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Financial Innovation and the Role of Derivative Securities: An Empirical Analysis of the Treasury STRIPS Program

MARK GRINBLATT and FRANCIS A. LONGSTAFF*

ABSTRACT

The role that financial innovation plays in financial markets is very controversial. To provide insight into this role, we examine how market participants use the highly successful Treasury STRIPS program. We find that investors use the option to create Treasury-derivative STRIPS primarily to make markets more complete and take advantage of tax and accounting asymmetries. Although liquidity-related factors help explain differences in the prices of Treasury bonds and STRIPS, we find little evidence that the option to strip and reconstitute securities is used for speculative or arbitrage-related purposes.

THE ROLE OF FINANCIAL INNOVATION is a central issue for both policymakers and researchers in finance.[1] Critics argue that financial innovations often have no economic role beyond allowing some investors to take highly leveraged speculative or arbitrage-related positions. In contrast, advocates argue that the introduction of new products makes financial markets more complete, reduces frictions and transaction costs, and leads to a more optimal allocation of risk in the economy.

To better understand the role played by financial innovation, this paper examines how investors use the successful Separate Trading of Registered Interest and Principal of Securities (STRIPS) program of the U.S. Treasury. This program allows investors to strip Treasury notes and bonds to create separate discount bonds, and to reconstitute previously stripped notes and

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[1]For example, see Ross (1989) and Tufano (1989).

bonds from the corresponding discount bonds. Identifying the determinants of stripping and reconstitution activities can provide insights into the underlying reasons for the use of derivatives by investors.

In academia, models of security design such as that of Allen and Gale (1988) suggest that successful derivatives allocate cash flows to the investors who value them the most, allowing securities to be held in their most valuable form. If a portfolio of STRIPS is more valuable than the underlying bond, investors can reengineer their portfolio by stripping the bond, and vice versa. If valuation differences are large enough, even investors with no net portfolio position, such as arbitrageurs, may profit by buying securities, stripping or reconstituting them, and then reselling the modified portfolio. This suggests that valuation differences, if they exist, could drive stripping and reconstitution activities.

We first investigate whether valuation differences exist. Although some large valuation differences exist, many of these may not represent real arbitrage because of the possibility that quoted prices poorly reflect prices at which trades could actually be executed, or because there are other types of measurement errors in the data. On the other hand, we find a strong positive relation between the value of the STRIPS portfolios relative to the Treasury bond and the total outstanding principal amount of the STRIPS. This implies a direct link between the liquidity and the pricing of these securities, and contributes to the literature documenting the existence of liquidity effects in the pricing of financial securities.[2]

We then test whether observed valuation differences are followed by stripping and reconstituting. We find no evidence that investors strip or reconstitute in response to observed valuation differences. Furthermore, we find that specific Treasury issues are often stripped by investors at the same time they are being reconstituted by other investors. These results suggest that investors have deeper motivations for stripping and reconstituting than exploiting valuation differences. Stripping activity is greater for Treasury securities with maturities for which discount bonds cannot be synthesized by alternative means. This supports traditional contingent-claims theory that financial innovation primarily occurs to make markets more complete. We also find that stripping and reconstitution activities are related to security-specific features such as the coupon rate, consistent with explanations based on asymmetries in the tax or accounting treatment of fully constituted and stripped securities. Although puzzles remain, these findings support the view that Treasury derivatives fulfill fundamental economic functions in completing markets and overcoming frictions.

The remainder of the paper is organized as follows. Section I describes the Treasury STRIPS program. Section II describes the data. Section III examines the relative pricing of Treasury securities and STRIPS. Section IV conducts the empirical analysis. Section V presents concluding remarks.

[2] For other examples, see Amihud and Mendelson (1986), Silber (1991), Boudoukh and Whitelaw (1993), Kamara (1994), Grinblatt (1995), and Longstaff (1995).

I. Stripping and Reconstituting Bonds

In this section, we describe the Treasury STRIPS program and discuss alternative hypotheses about why market participants strip and reconstitute bonds.

A. The Treasury STRIPS Program

The Treasury initiated its STRIPS program on February 15, 1985. Under this program, the principal or corpus (TPRN) and semiannual coupon payments (TINTS) of eligible Treasury notes and bonds are assigned separate CUSIP numbers and referred to generically as STRIPS. Any depository institution with a Federal Reserve book-entry securities account can request that their eligible Treasury securities be converted into STRIPS form. Once converted, individual stripped principal and coupon components can be traded separately. On May 1, 1987, the Treasury extended the program to allow institutions to reconstitute previously stripped notes and bonds. The current charge for a STRIPS request is $25 per transaction. Note that stripping a bond involves only an accounting entry; no market transactions are required.[3]

Since Treasury notes, bonds, and STRIPS are traded on a next-day settlement basis, an institution holding a note or bond can sell STRIPS today, send a request to strip the note or bond prior to 11:30 a.m. the following day, and then be able to deliver the STRIPS in settlement of the trade. Because of this, riskless arbitrage is possible unless the prices of notes, bonds, and STRIPS are consistent. Specifically, there is a stripping arbitrage if an investor can buy a Treasury note or bond at the market ask price, strip the issue, and then simultaneously resell the portfolio of STRIPS at the market bid price and still make a profit. Similarly, there is a reconstitution arbitrage if the reverse strategy is profitable. In either case, the arbitrage strategy is easily implemented.

