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Special Repo Rates: An Empirical Analysis

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ABSTRACT

Duffie (1996) examines the theoretical impact of repo "specials" on the prices of Treasury securities and concludes that, all else the same, an issue on special will carry a higher price than an otherwise identical issue. We examine this hypothesis and find strong evidence in support of it. We also examine whether the liquidity premium associated with "on-the-run" issues is due to repo specialness and find evidence of a distinct effect. Finally, we investigate whether auction tightness and percentage awarded to dealers are related to subsequent specialness and find that both variables are generally significant.

UNDERLYING THE CASH MARKET for U.S. Treasury securities is the financing or "repo" market. At any given time, the repo rate for most Treasury issues (the general collateral rate) is the same, but a few issues are typically "on special." An issue on special has associated with it a repo rate that is less than the prevailing general collateral rate. As a result, the owner of a security that is on special is able to obtain below-market financing rates via a repurchase agreement.

Duffie (1996) examines the theoretical causes of repo specials and their impact on the prices of Treasury securities in the context of a general equilibrium model. His primary conclusion is that specialness will be priced in the cash market, meaning that, all else the same, an issue on special (or likely to go on special) will carry a higher price than an otherwise identical issue. We investigate this hypothesis using data on repo specials and find clear evidence in support of it. We conclude that specialness is priced and that the magnitude of the cash market premium reflects both the future duration and magnitude of repo specialness.

We also examine whether the liquidity premium associated with "on-the-run" issues is due to repo specialness and find evidence of a distinct effect. Finally, as a test of Duffie's model, we investigate whether auction tightness and percentage awarded to nonbank primary dealers are related to subsequent specialness. The evidence is consistent with predictions, with both variables generally significant.

* University of Kentucky, Lexington, Kentucky. We thank Barney Hauptfuhrer and Peter Horowitz of Three Crown Capital Partners and Ken Schacter of Richards and O'Neil for sparking our interest in this subject and for providing some of the data used in this study. We have benefited from comments by and discussions with Darrell Duffie, Randy Jorgensen, David Kuipers, John McConnell, and Paul Swanson.

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The remainder of this article is organized as follows. In the next section, we provide a brief background discussion on the repo market and the effect of repo specials. Section II describes the data, presents summary statistics, and examines two particularly notable instances of repo specials. Section III contains empirical methods and results regarding the effect of repo specials. Section IV examines auction tightness, distribution of ownership, and repo specials. Section V summarizes the main results of the article.

I. Background

The Treasury repo market serves many participants. It provides the primary means for large dealers to finance their inventories, and it is a source of financing for purchasers wishing to acquire leveraged long positions. For these reasons, the repo market is often called the "financing" market to distinguish it from the spot or "cash" market. The repo market is also the basic vehicle for investors wishing to sell short and/or engage in yield curve arbitrage. As with the Treasury market in general, the repo market is screen-based with little or no transparency. As a result, volume information is not available, but amounts in the hundreds of billions of dollars per day are routinely cited.

A. Repo Agreements

As with any repo, the basic Treasury repo involves an investor selling securities today and agreeing to buy them back at a set price on a future date. Such an investor has "done a repo" or "repo'd out" the securities. A reverse repo is the opposite side of the transaction. The counterparty investor purchases securities and agrees to sell them back at an agreed upon price on a future date and has thereby "done a reverse" or "reversed in" the securities.[1] Settlement in the cash market for Treasury securities is next day, but settlement in the repo market is same day.

The length of a repurchase agreement is up to the parties involved. With an open or day-to-day repo (the most common arrangement), the understanding is that the repo agreement will be renegotiated every day, and, assuming mutually agreeable terms can be reached, no exchange of securities for cash (beyond the original exchange) occurs. Either party may terminate the agreement by making delivery or payment as appropriate.

B. Collateralized Lending via Repo

Although a repo has the form of a sale and repurchase agreement, its economic substance more closely resembles that of a collateralized loan. In effect, when investor A does a repo, he or she borrows money from investor B and gives the security to investor B as collateral. When the loan is repaid, the

[1] This discussion is necessarily brief. Stigum (1989 and 1990, Chapter 13) provides greater detail.

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collateral is returned. The interest on the loan is the difference between the sales price and the repurchase price.[2]

For example, suppose an investor purchases Treasury securities today. On the next business day, the investor must obtain the funds needed to pay for the securities. To do so, the investor can repo out the securities and use the cash received to settle the trade. When the term of the repurchase agreement is up, the investor can simply renew with the same or another counterparty, thereby providing ongoing financing for the position.

At any time, the investor can sell the securities, and, the following day, close the position by delivering the cash from the sale in exchange for the securities, thereby paying off the loan, and delivering the securities to complete the sale. The net effect of the repurchase agreement in this case is that the leveraged buyer has arranged to finance the position by borrowing money, using the securities purchased as collateral.

An investor wishing to go short faces the opposite situation of an investor wishing to finance a leveraged long position. The investor sells a particular security today in the cash market. Tomorrow, to make delivery, the investor obtains the security by doing a reverse, delivers it, and then uses the cash obtained from the sale of the security to pay the counterparty in the reverse. The short position can be maintained by renewing the reverse as it comes due. The investor can close the position by purchasing the security, and, the following day, delivering it in exchange for cash to close the reverse and, finally, using the cash to pay for the purchase.

C. Repo Rates

Because a repo calls for the purchase of securities at one price and the sale at another, there is an implicit interest rate. This implicit rate is called the repo rate, and repurchase agreements are negotiated based on it. The rate on a repurchase agreement may depend on which Treasury security is used as collateral. On a given day, most issues are viewed as "general collateral," and the repo rate on agreements involving these issues, called the general collateral rate (or just general rate), is the same.

For certain specific issues, however, the repo rate may be less than the general collateral rate. Such issues are said to be "on special," and the rate on a repo involving an issue that is on special is termed the special rate. Special rates are issue-specific, so different issues on special will generally have different rates associated with them.

When an issue is on special, a leveraged owner of the issue benefits from lower cost financing. To illustrate, suppose the general rate is 6 percent. A specific issue is on special, however, with a special rate of 2 percent. An investor who owns general collateral can obtain 6 percent financing via a

[2] Equivalently, a repo can be viewed as a combination of an asset sale and the simultaneous purchase of a forward contract on that asset. Also, some market participants view repos as a means of "renting" collateral and describe the market as a rental market.

