately. In general, when premium bonds are considered, the price of the bond exceeds the value of the equivalent STRIPS portfolio 47.53% of the time. On average, the bond price exceeds the STRIPS portfolio price by \$0.05, while 90% of the differences fall between \$0.55 and −\$0.26 (a negative number indicates that the value of the STRIPS portfolio exceeds the price of the corresponding bond).

The percentage of positive differences is greater when discount bonds are compared. Overall, in 72.96% of the observations, the bond price exceeds the value of the STRIPS portfolio. On average, the price of the bond exceeds the value of the STRIPS portfolio by \$0.14. The max-

[6]Benchmarking callable vs. noncallable bonds provides an opportunity to test whether pricing differences observed under the all-STRIPS replication technique are unique to callable only bonds or characterize noncallable issues as well. Results are important since factors such as differential taxation, differential sources of and nonsynchronous quotes in the data, or other unknown factors unique to STRIPS may affect the pricing of STRIPS in general and bias the results in this study.

TABLE II

Differences between Seasoned Noncallable Bonds and Equivalent STRIPS Portfolio (Bid Prices)

Bond Price as Percentage of Face Value	*Observations*	*Mean*	*% Positive*	*Maximum*	*95%*	*Median*	*5%*	*Minimum*
>120	917	0.21	70.88	1.77	0.85	0.16	−0.30	−0.89
(115, 120]	397	0.02	49.12	1.78	0.41	0.00	−0.28	−0.51
(110, 115]	670	−0.01	42.24	1.49	0.31	−0.03	−0.30	−0.60
(105, 110]	944	−0.01	41.63	1.21	0.34	−0.03	−0.27	−0.56
(100, 105]	1358	0.01	38.00	1.34	0.36	−0.03	−0.22	−0.48
Total premium	4286	0.05	47.53	1.78	0.55	−0.01	−0.26	−0.89
100	6	0.00	16.67	0.69	0.69	−0.10	−0.22	−0.22
[95, 100)	179	0.11	65.92	0.90	0.44	0.09	−0.15	−0.44
[90, 95)	34	0.21	94.12	0.44	0.42	0.22	−0.22	−0.33
[85, 90)	15	0.33	100.00	0.57	0.57	0.35	0.13	0.13
[80, 85)	5	0.19	100.00	0.30	0.30	0.24	0.01	0.01
Total Discount	233	0.14	72.96	0.90	0.44	0.13	−0.15	−0.44

Notes: Differences are calculated as the bond's bid price minus the bid value of the equivalent STRIPS portfolio. A \$100 par value for all bonds is assumed.

imum difference is \$0.90 and the minimum is −\$0.44, while the 90% range is 0.44 to −\$0.15. The average amount by which the bond price exceeds the STRIPS portfolio value and the percentage of positive differences seem to increase with the degree of discount from par.

Overall, results suggest a tax disadvantage of STRIPS in accordance with the Jordan et al. (1995) argument. However, the question still remaining is whether this disadvantage is big enough to overcome bid–ask-related costs. Given the number of transactions needed to construct the equivalent STRIPS portfolio, transaction costs can be significant and enough to eliminate most of the differences observed due to tax effects.

The previous comparisons are repeated by comparing the bid price of the bond to the ask price of the equivalent STRIPS portfolio. Results are presented in Table III. Overall, the bid price of a discount bond exceeds the ask value of the STRIPS portfolio 37.34% of the time. On average, the value of the STRIPS portfolio exceeds the value of the discount bond by \$0.04. More importantly, the maximum amount by which the bid price of a bond exceeds the value of the portfolio is \$0.72, while the 90% range is \$0.27 to −\$0.29. Results are similar when the degree of discount from par is considered. With respect to bonds selling at a premium, only 21.14% of the time does the bid price of the bond exceed

TABLE III

Differences between Seasoned Noncallable Bonds and Equivalent STRIPS Portfolio Prices (Bid–Ask Spread Adjusted)

Bond Price as Percentage of Face Value	*Observations*	*Mean*	*% Positive*	*Maximum*	*95%*	*Median*	*5%*	*Minimum*
>120	917	−0.10	36.53	1.47	0.57	−0.17	−0.66	−1.50
(115, 120]	397	−0.18	13.10	1.52	0.17	−0.20	−0.53	−0.85
(110, 115]	670	−0.17	11.34	1.19	0.11	−0.17	−0.48	−0.92
(105, 110]	944	−0.13	14.83	0.95	0.14	−0.14	−0.40	−0.91
(100, 105]	1358	−0.06	23.05	1.23	0.23	−0.07	−0.29	−0.82
Total premium	4286	−0.12	21.14	1.52	0.31	−0.12	−0.48	−1.50
100	6	−0.08	16.67	0.54	0.54	−0.10	−0.55	−0.55
[95, 100)	179	−0.04	35.75	0.72	0.31	−0.06	−0.29	−0.77
[90, 95)	34	−0.06	35.29	0.29	0.27	−0.05	−0.50	−0.62
[85, 90)	15	0.05	66.67	0.23	0.23	0.07	−0.16	−0.16
[80, 85)	5	−0.06	20.00	0.07	0.07	−0.02	−0.23	−0.23
Total discount	233	−0.04	37.34	0.72	0.27	−0.05	−0.29	−0.77

Notes: Differences are calculated as the bond's bid price minus the ask value of the equivalent STRIPS portfolio. A $100 par value for all bonds is assumed.

the ask value of the portfolio. On average, the ask value of the STRIPS portfolio exceeds the bid price of the bond by $0.12. The maximum amount by which the bond price exceeds the value of the portfolio is $1.52 and the 90% range is $0.31 to −$0.48.