Like Treasury notes and bonds, STRIPS are direct obligations of the Treasury and can be held by both U.S. and foreign investors and are eligible collateral for Treasury Tax and Loan Accounts. For income tax purposes, STRIPS are subject to the stripped bond rules of the Internal Revenue Code. The tax basis of a TINT or TPRN formed by stripping a Treasury note or bond is determined by multiplying the tax basis of the note or bond by the ratio of the market price of the TINT or TPRN to the total market value of all of the TINTs and the TPRN formed by stripping the security. Similarly, the tax basis of a note or bond formed by reconstitution is determined by adding together the tax basis for each of the individual TINTs and the TPRN that reconstitute the security.

[3] Daves and Ehrhardt (1993) study the pricing of stripped coupon and principal payments created through the STRIPS program. The principal amount stripped in a single transaction must be such that the resulting TINTS and TPRN components have face amounts in integral multiples of $1,000. Since the specific TPRN must be used to reconstitute a bond, the total principal amount outstanding of a bond can never exceed the original amount issued by the Treasury.

B. Why do Investors Strip and Reconstitute Bonds?

Before turning to the data, we first consider alternative explanations for why investors strip and reconstitute bonds. An explanation frequently offered in the practitioner literature is that stripping and reconstitution are arbitrage related.[4] Clearly, if there is a stripping arbitrage, arbitrageurs have the strongest possible incentives to purchase Treasury notes and bonds and then strip them. The reverse applies to reconstitution arbitrages. Security design theory such as that of Allen and Gale (1988) and Duffie and Jackson (1989) suggests that investors have economic incentives to restructure financial assets in a way that maximizes the combined market value of the assets. As an example, recall that many institutional investors mark their portfolios of Treasury securities to market every day. If one form of the security is more valuable than the other, they recognize accounting income immediately by either stripping or reconstituting the securities they hold even if the difference in prices is not large enough to violate transaction-cost-induced arbitrage bounds. Either way, the empirical implication is that observed valuation differences should be followed by stripping or reconstitution activity. One problematic implication with this hypothesis, however, is that it suggests a corner solution; if it is optimal to strip, then the entire issue should be stripped, and vice versa. As will be shown later, this type of extreme behavior is not observed in the markets.

Even without valuation differences, however, there may be other reasons for stripping and reconstitution. Foremost among these alternative explanations is that stripping occurs in order to make markets more complete. In particular, there must be at least one Treasury note or bond for each maturity for the market to be complete. Since each note or bond can be viewed as a portfolio of discount bonds, this is equivalent to requiring that there be a discount bond for each maturity by a simple matrix inversion argument. Clearly, if there are discount bonds available for all maturities, any pattern of fixed cash flows can be created from portfolios of discount bonds. Recall that discount bonds are essential in implementing a number of common investment strategies such as defeasing bonds or providing the collateral for guarantees of Brady bonds.

Given the current maturity structure of Treasury debt issues, stripping bonds with maturity dates later than 2006 serves to make the market more complete. This is because discount bonds with maturity dates beyond 2006 cannot be synthesized by portfolios of existing bonds. Specifically, Treasury bonds with maturities from 2007 to 2014 are callable on coupon payment dates during the last five years of the bond. Thus, an investor who purchases one of these bonds cannot be certain of whether the final 10 semiannual coupon payments will be received or of the timing of the final principal

[4] For example, see Livingston and Gregory (1989), Shapiro and Johnson (1990), and Klaffky and Kopprasch (1990).

payment.[5] This uncertainty prevents an investor from using these bonds in a strategy to synthesize a discount bond from a strip of coupon bonds with common coupon payment dates.[6] The only other way to synthesize a discount bond with a maturity date beyond 2006 would be if two coupon bonds shared a common maturity date but had different coupon rates. Currently, there are no such pairs of bonds with maturities beyond 2006. Hence, the STRIPS program is the only way to create longer-maturity discount bonds. If market completion is an important motivation for stripping securities, then stripping activity should tend to be greater for bonds with maturity dates later than 2006. Note, of course, that the market-completion hypothesis cannot explain why investors reconstitute bonds.

There are also explanations centering on the possibility that the accounting and/or tax treatment of STRIPS may differ from that of the underlying bond. Although too numerous to review individually, these explanations share the common feature that the private value of a STRIPS portfolio to an investor may differ from the private value of the fully constituted security, even though the market prices do not diverge sufficiently to allow arbitrage. An example of this is that in the mid-1980s the Japanese government allowed a favorable tax treatment for discount bonds representing stripped principal. Similarly, Japanese life insurance companies may pay dividends based on coupon income received, but not from principal received. Differences in the tax treatment of premium and/or discount coupon bonds and the tax treatment of discount bonds in the United States could also provide incentives to strip or reconstitute. Moreover, some classes of taxable investors who are able to exploit tax-timing opportunities similar to those described by Constantinides (1983), Constantinides and Ingersoll (1984), and Dammon, Dunn, and Spatt (1989) may find that stripping securities creates additional private value since there are now more tax-trading opportunities to exploit. Given the similarity of their empirical implications, it is not possible to differentiate between the many versions of the tax and/or accounting explanations that have been put forward.