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repurchase agreement. An investor who owns the specific issue can obtain financing at a much more attractive 2 percent rate.

It should be noted, however, that the benefit from the special financing rate comes at the expense of the investor on the other end of the repo. This second investor has done a reverse and has effectively loaned money at 2 percent at a time when the general collateral rate is 6 percent. Thus, for example, an investor who uses a reverse to establish a short position in an issue that is on special must loan money at below-market rates to maintain that position.

In addition to using the repo market to finance their own inventories, primary security dealers also arrange repos and reverses to assist customers in originating and financing their positions, often on a matched book basis. A dealer earns a spread by paying a lower rate on a repo than it receives from a matching reverse. Special repo rates represent a significant source of dealer profit, and dealers actively trade in an attempt to obtain securities likely to go on special.

On occasion, an investor in a reverse will choose to not deliver a security per agreement. This is termed a repo "fail." The effect is that the repo is renewed, but interest ceases to accrue (the repo rate drops to zero), thereby benefiting the borrower (the party doing the repo). A fail is understood to be an economic decision by the lender (the party doing the reverse) and carries no particular stigma. However, because the lender can always choose to fail to make delivery and thereby loan money at zero percent, negative special repo rates do not occur except under very unusual circumstances, but quoted rates of zero are observed.

D. Relation between the Cash and Financing Markets

As described above, a leveraged owner of a security that is on special benefits from low cost financing. Given this, it follows immediately that if two Treasury securities are identical in every way except that one is on special and the other is not, then the one that is on special is worth more. The difference in the prices of the two securities would simply be the present value of the savings associated with financing at the lower special rate as opposed to the higher general collateral rate.

To give a simple illustration of the relation between specialness and the price spread in the cash market, the following notation is used:

P = Price of a Treasury note that is not on special,
P' = Price of an identical note that is on special,
R_g = General collateral rate (simple interest per day),
R_s = Special financing rate (simple interest per day), and
m = Number of days the issue will be on special.

An investor who owns the issue on special enters into a repo agreement for m days at a rate R_s per day. This investor receives P' today and agrees to repurchase the security for $P' \times (1 + mR_s)$ in m days. Similarly, an investor

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who owns the issue not on special enters into a repo agreement, receives P, and agrees to repurchase the security for $P \times (1 + mR_g)$ in m days.

After m days, the specialness ends, so the two issues are identical in every respect and must, therefore, have the same price. In other words, it must be the case that

$$P \times (1 + mR_g) = P' \times (1 + mR_s). \tag{1}$$

This expression can be rearranged to give the price differential, ΔP:

$$\Delta P = P' - P = m \times (PR_g - P'R_s). \tag{2}$$

This result shows that the note that is on special is worth more than the note that is not on special, and the difference is simply equal to the interest savings per day, $PR_g - P'R_s$, multiplied by the number of days that special financing is available.

Rewriting equation (2) to isolate the price of the issue on special results in:[3]

$$P' = P\,\frac{(1 + mR_g)}{(1 + mR_s)}. \tag{3}$$

Recalling that $R_g > R_s$, equation (3) again indicates that a security that is on special will have a higher price than an otherwise identical security.

For example, suppose the general rate is 6 percent per year (0.06/360 per day), and the special rate is 2 percent per year (0.02/360 per day).[4] A note is expected to remain on special for 45 days. An otherwise identical note that is not on special sells for 100. With these numbers, the price of the issue that is on special is:

$$P' = 100\,\frac{(1 + 45 \times 0.06/360)}{(1 + 45 \times 0.02/360)} \tag{4}$$

or $P' = 100.50$. The extra 0.50, which amounts to $5,000 per $1 million, is the cash market value of the special financing. No arbitrage opportunity exists since the only way to short the higher priced security is to enter into a reverse repo at the special rate.

The basic point that emerges from this analysis is that specialness in the financing market will be priced in the cash market. All else the same, a note that is on special is worth more than an otherwise equivalent note. Furthermore, the magnitude depends on both the degree of specialness, $R_g - R_s$, and the length of time, m, the issue is anticipated to trade special.

It is important to recognize that the relation between the cash market price and financing market specialness is not as straightforward as the simple result

[3] This basic pricing relation is due to Duffie (1996), where it appears in Proposition 1 as a consequence of equilibrium in the cash and financing markets. The simple no-arbitrage argument given here appears in Jordan and Jordan (1996).

[4] Our use of simple interest and 360-day years is consistent with repo market conventions.

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in this section indicates. In reality, future financing rates, both general and specific, are unknown, and the length of time an issue will be on special is similarly unknown. Therefore, on any given day, the impact on the cash price from specialness depends on market expectations concerning the magnitude and the duration of future specialness. A relatively small degree of specialness could have a large cash market effect if it is expected to persist for a long period; conversely, a relatively large degree of specialness could have a small effect if it is expected to disappear quickly. Further, an issue may carry a premium even if it is not currently on special if there is the possibility that it will be on special in the future.

II. Data and Preliminary Analyses

A. Data

The primary data for this study are daily overnight general collateral rates and special financing rates for all issues on special for the period September 16, 1991 through December 31, 1992, as reported by the New York Fed, for a total of 324 trading days.[5] Daily bid prices for all traded Treasury issues over this period are also obtained from the New York Fed.[6] The financing rate data examined include varying numbers of observations on 2-, 3-, 4-, 5-, 7-, and 10-year notes, which are all the note types in existence during the period we study. As is commonly the case, our empirical methods do not allow us to fit reliably the far end of the yield curve, so recently issued 30-year bonds are excluded from the analysis. No older bonds are on special during the period covered by our data.

B. Summary Statistics

Summary statistics for the financing rates sample appear in Table I. As shown, there are 50 distinct notes that were on special during the period September 1991 through December 1992. There are a total of 10,212 price quotes on these issues during the sample period. Of this total, special financing rates are observed approximately 14 percent (1,427 observations) of the time.