Comparisons of Table III with Table I clearly suggest that, although it may contribute to the phenomenon, the tax disadvantage of STRIPS is not enough to explain the magnitude and the frequency of the violations of the boundary condition (2). In almost 100% of the cases where the callable bond is selling at a discount, the bid price of the callable bond exceeds the ask value of the STRIPS portfolio. The magnitude of the violations is also well above the differences reported for noncallable bonds. This is true irrespective of the degree of discount of the callable bond. The same is true for callable bonds selling at a premium between 100% and 105% of par value.

Since negative implied option values are observed mainly for the embedded call option and in light of the above analysis, mean pricing differences between the callable bond and the equivalent STRIPS portfolio with the same maturity as the callable bond maturity (rather than the minimum value noncallable) are compared to the mean pricing difference for noncallable bonds. The pricing difference is defined as the

TABLE IV

Comparison of Mean Pricing Differences for Callable and Noncallable Bonds (Bid–Ask Spread Adjusted)

Bond Price as Percentage of Face Value	*Callable Bonds*			*Noncallable Bonds*			
	Observations	*Mean$_c$*	SD	*Observations*	*Mean$_{nc}$*	SD	*t-Value*
>120	463	5.95	2.201	917	0.10	0.389	78.06
(115, 120]	57	2.86	0.986	397	0.18	0.230	46.29
(110, 115]	73	2.08	1.260	670	0.17	0.209	35.15
(105, 110]	136	3.03	3.288	944	0.13	0.186	26.80
(100, 105]	151	1.46	3.932	1358	0.06	0.164	12.97
100	4	0.34	0.688	6	0.08	0.355	0.81
[95, 100)	72	−0.85	0.534	179	0.04	0.188	−19.38
[90, 95)	29	0.73	0.412	34	0.06	0.198	−9.90
[85, 90)	3	−0.56	0.298	15	−0.05	0.106	−5.65

Notes: The pricing difference is defined as the ask value of a STRIPS portfolio minus the bid price of the bond (callable or noncallable). The STRIPS portfolio has the same cash flows and maturity as the bond (callable or noncallable) against which it is being compared. Mean$_c$ denotes the mean pricing difference for callable bonds and Mean$_{nc}$ the mean pricing difference for noncallable bonds. The expectation is that, due to the existence of the embedded option, Mean$_c$ will always be greater than or equal to Mean$_{nc}$. SD denotes the standard deviation for pricing differences and *t*-value denotes the *t*-value for testing the hypothesis that (Mean$_c$ − Mean$_{nc}$) ≧ 0. A $100 par value is assumed for all bonds.

ask value of the STRIPS portfolio minus the bid price of the callable bond. The expectation is that, due to the presence of the embedded call option, the mean pricing difference for callable bonds should be no lower than the one for noncallable issues. When the option is at or in the money (or equivalently the callable bond is selling at par or at a premium) the mean pricing difference for callable bonds should significantly exceed the one for noncallable issues. When the call option is deep out of the money (the callable is selling at a considerable discount) its value should be very close to zero and, thus, the mean pricing difference for the callable bonds should be very close to the mean pricing difference of other noncallable issues. However, under no circumstances should the mean pricing difference for callable bonds be significantly lower than the mean pricing difference for noncallable issues selling at about the same degree of discount.

Table IV presents a summary of the results. As expected, when the callable bond is selling at par or a premium, the mean pricing difference for callable bonds exceeds the one for noncallable issues. Furthermore, although a significant number of violations are reported for callable bonds selling at a premium between 100% and 105% of par value, overall, the average call value is positive (since the mean pricing difference is positive). However, contrary to expectations, the mean pricing difference for discount callable bonds is significantly lower than the one for noncallable discount issues.

Overall, results suggest a significant overpricing of some of the callable bonds and, thus, the existence of negative implied option values. This overpricing seems to persist for callable bonds for which the implied call option is near or out of the money. Tax effects associated with the cash flow replication technique cannot be a possible explanation since the analysis has been adjusted for that by comparing callable and noncallable bonds selling at the same degree of discount.

Since callable bonds were issued before 1985, an argument can be made that due to lack of liquidity prices of such bonds can deviate significantly from the value of the replicating portfolio. Although it considerably reduces the sample size of noncallable issues, repeating the previous analysis for the sample of noncallable bonds issued before 1985 suggests results are no different than the ones obtained with the entire sample.

CONCLUSIONS

This note reexamines the STRIPS tax disadvantage argument used by Jordan et al. (1995, 1998) as an explanation of the callable U.S. Treasury bond puzzle. This note clearly shows that this tax disadvantage is not large enough to explain either the magnitude or the frequency of the mispricing of callable U.S. Treasury bonds that has been documented in past research.

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