The tax-trading story, which implies that taxable investors who are long bonds should strip those securities to create tax options, but not reconstitute securities since that eliminates tax options, is more complex than this overly simple version of it suggests.[7] Taken together, however, these arguments

[5] Longstaff (1992) examines the call policy followed by the Treasury.

[6] If it were not for the seven-year gap in the term structure of noncallable Treasury bonds, then an investor could strip away the coupon of an N-year bond by taking a short position in a portfolio of coupon bonds with maturities $0.5, 1.0, 1.5, \ldots, N - 0.5$. The fact that all of the bonds with maturities between 2007 and 2014 are callable precludes an investor from implementing this coupon-stripping strategy.

[7] Investors who are long a single STRIP would prefer to hold a portfolio of coupon bonds that synthetically creates the STRIP because the latter has the greater tax option. Moreover, if investors are able to take short positions in Treasury securities, they prefer to take short positions in a portfolio of STRIPS than a short position in an equivalent coupon bond. In general, the complexity of the effects of tax trading options in a general equilibrium setting make it difficult to determine the net effect on the relative pricing of Treasury bonds and STRIPS.

imply that stripping and reconstitution activities may be related to accounting-like features such as the coupon rate or the current price of the fully constituted security.

Another nonarbitrage-based explanation is liquidity. Typically, newer issues of Treasury notes and bonds are more liquid than older issues. In fact, newer issues of Treasury notes and bonds are often in such high current demand that they can be financed at special repo rates which are much lower than general collateral repo rates. In contrast, older issues are much less likely to become special in the repo market.[8] Thus, as notes and bonds age, they have a tendency to become less liquid. On the other hand, discussions with traders and other market participants indicate that since STRIPS often come from a variety of underlying bonds, there is no general relation between age and liquidity in the STRIPS market. If investors prefer to hold more liquid securities, then the tendency for a bond to become less liquid over time may provide an incentive for investors to strip the issue more as it ages, and similarly, to reconstitute the issue less.

In summary, these arguments suggest possible explanatory variables for stripping and reconstitution activities such as valuation differences, the potential to complete the market, and the coupon rate, price, and age of the underlying bond. These potential relations provide the basis for the empirical tests conducted in this paper.

II. The Data

To study stripping and reconstitution activities, we obtain data on the amount outstanding, the amount stripped, and the amount reconstituted for each noncallable Treasury note and bond eligible for the STRIPS program for each month during the sample period. The data are obtained directly from the *Monthly Statement of the Public Debt* issued by the U. S. Treasury. The sample period covers the 54-month period from July 1990 to December 1994. July 1990 is the first month included in the sample period since it is the first month in which STRIPS prices from Bear Stearns are reported in the *Wall Street Journal*. To be included in the sample, we require that each eligible bond have at least 12 months of data. This results in a sample of 58 Treasury notes and bonds.

Table I provides summary statistics for the total principal amount outstanding, the average percentage amount stripped, and the average monthly percentage amounts stripped and reconstituted for each of the Treasury securities in the sample. Of the 58 notes and bonds in the sample, the first 31 are Treasury notes, the 32nd through the 35th are 20-year Treasury bonds, and the remaining 23 are 30-year Treasury bonds. As illustrated, the average percentage amount stripped is much lower for the notes than for the bonds, and stripping and reconstitution activity is much more prevalent

[8] For a discussion of the special repo market, see Duffie (1996) and Grinblatt (1995).

for bonds than for notes. Table I also shows that both stripping and reconstitution occur in approximately 80 percent of the months for the majority of the bonds in the sample. This type of activity is difficult to reconcile with the valuation difference hypothesis; if investors respond to price differences only, we should observe either stripping or reconstitution activity, but not both simultaneously. Of course, during a particular hour or day, only stripping or only reconstitution may be occurring and our monthly data may be too coarse to detect this fine structure.

The data set also includes end-of-month bid prices for the eligible notes and bonds and associated STRIPS. The price data are obtained from the *Wall Street Journal*, which reports end-of-day quotations from Bear Stearns.[9] The note and bond prices in the data set are adjusted for accrued coupon through the settlement day, which is two days after the pricing quotation date.[10] In particular, we accrue coupon on the standard actual/actual basis where coupon accrues from the last coupon payment date to the settlement date, and the accrual equals the actual number of calendar days divided by the actual number of calendar days during the semiannual coupon period times the semiannual coupon amount.

III. Valuation Differences

The hypothesis that investors strip and reconstitute securities in response to valuation differences assumes, of course, that these differences exist. This assumption, however, is difficult to reconcile with standard no-arbitrage or equilibrium asset pricing theory. To this end, we first examine whether valuation differences do in fact occur before studying their relation to stripping and reconstitution activities.

Table II reports summary statistics for the differences in the price between the portfolio of STRIPS and the Treasury notes and bonds whose future cash flows the STRIPS portfolio replicates. In Table II, we only include observations where the total outstanding principal amount of both the bond and the TPRN exceeds $500,000,000. We use this filter to avoid including illiquid issues for which quoted prices might include significant measurement error. Note that this reduces the size of N given in Table II from that

[9] Ask price data are also reported in the *Wall Street Journal*. Jordan, Jorgensen, and Kuipers (1999), however, argue that these ask prices are not representative of actual market ask prices. Discussions with Treasury bond and STRIPS dealers confirm that the bid-ask spreads implied by the prices in the *Wall Street Journal* are much larger than actual spreads observed in the market. Our diagnostic tests also indicate that the bid prices of the securities are more comparable than the ask prices. For these reasons, we use only bid prices in this test. We note, however, that the results are qualitatively similar when ask prices are used instead of bid prices.