On any given day in the sample period, there are about 130 notes outstanding, of which four to six are typically on special to some degree. The average

[5] The data on financing rates are obtained from Attachment 2 of a report, dated January 25, 1993, by E. Gerald Corrigan, President of the Federal Reserve Bank of New York, to the Honorable Edward J. Markey, Chairman, Subcommittee on Telecommunications and Finance of the Committee on Energy and Commerce, United States House of Representatives. According to the report, the Federal Reserve Bank of New York began routinely monitoring and collecting financing rates in September of 1991 following the Salomon Brothers scandal in the spring and summer of 1991. The data contain representative quotes only, so separate bid and ask quotes are not available. On some days, a range of rates is reported. We used the midpoint of the range in such cases. We rerun the analyses in the paper using the low quotes and, separately, the high quotes. We find no differences in results.

[6] We thank Mark Fisher at the Board of Governors for kindly providing this data. The underlying data contain bid prices only.

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Table I

Summary Statistics

Summary statistics for notes that were on special during the period September 1991 through December 1992. A note is on special if the repo rate for that note is below the general collateral rate. General collateral rates are the average of the high and low general collateral rates reported for each day that an issue in the sample was on special. Special rates are the average of the high and low special rates reported each day that an issue is on special. A note is on the run if it is the most recently issued of its type.

	Type of Note						
	2-year	3-year	4-year	5-year	7-year	10-year	Total
Number of notes	14	6	1	16	8	5	50
Number on-the-run	13	6	0	15	6	4	44
Total observations	2,749	1,110	324	2,980	1,867	1,182	10,212
Special observations	124	293	4	442	318	246	1,427
Avg. days on special per note issue	8.9	48.8	4.0	27.6	39.8	49.2	28.5
Special days that are also on-the-run days	70.2%	75.4%	0.0%	46.6%	63.5%	81.7%	64.3%
Avg. general collateral rate	3.83%	3.95%	3.40%	3.87%	3.91%	3.82%	3.88%
Avg. special rate	3.07%	2.86%	2.38%	2.71%	2.56%	2.21%	2.65%
Avg. general rate − special rate	0.76%	1.09%	1.03%	1.16%	1.35%	1.61%	1.23%

number of days that notes of each maturity class are on special during our sample period ranges from 4 to 49.2; the overall average is 28.5 days. However, these values probably understate the average number of days that the notes are on special over their entire lives. For example, several of the notes were issued before the start of our sample period and may have been on special during this time. Similarly, most of the notes mature after the end of our sample period, and no information concerning specialness beyond December 1992 is available.

Issues are frequently on special early in their lives. In our case, 64 percent of the special observations occur while the issue is "on the run."[7] The average spread across all note types observed between the general collateral rate and the special financing rate (on days when specialness occurs) is 123 basis points. The special repo rates on individual issues range from 10 to almost 400 basis points below the general collateral rates.

[7] A particular Treasury issue is "on the run" when it is the most recently issued of its type and "off the run" otherwise. The immediately off the run issue is called the "old" issue. An issue that is two issues off the run is called the "old, old" issue, and so forth. The length of time an issue is on the run is usually either one month (2- and 5-year notes) or one quarter (most other notes and, until recently, bonds).

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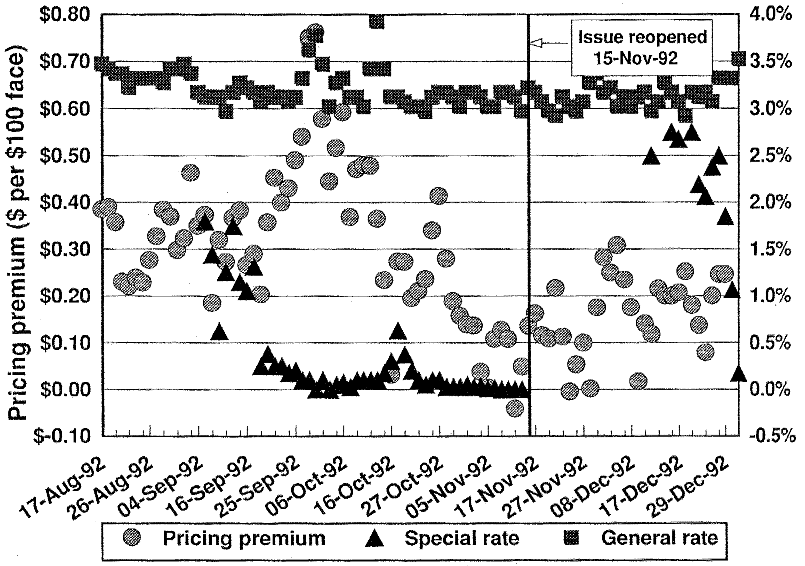

Figure 1. Repo Specials and Pricing Premiums. Price premiums and special repo rates for the 6⅜ 10-year note issued August 17, 1992. A special rate exists if the note can be financed in the repo market at a rate less than the prevailing general collateral rate. Price premium (left vertical axis) is the difference between the issue's price and the estimated price of an otherwise identical issue. On the right vertical axis, general collateral rates are plotted for each day; special rates are shown for days the issue is on special.

C. Case Studies

Before moving to a more detailed analysis, we examine two particularly notable cases of repo specialness from our sample period. These are examined to illustrate how pronounced and prolonged specialness can be and also because commentary is available from the New York Fed as to the causes of the specialness.

C.1. The 6⅜ 10-Year Note of August 2002

In the *Joint Report on the Government Securities Market* (1992), the Treasury indicated that it would be prepared, in the future, to reopen any issue (i.e., sell additional securities) that (p. 11) "is the subject of an acute, protracted shortage." To date, the only instance of such a reopening is the $10 billion, 6⅜ 10-year note issued August 17, 1992 and subsequently reopened November 15, 1992.

Of the 50 notes in our sample, the 6⅜ 10-year displays the most dramatic specialness. To illustrate, Figure 1 shows the difference between the price on this issue and the estimated price of an otherwise identical note, assuming a $100 face value.[8] The general collateral rate and the special rate (on days when

[8] Details regarding the estimation of the reference note price are presented in the next section.

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the note was on special) are also shown, plotted relative to the right vertical axis. The period covered is August 17, 1992 through December 31, 1992, the end of our sample period.

Examining Figure 1, the general collateral rate was relatively constant over the period at about 3 percent. As shown, the 6⅜ note began to go on special several weeks after it was auctioned. Beginning in mid-September, the repo rate on this issue fell to zero or near-zero and remained there until the issue was reopened in mid-November (the next regular auction date, and, thus, the date the issue would go off-the-run).