[10] Discussions with the data vendor indicate that the Bear Stearns data reported in the *Wall Street Journal* are based on a two-day settlement period rather than the one-day settlement period standard in Treasury security markets.

Table I

Summary Statistics for the Notes and Bonds Eligible for the STRIPS Program

Issue size is measured in $ millions. The total stripped is the average proportion of the total outstanding principal amount of each bond held in stripped form. The monthly stripped and reconstituted are the average monthly proportions of the total outstanding principal amount of each bond that is stripped and reconstituted. *N* denotes the number of monthly observations. The overall statistics are based on equal weightings of all observations. The sample consists of monthly observations from July 1990 to December 1994.

Number	Coupon	Maturity Date	Year Issued	Issue Size	Total Stripped Min.	Total Stripped Ave.	Total Stripped Max.	Monthly Stripped Min.	Monthly Stripped Ave.	Monthly Stripped Max.	Monthly Reconst. Min.	Monthly Reconst. Ave.	Monthly Reconst. Max.	Months with Stripping	Months with Reconst.	Months with Both	*N*
Treasury notes																	
1	11.625	11 1994	84	6658.6	0.154	0.235	0.329	0.000	0.013	0.069	0.000	0.012	0.108	42	46	38	52
2	11.250	2 1995	85	6933.9	0.060	0.143	0.240	0.000	0.009	0.048	0.000	0.007	0.032	38	44	34	53
3	11.250	5 1995	85	7127.1	0.160	0.297	0.421	0.000	0.010	0.038	0.000	0.007	0.035	40	42	32	54
4	10.500	8 1995	85	7955.9	0.069	0.235	0.380	0.000	0.011	0.051	0.000	0.005	0.030	41	43	34	54
5	9.500	11 1995	85	7518.6	0.111	0.322	0.533	0.000	0.014	0.059	0.000	0.007	0.053	49	42	39	54
6	8.875	2 1996	86	8575.2	0.023	0.084	0.208	0.000	0.009	0.057	0.000	0.006	0.028	36	38	28	54
7	7.375	5 1996	86	20085.7	0.011	0.032	0.098	0.000	0.004	0.024	0.000	0.002	0.018	36	34	29	54
8	7.250	11 1996	86	20258.8	0.012	0.071	0.125	0.000	0.004	0.026	0.000	0.002	0.012	37	34	27	54
9	8.500	5 1997	87	9921.2	0.007	0.072	0.138	0.000	0.006	0.055	0.000	0.004	0.029	35	34	29	54
10	8.625	8 1997	87	9382.8	0.000	0.078	0.172	0.000	0.005	0.051	0.000	0.002	0.025	29	20	17	54
11	8.875	11 1997	87	9808.3	0.001	0.133	0.251	0.000	0.010	0.046	0.000	0.005	0.027	34	31	25	54
12	8.125	2 1998	88	9159.1	0.000	0.041	0.127	0.000	0.005	0.044	0.000	0.003	0.022	31	22	21	54
13	9.000	5 1998	88	9258.4	0.003	0.117	0.277	0.000	0.008	0.054	0.000	0.003	0.015	30	27	24	54
14	9.250	8 1998	88	11342.7	0.011	0.078	0.234	0.000	0.007	0.038	0.000	0.003	0.013	32	27	25	54
15	8.875	11 1998	88	9902.9	0.001	0.130	0.300	0.000	0.010	0.058	0.000	0.004	0.027	35	32	25	54
16	8.875	2 1999	89	9719.6	0.000	0.054	0.179	0.000	0.006	0.056	0.000	0.003	0.026	29	23	21	54
17	9.125	5 1999	89	10047.1	0.086	0.174	0.339	0.000	0.007	0.038	0.000	0.003	0.026	32	28	25	54
18	8.000	8 1999	89	10163.6	0.008	0.065	0.212	0.000	0.005	0.046	0.000	0.002	0.017	26	17	17	54
19	7.875	11 1999	89	10774.0	0.000	0.086	0.280	0.000	0.008	0.051	0.000	0.003	0.034	29	23	20	54
20	8.500	2 2000	90	10771.7	0.000	0.043	0.168	0.000	0.005	0.020	0.000	0.002	0.026	26	18	18	53
21	8.875	5 2000	90	10496.2	0.001	0.154	0.421	0.000	0.013	0.089	0.000	0.005	0.041	33	26	22	53
22	8.750	8 2000	90	11080.7	0.000	0.097	0.286	0.000	0.009	0.064	0.000	0.003	0.037	26	21	18	52
23	8.500	11 2000	90	11519.7	0.000	0.091	0.246	0.000	0.009	0.053	0.000	0.004	0.032	30	22	20	49
24	7.750	2 2001	91	11312.8	0.000	0.055	0.177	0.000	0.006	0.044	0.000	0.002	0.038	20	15	14	46
25	8.000	5 2001	91	12398.1	0.000	0.082	0.200	0.000	0.008	0.044	0.000	0.003	0.028	26	18	17	43

26	7.875	8 2001	91	12339.2	0.000	0.062	0.171	0.000	0.008	0.038	0.000	0.004	0.036	23	18	16	40
27	7.500	11 2001	91	24226.1	0.000	0.020	0.057	0.000	0.004	0.022	0.000	0.002	0.020	21	17	15	37
28	7.500	5 2002	92	11714.4	0.006	0.046	0.084	0.000	0.004	0.031	0.000	0.003	0.012	16	11	7	31
29	6.375	8 2002	92	23859.0	0.002	0.010	0.021	0.000	0.001	0.005	0.000	0.000	0.004	9	5	2	28
30	6.250	2 2003	93	23564.0	0.000	0.001	0.001	0.000	0.000	0.002	0.000	0.000	0.001	6	4	3	22
31	5.750	8 2003	93	28011.4	0.000	0.004	0.007	0.000	0.002	0.007	0.000	0.001	0.005	6	4	2	16
20-year Treasury bonds																	
32	11.625	11 2004	84	8301.8	0.224	0.406	0.562	0.000	0.068	0.409	0.000	0.059	0.271	43	49	42	52
33	12.000	5 2005	85	4260.8	0.195	0.387	0.641	0.000	0.035	0.254	0.000	0.039	0.245	47	46	41	54
34	10.750	8 2005	85	9269.7	0.053	0.084	0.117	0.000	0.021	0.086	0.000	0.021	0.133	49	51	46	54
35	9.375	2 2006	86	4755.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2	0	0	53
30-year Treasury bonds																	
36	11.250	2 2015	85	12667.8	0.447	0.720	0.843	0.000	0.053	0.172	0.000	0.057	0.197	51	52	49	54
37	10.625	8 2015	85	7149.9	0.557	0.709	0.781	0.000	0.048	0.240	0.000	0.047	0.209	52	50	49	54
38	9.875	11 2015	85	6899.9	0.469	0.656	0.735	0.000	0.059	0.294	0.000	0.060	0.374	48	50	46	54
39	9.250	2 2016	86	7266.9	0.067	0.144	0.368	0.000	0.037	0.226	0.000	0.037	0.191	50	49	47	54
40	7.250	5 2016	86	18823.6	0.019	0.058	0.117	0.000	0.003	0.025	0.000	0.004	0.038	29	42	26	54
41	7.500	11 2016	86	18864.5	0.048	0.121	0.428	0.000	0.007	0.077	0.000	0.013	0.081	39	47	36	54
42	8.750	5 2017	87	18194.2	0.568	0.684	0.803	0.001	0.026	0.088	0.001	0.026	0.120	54	54	54	54
43	8.875	8 2017	87	14016.9	0.274	0.435	0.637	0.000	0.033	0.106	0.000	0.032	0.104	51	52	49	54
44	9.125	5 2018	88	8708.6	0.605	0.735	0.834	0.000	0.025	0.109	0.000	0.022	0.108	51	50	47	54
45	9.000	11 2018	88	9032.9	0.753	0.845	0.912	0.000	0.022	0.101	0.000	0.022	0.124	51	51	48	54
46	8.875	2 2019	89	19250.8	0.613	0.732	0.841	0.002	0.027	0.112	0.000	0.026	0.080	54	54	54	54
47	8.125	8 2019	89	20213.8	0.124	0.331	0.479	0.000	0.022	0.103	0.001	0.025	0.068	50	54	50	54
48	8.500	2 2020	90	10229.7	0.457	0.603	0.701	0.000	0.033	0.154	0.000	0.030	0.126	53	53	52	54
49	8.750	5 2020	90	10158.9	0.131	0.702	0.825	0.005	0.038	0.189	0.000	0.026	0.133	53	51	51	53
50	8.750	8 2020	90	21418.6	0.000	0.681	0.860	0.000	0.034	0.243	0.000	0.019	0.072	50	50	50	52
51	7.875	2 2021	91	11113.4	0.008	0.133	0.234	0.000	0.023	0.132	0.000	0.021	0.108	43	41	39	46
52	8.125	5 2021	91	11958.9	0.006	0.526	0.678	0.001	0.045	0.140	0.000	0.030	0.102	43	42	42	43
53	8.125	8 2021	91	12163.5	0.000	0.310	0.624	0.000	0.047	0.157	0.000	0.032	0.095	39	36	36	40
54	8.000	11 2021	91	32798.4	0.000	0.491	0.806	0.000	0.055	0.176	0.000	0.034	0.148	35	33	33	37
55	7.250	8 2022	92	10852.8	0.002	0.107	0.228	0.000	0.023	0.190	0.000	0.015	0.088	24	21	18	28
56	7.625	11 2022	92	10699.6	0.004	0.282	0.627	0.000	0.040	0.186	0.000	0.016	0.069	22	20	18	25
57	7.125	2 2023	93	18375.1	0.000	0.068	0.210	0.000	0.019	0.101	0.000	0.010	0.056	15	13	12	22
58	6.250	8 2023	93	22909.0	0.000	0.005	0.015	0.000	0.002	0.010	0.000	0.001	0.004	10	5	4	16
Overall				12021.4	0.000	0.257	0.912	0.000	0.019	0.409	0.000	0.015	0.374	34.2	32.8	29.4	47.8

Table II

Summary Statistics for the Valuation Differences

The valuation difference is defined as the price of the portfolio of STRIPS minus the price of the fully constituted Treasury note or bond. The valuation differences are expressed in units of $1 per $100 face amount. The overall statistics are based on equal weightings of all observations. N denotes the number of monthly observations. The sample consists of monthly observations from July 1990 to December 1994.