Following the reopening, the special rates disappeared until mid-December when the issue began to trade special again. Right at the end our data, it was again quoted with a near-zero special repo rate. Thus, the reopening may have been only partially successful. The price premium on the issue reaches its peak of almost $0.80 per $100 face value in late September. The premium shrinks as November 15 approaches.

According to the New York Fed, market participants attributed the prolonged specialness in this issue to "extremely large" short positions established by underwriters to hedge "a tremendous volume" of corporate debt issuance.[9] In addition, because of aggressive pricing, dealers had sizeable unsold positions for an extended period of time, thereby creating a long-term need for hedging. As is usually the case, the on-the-run issue is the preferred hedging vehicle because of its greater liquidity. Also, according to the New York Fed, some market participants "attempted to profit from their perception of an imbalance between the level of these short positions and the availability of the 10-year note," but no details are supplied.

C.2. The 6⅛ 5-year note of November 1996

Some issues remain on special long after they have gone off the run. A good example is the 6⅛ 5-year note issued December 31, 1991. Five-year notes are auctioned monthly, so this issue was off the run January 31, 1992. As Figure 2 shows, however, it remained on special for several months thereafter.

According to the Corrigan report, the specialness in this issue again resulted from sizeable dealer short hedges and, additionally, a relatively large, legally-acquired long position held by a single, non-dealer firm.[10] This firm made its securities available to dealers "when it was possible to ensure a sufficient profit after expenses." Particularly strong market interest in the note is also cited. Over the period examined in Figure 2, the October and November 5-year notes, among others, also displayed significant specialness.

The two repo market episodes considered in this section are very consistent with Duffie's model. In both cases, unusually large short positions existed for long periods, creating a prolonged demand for the issue in the financing market. Further, in the second case, a large holder of the issue existed which,

[9] This information is obtained from pp. 25–27 of the Corrigan report described in footnote 5.
[10] This information is on pp. 18–20 of the report described in footnote 5.

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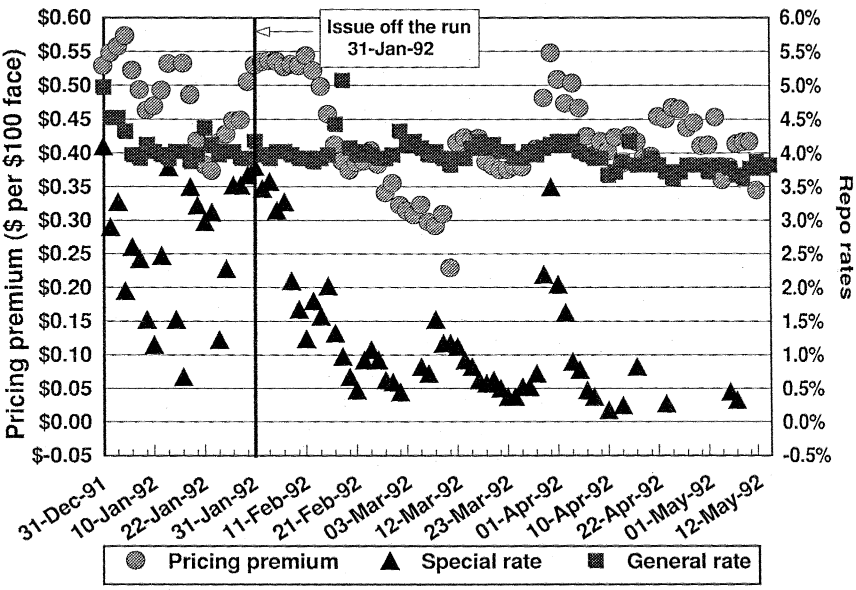

Figure 2. Repo Specials and Pricing Premiums. Price premiums and special repo rates for the 6⅛ 5-year note issued December 31, 1991. A special rate exists if the note can be financed in the repo market at a rate less than the prevailing general collateral rate. Price premium (left vertical axis) is the difference between the issue's price and the estimated price of an otherwise identical issue. On the right vertical axis, general collateral rates are plotted for each day; special rates are shown for days the issue is on special.

it appears, incurred transactions costs in supplying the issue to the repo market. In Duffie's model, when demand for an issue is unusually large, special repo rates come into being precisely to entice such holders into supplying their collateral to the market.

III. Methods and Results

A. Construction of Reference Prices

To examine the relation between special financing rates and relative cash market prices, the price of a Treasury note on special is compared to that of an otherwise identical note, i.e., a note with the same coupon rate and same time to maturity. Since such an issue does not generally exist, its price must be estimated.

To guard against method-specific results, we use three different procedures to estimate reference prices. First, and most simply, the two outstanding issues with the closest maturity dates to the note on special are selected, with the constraint that their maturity dates straddle that of the issue on special.[11]

[11] We also exclude any notes exhibiting specialness in choosing the issues used to construct these reference yields.

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Linear interpolation is used to determine the appropriate yield on the note on special.[12]

Specifically, let M_1, M_2, and M_3 be the maturities of the three issues, with M_2 as the maturity of the issue on special. Y_1 and Y_3 are the yields on the other two issues. Then the yield on an issue with the same maturity as the middle issue, Y, is estimated as:

$$Y = \frac{M_3 - M_2}{M_3 - M_1} Y_1 + \frac{M_2 - M_1}{M_3 - M_1} Y_3 \tag{5}$$

The yield from equation (5) is then used to calculate the price that a note with the same maturity and coupon rate should have if it were not subject to special financing rates.

Next, using data on U.S. Treasury coupon STRIPS, we estimate the Treasury discount function for each day in our sample using both a cubic spline procedure and the Cox, Ingersoll, and Ross (CIR, 1984) model. We then use the estimated discount functions to calculate the reference prices. For the sake of brevity, we do not discuss these approaches here. Cubic splines have been widely used in the past, and their application is particularly simple with STRIPS data.[13] Our application of the CIR model to STRIPS data closely follows Jordan and Kuipers (1997).

Table II presents basic summary statistics for the differences between the prices of issues exhibiting specialness at some point in our sample and their estimated reference prices. For each note type and estimation method, the average difference (per \$100 face value) between the actual and reference price, ΔP, is shown. The average is calculated separately for days on which the issue examined is on special and not on special.