Number	Coupon	Maturity Date	Average	Standard Deviation	Mean Absolute	Minimum	Median	Maximum	N
Treasury notes									
1	11.625	11 1994	−0.053	0.117	0.087	−0.466	−0.023	0.194	50
2	11.250	2 1995	−0.007	0.090	0.062	−0.150	−0.021	0.363	35
3	11.250	5 1995	−0.004	0.107	0.073	−0.308	−0.013	0.372	52
4	10.500	8 1995	0.030	0.118	0.075	−0.155	−0.002	0.544	52
5	9.500	11 1995	0.024	0.119	0.074	−0.144	−0.001	0.607	52
6	8.875	2 1996	0.030	0.158	0.072	−0.088	−0.003	0.809	30
7	7.375	5 1996	−0.004	0.252	0.137	−0.782	0.010	0.857	31
8	7.250	11 1996	0.058	0.204	0.108	−0.292	0.034	1.093	37
9	8.500	5 1997	−0.056	0.132	0.101	−0.326	−0.019	0.180	30
10	8.625	8 1997	−0.090	0.160	0.126	−0.523	−0.045	0.153	28
11	8.875	11 1997	−0.075	0.125	0.102	−0.389	−0.047	0.136	35
12	8.125	2 1998	−0.048	0.132	0.100	−0.361	−0.043	0.285	21
13	9.000	5 1998	−0.060	0.128	0.095	−0.419	−0.026	0.243	27
14	9.250	8 1998	−0.016	0.092	0.070	−0.168	−0.026	0.261	24
15	8.875	11 1998	0.000	0.123	0.092	−0.244	0.006	0.286	29
16	8.875	2 1999	−0.005	0.098	0.063	−0.162	−0.008	0.298	18
17	9.125	5 1999	−0.000	0.178	0.124	−0.512	0.001	0.475	52
18	8.000	8 1999	0.001	0.100	0.070	−0.124	−0.008	0.293	17
19	7.875	11 1999	0.041	0.159	0.099	−0.134	0.003	0.550	24
20	8.500	2 2000	−0.009	0.142	0.096	−0.284	0.017	0.375	19
21	8.875	5 2000	−0.016	0.213	0.145	−0.707	0.025	0.317	26
22	8.750	8 2000	0.018	0.160	0.110	−0.410	0.008	0.417	21
23	8.500	11 2000	−0.001	0.155	0.101	−0.430	0.003	0.406	21
24	7.750	2 2001	−0.045	0.283	0.142	−1.056	0.019	0.213	17
25	8.000	5 2001	0.006	0.140	0.098	−0.399	0.030	0.210	20
26	7.875	8 2001	0.000	0.127	0.101	−0.205	−0.041	0.229	17

27	7.500	11 2001	0.009	0.088	0.057	−0.114	−0.002	0.170	10
28	7.500	5 2002	−0.026	0.126	0.092	−0.346	−0.025	0.147	16
29	6.375	8 2002	0.016	0.045	0.032	−0.016	−0.016	0.047	2
30	6.250	2 2003	—	—	—	—	—	—	0
31	5.750	8 2003	—	—	—	—	—	—	0
20-year Treasury bonds									
32	11.625	11 2004	−0.066	0.198	0.156	−0.678	−0.077	0.423	48
33	12.000	5 2005	−0.023	0.228	0.169	−0.670	−0.025	0.455	52
34	10.750	8 2005	−0.092	0.222	0.173	−0.654	−0.034	0.224	47
35	9.375	2 2006	—	—	—	—	—	—	0
30-year Treasury bonds									
36	11.250	2 2015	0.003	0.170	0.121	−0.385	0.014	0.514	50
37	10.625	8 2015	0.006	0.182	0.121	−0.425	0.016	0.550	50
38	9.875	11 2015	0.027	0.158	0.112	−0.426	0.021	0.514	52
39	9.250	2 2016	−0.000	0.157	0.113	−0.470	0.008	0.425	49
40	7.250	5 2016	−0.087	0.166	0.147	−0.409	−0.071	0.328	45
41	7.500	11 2016	−0.027	0.143	0.104	−0.448	−0.016	0.357	52
42	8.750	5 2017	0.015	0.138	0.097	−0.427	0.017	0.446	52
43	8.875	8 2017	0.014	0.149	0.100	−0.458	0.012	0.512	50
44	9.125	5 2018	0.023	0.142	0.107	−0.282	0.012	0.511	52
45	9.000	11 2018	0.022	0.143	0.107	−0.301	0.026	0.520	52
46	8.875	2 2019	0.033	0.149	0.101	−0.393	0.037	0.508	48
47	8.125	8 2019	0.009	0.133	0.096	−0.309	0.005	0.448	50
48	8.500	2 2020	0.024	0.133	0.088	−0.350	0.014	0.522	50
49	8.750	5 2020	0.023	0.136	0.097	−0.345	0.023	0.502	48
50	8.750	8 2020	0.014	0.141	0.087	−0.417	−0.000	0.562	45
51	7.875	2 2021	0.004	0.122	0.079	−0.283	−0.017	0.447	39
52	8.125	5 2021	0.034	0.149	0.097	−0.314	0.016	0.546	36
53	8.125	8 2021	0.028	0.127	0.082	−0.328	0.002	0.339	33
54	8.000	11 2021	0.009	0.117	0.079	−0.354	0.002	0.272	30
55	7.250	8 2022	0.036	0.242	0.132	−0.448	0.012	0.779	18
56	7.625	11 2022	0.009	0.144	0.099	−0.337	0.033	0.343	16
57	7.125	2 2023	0.014	0.079	0.064	−0.119	0.027	0.105	9
58	6.250	8 2023	—	—	—	—	—	—	0
Overall			−0.004	0.157	0.104	−1.056	−0.004	1.093	1886