Examining part A of Table II, the linearly interpolated reference prices are generally quite close, on average, to the actual prices when the issue examined is not on special. The average difference across all note types in this case is 0.02 percent of face value (versus a tick size in our Treasury data of 1/32 or 0.0325 of face). The average differences are small and positive for all but the 10-year

[12] The same procedure is used in Jegadeesh (1993), who estimates price premiums for newly auctioned Treasuries. Based on a simulation study, he reports that linear interpolation produces very accurate, on average, reference yields. To the extent that the yield curve is positively sloped and concave, linear interpolation can be expected to produce very slightly downward-biased yield estimates.

[13] Because coupon effects are absent, we fit the coupon STRIPS term structure directly using 4 segments with knot points at 3, 8, and 22 years. This relatively small number of segments is sufficient to fit the coupon STRIPS data extremely well; in fact, three would probably be sufficient. The specific knot point placements were chosen based on an extensive analysis of MSE's resulting from various knot point placements for a four-segment estimation. For details on cubic spline estimation, see, e.g., Litzenberger and Rolfo (1984). We use coupon STRIPS only because of evidence regarding anomalous pricing of principal STRIPS, e.g., Daves and Ehrhardt (1993).

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Table II

Actual versus Reference Prices

Average differences between actual note prices and reference prices for issues that were on special during the period September 1991 through December 1992. A note is on special if the repo rate for that note is below the general collateral rate. ΔP is computed as the price of the issue on special less its reference price, assuming a \$100 face value. Reference prices are computed in three ways: linear interpolation of the yield curve (A), fitting the Cox, Ingersoll, and Ross (1984) model to coupon STRIPS data to estimate the term structure (B), and cubic spline estimation of the coupon STRIPS term structure (C). The average value of ΔP is reported separately for days when the issue is and is not on special.

Reference Yield Procedure	Type of Note						
	2-year	3-year	4-year	5-year	7-year	10-year	Average
A. Linear interpolation							
ΔP (Not on special)	0.019	0.045	0.055	0.059	0.077	−0.206	0.020
ΔP (On special)	0.052	0.151	0.107	0.251	0.417	0.167	0.235
B. CIR							
ΔP (Not on special)	0.041	−0.002	−0.049	−0.117	0.200	0.701	0.087
ΔP (On special)	0.012	0.123	0.119	0.286	0.885	1.704	0.606
C. Splines							
ΔP (Not on special)	−0.034	0.015	−0.046	0.074	0.219	0.458	0.098
ΔP (On special)	−0.040	0.190	−0.042	0.439	0.742	1.313	0.563

notes. For the 10-year notes, the difference is negative and somewhat larger (in absolute value) at −0.206 percent of face value.[14]

In parts B and C of Table II, the CIR and spline estimated differences exhibit somewhat greater variability, but are still generally small. In contrast to the linear interpolation procedure, the 10-year note differences are positive. With the exception of the 2-year notes in parts B and C, the average price differences in Table II are noticeably larger when the issue examined is on special. Across all note types, the average price difference is about six to eight times larger when specialness exists. The significance of these differences is explored in the next subsection.

B. Procedures and Results

To examine the pricing effect of specialness and on-the-run status, the deviation between each note's price and its reference price, $\Delta P_{it} = P'_{it} - P_{it}$, is calculated for each day in the sample period that the issue was outstanding. These values are used to estimate the following regression equation:

$$\Delta P_{it} = \sum_{j=1}^{6} \alpha_j D_{jt} + \alpha_7\, Special_{it} + \alpha_8 OTR_{it} + \epsilon_{it} \tag{6}$$

[14] The overall negative value for 10-year notes is due to the fact that in three of the five cases, both issues used in the linear interpolation are old 20-year bonds. In a fourth case, one of the two issues is also an old 20-year bond. These bonds, of which there are relatively few, are usually quoted with higher prices than similar issues. Beim (1992) attributes this to a scarcity effect.

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where

D_{jt} = dummy variables taking on a value of 1 if issue i is of type j, and 0 otherwise, $j = 1$ to 6, representing 2-, 3-, 4-, 5-, 7-, and 10-year notes, respectively;

$Special_{it}$ = dummy variable taking on a value of 1 if issue i is on special on day t and 0 otherwise;

OTR_{it} = dummy variable taking on a value of 1 if issue i is on the run on day t and 0 otherwise;

α_j = for $j = 1$ to 6, estimated regression intercepts;

α_7, α_8 = estimated regression slope coefficients; and

ϵ_{it} = regression residuals.

The specification in equation (6) allows for different intercepts for the different note types, thereby allowing for potential differences between actual and reference prices specific to note types, but unrelated to specialness or on-the-run status.[15] Because we pool time-series and cross-sectional data, and the errors for any particular issue are likely to be highly correlated over time, we make no particular assumptions about the regression residuals (other than a zero mean) and instead use a heteroskedasticity- and autocorrelation-consistent (HAC) standard error in all hypothesis tests.[16] Under a null hypothesis of no effect from either specialness or on-the-run status, the hypothesized values for α_7 and α_8 are zero. The results are reported in Table III.[17]

Part A of Table III reports the coefficients and associated t-statistics for the specialness and on-the-run dummies when the linear interpolation procedure is used to establish the reference prices. As indicated, specialness and on-the-run status are highly significant, both considered jointly and in isolation. In fact, the smallest t-value observed is 8.81, even though the HAC standard errors used to calculate the t-statistics are typically several times larger than the ordinary least squares (OLS) errors.

[15] Price deviations may exist for a number of reasons, including tax effects (Jordan and Jordan (1991)) and seasoning effects (Carayannopoulos (1996)) along with coupon effects and differences in liquidity.

[16] We obtain the HAC standard errors by estimating eq. (1) using Hansen's (1982) generalized method of moments with Parzen (1957) weights. The standard errors are similar to those obtained using the Newey-West (1987) approach, but appear to have somewhat superior properties. Details can be found in Andrews (1991). Because the model is linear, the estimated intercept and slope coefficients are identical to OLS estimates.

[17] Only the slope coefficients are reported in Table III and subsequent tables. Based on a suggestion from an anonymous referee, we also examined the effect of including bond age and premium/discount status in the regressions underlying Tables III and subsequent tables. As in previous studies, these variable are significant, but they do not alter any reported results. The full results from these augmented regressions are available on request. Also based on a suggestion from the referee, we examine yield differences instead of price differences, and we find that the results are very similar. These estimates are available on request.