reported in Table I.[11] On average, there is virtually no difference between the prices of the STRIPS and the Treasury notes and bonds; the overall difference between the prices is − 0.4 cents per $100 face amount. Table II shows, however, that there is variation in the mean differences across the notes and bonds in the sample. For example, approximately one-half of the notes in Table II have negative means, and the last 16 bonds have positive means. The economic magnitude of these means, however, is typically small. Although most of the means are close to zero, a number of individual valuation differences appear large. For example, 51.9 percent of these valuation differences exceed a threshold of 10 cents per $100 notional, which is roughly on the same order as market bid-ask spreads. Before concluding that there are actually significant valuation differences, however, it is important to take two additional factors into consideration: transaction costs and the possibility of measurement error in the data.

The valuation differences reported in Table II are based on bid prices for both the underlying Treasury notes and bonds and the STRIPS. Equilibrium theory, however, suggests that it is the midpoint of the bid-ask range that should be the same for the Treasury bond and the STRIPS. By using bid prices, we introduce the possibility of a small bias in the estimated valuation differences if there is a difference in the size of the bid-ask spread between the note or bond and the STRIPS portfolio. To ascertain the magnitude of the bid-ask spread in the market, we conducted a number of in-depth interviews with traders at several major Wall Street Treasury bond and STRIPS dealers. Though anecdotal, this evidence suggests that the bid-ask spreads faced by the lowest-cost arbitrageurs in this market are on the order of 0.03 for liquid Treasury bonds and 0.06 to 0.12 for a typical TINT or TPRN. Given these estimates, the size of the bias in the estimated valuation differences is probably on the order of 0.03 to 0.05; the potential effect of using bid prices rather than the midpoint of the (true but unknown) bid-ask range appears to be small.

The consequences of measurement errors in the bid prices quoted in the *Wall Street Journal* are more likely to be significant. If quoted bid prices do not reflect the actual levels at which trades could be executed, finding that the observed pricing difference exceeds the transaction cost threshold of the marginal arbitrageur does not necessarily mean that there is an arbitrage. For this reason, tests that simply compare the size of the estimated valuation differences to some benchmark cannot provide conclusive evidence that these valuation differences are significant. Even finding that observed valuation differences display persistent behavior may not provide conclusive

[11] We also conduct the analysis using filters of $200,000,000 and $1,000,000,000. The results are very similar to those reported in the paper. We note that this liquidity filter eliminates all but two observations for on-the-run bonds. Since on-the-run bonds may have special repo considerations that would complicate their analysis, we eliminate these two observations from the sample. For consistency with later results, we also eliminate 30 observations from the sample for which some variables used in subsequent regressions are missing.

evidence of the existence of valuation differences since data errors may also display persistence. This is relevant since we find that of the 69 valuation differences that exceed 30 cents per $100 face amount, 52 (75.3 percent) are followed by positive valuation differences the next month. Similarly, of the 82 valuation differences of less than −30 cents per $100 face amount, 58 (70.7) percent are followed by negative valuation differences the next month. If consecutive valuation differences are assumed to be independent, then the z-statistics from a standard binomial test for the hypothesis that 50 percent of the subsequent valuation differences are positive are 4.21 and −3.75 respectively, which is highly statistically significant. If we require that the subsequent valuation difference exceeds a realistic transaction cost threshold of 10 cents, however, then we can no longer conclude that the proportion of subsequent valuation differences exceeding this threshold is significantly different from 50 percent. These results, though provocative, may not be definitive evidence of actual valuation differences because they may simply reflect the presence of serially correlated measurement errors in reported quotes.[12]

To address this issue, we test whether valuation differences exist by using a regression approach that allows us to simultaneously control for sources of data measurement error while conditioning on nonprice variables that are likely to be uncontaminated by price measurement error. Finding that there is predictable variation in the observed valuation differences which is related to the nonprice variables even after controlling for data measurement errors would provide evidence of the existence of valuation differences in the market.

In this regression, we use four variables to control for the effects of measurement error in the data. The first is simply the lagged value of the observed valuation difference. If data measurement error takes the form of prices that are only infrequently updated or are computed as a spread off of some other price, then there could be spurious persistence in the observed valuation difference. Including the lagged value of the valuation difference should control for this type of error.