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Table III

Impact of Repo Market Specialness and On-The-Run Status

Estimated coefficients and tests of significance from a regression of the form:

$$\Delta P_{it} = \sum_{j=1}^{6} \alpha_j D_{ij} + \alpha_7 Special_{it} + \alpha_8 OTR_{it} + \varepsilon_{it}.$$

Positive and significant values of α_7 and/or α_8 indicate rejection of the null hypothesis of no effect from repo specialness and/or on-the-run status. A heteroskedasticity- and autocorrelation-consistent (HAC) standard error is used in all hypothesis tests. ΔP is computed as the price of the issue on special less its reference price, assuming a $100 face value. Reference prices are computed in three ways: linear interpolation of the yield curve (A), fitting the Cox, Ingersoll, and Ross (1984) model to coupon STRIPS data to estimate the term structure (B), and cubic spline estimation of the coupon STRIPS term structure (C). A note is on special if the repo rate for that note is below the general collateral rate; it is on the run if it is the most recently issued note of its type. Variable definitions and coefficients are as follows:

ΔP_{it} = difference between actual and reference prices for note i on day t;
D_{jt} = dummy variables equal to 1 if issue i is of type j, else 0, j = 1 to 6, representing 2-, 3-, 4-, 5-, 7-, and 10-year notes;
$Special_{it}$ = dummy variable equal to 1 if issue i is on special on day t, else 0;
OTR_{it} = dummy variable equal to 1 if issue i is on the run on day t, else 0;
α_j = for j = 1 to 6, estimated regression intercepts;
α_7, α_8 = estimated regression slope coefficients; and
ϵ_{it} = regression residuals.

Reference Yield Procedure	Estimated Coefficients (t-Statistics)		
	Specialness (α_7)	On-the-Run (OTR, α_8)	Adj. R^2
A. Linear interpolation	0.2232		0.311
	(19.15)		
	0.1055	0.2116	0.415
	(8.81)	(15.47)	
B. CIR	0.4705		0.488
	(20.43)		
	0.2535	0.3903	0.543
	(9.90)	(13.10)	
C. Splines	0.4083		0.465
	(22.10)		
	0.2049	0.3658	0.551
	(10.39)	(15.48)	

The results from the other reference price estimation procedures in parts B and C of Table III are similarly significant, although the estimated magnitudes of the effects are somewhat larger. Overall, the data strongly support the conclusion that specialness is priced, indicating that a note on special will have a premium of 0.10 to 0.25 percent relative to an otherwise identical issue. Also, Table III indicates that note type, on-the-run status, and repo specialness can collectively account for as much as half of the variation in the price differentials.

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The results in Table III additionally suggest that a separate, highly significant on-the-run effect exists. However, as discussed above, an issue that is not on special on a particular day may nonetheless carry a price premium based on market expectations of future specialness, so this evidence is somewhat ambiguous. Subsequent tests address this question more closely.

The price impact of repo specials should depend, in part, on the degree of specialness. As suggested by the basic no arbitrage condition given in equation (2), we calculate the degree of specialness as $PR_g - P'R_s$, (i.e., the interest saving available from specialness) for each issue on each day special financing is available for that issue. We then estimate a regression that is identical to equation (6) except that the specialness dummy variable is replaced by the calculated degree of specialness. Table IV reports the results.

Examining Table IV, both the degree of specialness and the on-the-run dummy are highly significant regardless of which procedure is used to establish the reference yields. The coefficient on the degree of specialness ranges from 25 to 52, depending on procedure. From equation (2), the coefficient can be loosely interpreted as the number of days of future specialness (at the current level) reflected in the pricing differential. Comparing Tables III and IV, the impact of on-the-run status is essentially identical. However, since the procedure underlying Table IV only crudely captures the impact of future specialness, the evidence still does not clearly establish whether a separate on-the-run effect exists.

Finally, we investigate the most precise prediction regarding the impact of specialness by examining whether the price differential we observe on a given day reflects the value of all future specialness. In particular, if the market has perfect foresight (or unbiased expectations) concerning both the magnitude and duration of future specialness, then the price differential today should be equal to (or not systematically different from) the sum of all subsequently observed specialness.

To examine this hypothesis, for each issue and each day, the value of all future specialness for that issue from the current day forward, FSP_{it}, is computed as:

$$FSP_{it} = \sum_{t=q}^{N} (P_{it} R_{gt} - P'_{it} R_{i,st}) \tag{7}$$

where q is the quote date and N is the last trade day for note i (or the end of the sample period).[18] Once again, we reestimate the regression in equation (6), now substituting the value of all future specialness as given in equation (7) for the specialness dummy.

[18] We account for weekends by multiplying the degree of specialness by 3 if a note was on special on Friday since a Friday-to-Monday "overnight" repo is actually a 3-day loan. This is consistent with market practice. Holidays are treated similarly.

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Table IV

Impact of Degree of Repo Market Specialness

Estimated coefficients and tests of significance from a regression of the form:

$$\Delta P_{it} = \sum_{j=1}^{6} \alpha_j D_{jt} + \alpha_7 DSP_{it} + \alpha_8 OTR_{it} + \epsilon_{it}.$$

Positive and significant values of α_7 and/or α_8 indicate rejection of the null hypothesis of no effect from repo specialness and/or on-the-run status. A heteroskedasticity- and autocorrelation-consistent (HAC) standard error is used in all hypothesis tests. ΔP is computed as the price of the issue on special less its reference price, assuming a \$100 face value. Reference prices are computed in three ways: linear interpolation of the yield curve (A), fitting the Cox, Ingersoll, and Ross (1984) model to coupon STRIPS data to estimate the term structure (B), and cubic spline estimation of the coupon STRIPS term structure (C). A note is on special if the repo rate for that note is below the general collateral rate; it is on the run if it is the most recently issued note of its type. Variable definitions and coefficients are as follows:

ΔP_{it} = difference between actual and reference prices for note i on day t;
D_{jt} = dummy variables equal to 1 if issue i is of type j, else 0, j = 1 to 6, representing 2-, 3-, 4-, 5-, 7-, and 10-year notes;
DSP_{it} = degree of repo specialness for issue i on day t (the potential interest savings due to specialness), calculated as the price of reference issue multiplied by the general collateral rate less the price of the issue on special multiplied by the special rate;
OTR_{it} = dummy variable equal to 1 if issue i is on the run on day t, else 0;
α_j = for j = 1 to 6, estimated regression intercepts;
α_7, α_8 = estimated regression slope coefficients; and
ϵ_{it} = regression residuals.

	Estimated Coefficients (t-statistics)		
Reference Yield Procedure	Degree of Specialness (DSP, α_7)	On-the-Run (OTR, α_8)	Adj. R^2
A. Linear interpolation	25.92	0.2145	0.423
	(8.30)	(16.37)	
B. CIR	52.43	0.4188	0.541
	(8.29)	(14.86)	
C. Splines	47.06	0.3792	0.554
	(9.19)	(16.79)	

In the revised regression, a coefficient that is insignificantly different from one would lend support to the hypothesis that the pricing differential reflects the value of current and future specialness. However, many of the notes mature after the end of the sample period; consequently, the price differential could reflect special financing that is expected to occur after the sample period and our measure is therefore a lower bound on future specialness. However, significant repo specials are generally observed only relatively early in the life of an issue.

Table V presents the regression results. As before, in all cases, the coefficient on the specialness variable is highly significant. More interestingly, the coef-

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Table V

Impact of Total Future Repo Market Specialness

Estimated coefficients and tests of significance from a regression of the form:

$$\Delta P_{it} = \sum_{j=1}^{6} \alpha_j D_{jt} + \alpha_7 FSP_{it} + \alpha_8 OTR_{it} + \epsilon_{it}.$$

Positive and significant values of α_7 and/or α_8 indicate rejection of the null hypothesis of no effect from repo specialness and/or on-the-run status. A heteroskedasticity- and autocorrelation-consistent (HAC) standard error is used in all hypothesis tests. ΔP is computed as the price of the issue on special less its reference price, assuming a \$100 face value. Reference prices are computed in three ways: linear interpolation of the yield curve (A), fitting the Cox, Ingersoll, and Ross (1984) model to coupon STRIPS data to estimate the term structure (B), and cubic spline estimation of the coupon STRIPS term structure (C). A note is on special if the repo rate for that note is below the general collateral rate; it is on the run if it is the most recently issued note of its type. Variable definitions and coefficients are as follows:

ΔP_{it} = difference between actual and reference prices for issue i on day t;
D_{jt} = dummy variables equal to 1 if issue i is of type j, else 0, j = 1 to 6, representing 2-, 3-, 4-, 5-, 7-, and 10-year notes;
FSP_{it} = total future specialness for issue i on day t, representing the value of all future savings due to repo market specialness, calculated by summing the degree of repo specialness on the current and all future days. The degree of repo specialness on a given day is the price of the reference issue multiplied by the general collateral rate less the price of the issue on special multiplied by the special rate;
OTR_{it} = dummy variable equal to 1 if issue i is on the run on day t, else 0;
α_j = for j = 1 to 6, estimated regression intercepts;
α_7, α_8 = estimated regression slope coefficients; and
ϵ_{it} = regression residuals.

Reference Yield Procedure	Estimated Coefficients (t-statistics): Total Future Specialness (FSP, α_7)	On-the-Run (OTR, α_8)	Adj. R^2
A. Linear interpolation	0.7375 (13.18)	0.1466 (12.24)	0.474
B. CIR	1.1664 (9.06)	0.3360 (11.19)	0.552
C. Splines	1.1109 (10.54)	0.2942 (12.49)	0.576

ficients in the second and third regressions (CIR- and spline-based) are 1.17 and 1.11, both of which are about one standard error from one. For the first regression, however, the coefficient is 0.74, which, given the small errors in these regressions, is significantly less than one. These estimates strongly suggest that the value of future specialness is reflected on, at least, a near one-for-one basis.

Table V also shows that the coefficient on the on-the-run dummy remains significant, although its magnitude is somewhat reduced. Since the effect of future specialness is now included in the regression, the available evidence

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indicates that an on-the-run premium exists that is not explained by expectations of future specialness and is thus a distinct effect.

IV. Auction Tightness, Distribution of Ownership, and Repo Specials

Treasury securities are sold at regularly scheduled auctions. Some Treasury auctions are "tighter" than others in the sense that the demand for the newly-issued note or bond is high relative to the amount auctioned. In a study of Treasury auctions, Jegadeesh (1993) reasons that tighter auctions will, because of a winner's curse, result in lower profits to those submitting winning bids and subsequently selling the issue in the post-auction period. However, contrary to this hypothesis, he finds that auctions with higher "bid-to-cover" ratios (the ratio of total bids tendered to the amount auctioned) typically result in higher profits. These are profits from cash market transactions; repo rates are not considered.

As a possible explanation for this result, Duffie notes that dealers commonly acquire short positions in when-issued trading (often by selling the issue to customers in advance of the auction) and subsequently covering by bidding at the auction. If an auction is tight, a larger than anticipated pool of unsuccessful bidders with short positions may need to cover in either the cash or repo markets in the postauction period. In the context of Duffie's model, an unexpectedly large demand for the security in the repo market leads to scarcity and special financing rates.[19] In other words, when dealer awards are small relative to short positions, dealers have to cover in the postauction period. The specific issue needed to cover becomes scarce and trades on special as a result.

In addition to demand for the issue in the repo market, the distribution of ownership of the issue is also important in Duffie's model. For example, if an issue is largely held by "off-the-street" investors who do not need financing and thus do not generally participate in the repo market (or, in Duffie's model, must incur significant transactions costs to do so), the available supply for repo transactions will be reduced.[20] Special repo rates must be offered to induce such investors into making their collateral available.[21]

In contrast, if an issue is largely held "on-the-street" by dealers needing to finance inventory via repo agreements, then the issue will be readily available to investors with short positions. Thus, we hypothesize that postauction avail-

[19] Alternatively, however, a tight auction may simply indicate strong buyer interest apart from any short positions, and subsequent price appreciation in an issue may simply be due to demand in the cash market. This alternative is also consistent with Jegadeesh's findings, but repo specialness plays no particular role. Ideally, what would be examined is the relation between the aggregate short positions established preauction, auction tightness, and subsequent repo rates. However, data on when-issued positions appear to be unavailable.

[20] The specific distinction between on-the-street versus off-the-street ownership does not appear in Duffie; instead, it is our interpretation of an implication of Duffie's model.

[21] In Cornell and Shapiro (1989), for example, the extremely low special rates associated with the 9¼ percent, February 2016, 30-year issue were attributed by market participants to large holdings by Japanese investors who did not participate in the repo market.

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ability of the issue on-the-street will be negatively related to future repo specialness.

Some evidence regarding this hypothesis exists. In addition to the result discussed above, Jegadeesh (1993) also reports a significant negative relation between the fraction of a Treasury issue awarded to commercial banks and dealers and subsequent profits to successful bidders. He interprets this finding as an indication of (possibly illegal) information sharing among bidders. The explanation considered here is a plausible (and simple) alternative.

To investigate whether auction tightness and distribution of ownership are in fact significantly related to subsequent repo specials as suggested by Duffie's model, we estimate the following regression:

$$FSP_{ij} = \sum_{k=1}^{6} \alpha_k D_k + \alpha_7 BTC_i + \alpha_8 DEALER_i + \epsilon_{ij} \tag{8}$$

where

FSP_{ij} = the value of all future specialness for note i (computed as in equation (7)) from the issue date until the end of the postauction week j, $j = 1$ to 4;

D_k = dummy variables taking on a value of 1 if issue i is of type k, and 0 otherwise, $k = 1$ to 6, representing 2-, 3-, 4-, 5-, 7-, and 10-year notes, respectively;

BTC_i = the ratio of the amount of total bids to the amount issued for note i (bid-to-cover ratio, as reported in *The Wall Street Journal,* various issues);

$DEALER_i$ = the percentage of the issue awarded to nonbank primary dealers (amount award to dealers divided by amount auctioned to the public, as reported in the *Treasury Bulletin,* various issues);

α_k = for $k = 1$ to 6, estimated regression intercepts;

α_7, α_8 = estimated regression slope coefficients; and

ϵ_{ij} = regression residuals.

The variable BTC_i, the bid-to-cover ratio, measures auction tightness. A positive and significant coefficient would support Duffie's argument. The variable $DEALER_i$ measures the availability of the issue on-the-street. A negative and significant coefficient would be consistent with the hypothesis described above.

As in Jegadeesh (1993), equation (8) is estimated four times. The only difference is the length of time over which the value of future specialness, FSP_{ij}, is computed, ranging from one to four weeks.[22] Of the 50 issues that appear in our sample, 11 are not usable in this regression because they were auctioned before our data begin. Because we have a single cross-section with a

[22] The future specialness values used are based on the linear interpolation procedure. The results using the CIR- and spline-based estimates are similar and available from the authors.

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Table VI

Auction Tightness, Awards to Dealers, and Special Repo Rates

Estimated coefficients and tests of significance from a regression of the form:

$$FSP_{ij} = \sum_{k=1}^{6} \alpha_k D_k + \alpha_7 BTC_i + \alpha_8 DEALER_i + \epsilon_{ij}.$$

Significant values of α_7 and/or α_8 indicate rejection of the null hypothesis of no effect from auction tightness and/or awards to dealers. Results use the linear interpolation reference yield procedure. Ordinary least squares (OLS) standard errors are used in all hypothesis tests. Variable definitions and coefficients are as follows:

FSP_{ij} = the value of future specialness for note i calculated by summing the degree of repo specialness from the issue date until the end of post-auction week 1 (A), 2 (B), 3 (C), and 4 (D). The degree of repo specialness on a given day is the price of the reference issue multiplied by the general collateral rate less the price of the issue on special multiplied by the special rate;
D_k = dummy variables equal to 1 if issue i is of type j, else 0, $j = 1$ to 6, representing 2-, 3-, 4-, 5-, 7-, and 10-year notes;
BTC_i = the ratio of the amount of total bids to the amount issued for issue i (bid-to-cover ratio, as reported in *The Wall Street Journal,* various issues);
$DEALER_i$ = the percentage of the issue awarded to nonbank primary dealers (amount award to dealers divided by amount auctioned to the public, as reported in the *Treasury Bulletin,* various issues);
α_j = for $j = 1$ to 6, estimated regression intercepts;
α_7, α_8 = estimated regression slope coefficients; and
ϵ_{it} = regression residuals.

	Estimated Coefficients (t-statistics)		
Postauction Period	Bid-to-Cover Ratio (BTC, α_7)	% Sold to Dealers ($DEALER$, α_8)	Adj. R^2
A. 1 Week	0.0094		0.083
	(1.88)		
	0.0070	−0.0454	0.163
	(1.44)	(−2.04)	
B. 2 Weeks	0.0210		0.256
	(2.60)		
	0.0174	−0.0714	0.315
	(2.18)	(−1.96)	
C. 3 Weeks	0.0427		0.298
	(2.76)		
	0.0329	−0.190	0.428
	(2.29)	(−2.91)	
D. 4 Weeks	0.0490		0.319
	(2.56)		
	0.0374	−0.226	0.434
	(2.09)	(−2.77)	

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limited sample size, we use OLS standard errors in all hypothesis tests. Table VI reports the results.

Examining Table VI, the coefficient on the bid-to-cover ratio is positive in each case. With the exception of the one-week results in part A, the coefficient is significantly different from zero at the five percent level or smaller, considered both in isolation and in conjunction with percentage awarded to dealers. Thus, significant support for Duffie's conjecture exists. In addition, the coefficients on the percentage allotted to nonbank primary dealers are reliably negative, suggesting that availability of the issue in the dealer community is an important determinant of future repo specialness.

V. Summary and Conclusions

Duffie (1996) presents a theoretical model of the causes and effects of Treasury market repo specials. The central prediction is that, all else the same, an issue on special should command a higher price than an otherwise identical issue, and the price premium should reflect market expectations regarding the magnitude and duration of future specialness. We test this hypothesis and find strong support for it.

We also test whether the liquidity premium associated with on-the-run issues is due to repo specialness and find evidence of a distinct on-the-run effect. Finally, as a test of Duffie's model, we investigate whether auction tightness and percentage awarded to nonbank primary dealers are related to subsequent specialness. The evidence is consistent with predictions, with both variables generally significant.

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