The second variable is the change in the bond price during the previous month. This variable provides controls for the possibility that the less-liquid STRIPS prices are not updated as frequently as the more actively traded notes or bonds. Since the current bond price appears with opposite signs on each side of the regression when the change in the bond price is included,

[12] We are clearly adopting the most conservative interpretation of these results. In actuality, for the persistence results to be attributable to serially correlated data errors, one would need to argue that the STRIPS (which are generally less liquid than the bonds) may not trade or have persistent biases in reported prices for multiple months. Although we have no direct evidence about how frequently STRIPS trade, conversations with traders and the frequency with which STRIPS are created by stripping the bond (as displayed in Table I) strongly suggest that most STRIPS are traded many times during a typical month. Furthermore, since our data are monthly, we cannot rule out the possibility that short-lived intramonth arbitrages exist in the STRIPS market.

finding that the regression coefficient is significantly negative provides evidence that STRIPS prices are less frequently updated than are bond prices. This is true independent of whether or not there are significant valuation differences in the market. If the prices of the STRIPS are not updated at all, then the regression coefficient for the change in bond price should equal -1. If the observed valuation difference is an artifact of the bond price changing without a corresponding change in the prices of the associated STRIPS, then including the change in the bond price as a control variable should help identify this type of measurement error.

Third, we include the square of the change in the bond price during the previous month as a control variable. This measure tends to be larger in volatile markets and is motivated by the possibility that the reported prices of less liquid securities may be interpolated from the prices of more liquid securities, rather than on the basis of current market quotations or trades. Since interpolation methods often use linear or duration-based approximations, these techniques may miss the effects of second-order or convexity terms in updating prices after a large market move. Including the squared price change in the regression should provide some control for errors of this nature. Finally, we include the age of the underlying Treasury note or bond as the fourth control variable. This measure controls for the possibility that price quotations for older and less liquid Treasury notes and bonds may not be updated as frequently or be as reliable.[13]

As an explanatory variable in this regression, we use the percentage of the total issue held in stripped form, a measure which should largely be free of price measurement error. The motivation for this variable is that it provides information about the relative supply of STRIPS to that of the fully constituted security. Table III presents the regression results. In addition to the OLS t-statistics, we also report t-statistics based on the standard deviation of parameter estimates obtained by a standard multivariate bootstrap procedure. In particular, we resample the data with replacement by month and also include date dummies in the regressions. Resampling by month allows the bootstrap to be robust to any cross-sectional correlation in residuals while the date dummies control for potential time-series variation in the means of the residuals. Standard results can be used to show that the bootstrapped t-statistics are robust to departures from the usual OLS assumptions about independently and identically normally distributed residuals in this panel data regression.

As shown in Table III, several of the control variables are significant. The coefficient for the lagged valuation difference is positive and highly significant. This result may suggest that the valuation differences have a strong

[13] In addition to including control variables in the regression, we perform a variety of other diagnostics to check the accuracy of the underlying data. For example, since bond price data (but not STRIPS price data) are available from CRSP, we run comparisons of the Bear Stearns and CRSP bond price data. The differences in the prices are minor and do not affect the properties of the computed valuation differences.

Table III

Regression Results from Regression of Valuation Differences on the Explanatory Variables

Valuation difference is the difference between the price of the portfolio of STRIPS and the price of the underlying Treasury note or bond. Price change is the change in the value of the underlying note or bond during the previous month. The age of the bond is measured in years. The total number of observations is 1,886.

	Constant	Lagged Valuation Difference	Price Change	Squared Price Change	Age	Total Percentage Stripped	Adj. R^2
Coefficient	0.0080	0.1539	−0.0048	−0.0019	−0.0028	0.0724	0.0597
t-statistic	0.08	6.89	−3.59	−6.75	−1.79	5.21	
Bootstrapped *t*-statistic	0.09	3.94	−1.87	−2.14	−1.27	2.88	

persistent component that is consistent with the presence of data errors induced by illiquidity or infrequently updated prices. It is important to note, however, that this result could also be interpreted as evidence of predictable time variation in actual valuation differences. Similarly, both the change in price and the squared price change are significant based on the OLS *t*-statistics, although the change in price is slightly less than significant based on the bootstrapped *t*-statistics. We also estimate the regression without using the change in the bond price as an explanatory variable. The regression results for the remaining variables are virtually the same as those reported in Table III. The age of the bond enters with a negative sign, but is not statistically significant based on either the OLS or the bootstrapped *t*-statistics.[14]

Table III also shows that the percentage of the total issue held in stripped form is highly significant. The positive sign for the coefficient implies that the portfolio of STRIPS is more valuable relative to the underlying note or bond when the percentage of the total issue stripped is larger. Since stripping the issue increases the supply of STRIPS while decreasing the supply of the underlying note or bond, these results are consistent with the presence of a liquidity effect in the pricing of these Treasury securities; the relative price of the STRIPS appears to be directly related to their relative supply. These findings suggest that there is systematic variation in observed valu-

[14] The negative sign of this coefficient is counterintuitive since we would expect that as the bond ages and becomes less liquid, its value should decrease and the measured valuation difference widen. To explore this, we estimate the regression in Table III using dummy variables for each of the notes and bonds to control for cross-sectional differences in the means of the valuation differences. When these dummy variables are included, the coefficient on the age of the bond is close to zero, implying that the negative coefficient for age arises because the oldest bonds in the sample also have the most significantly negative mean valuation differences, and not because the valuation differences for individual bonds widen as time passes.

ation differences even after controlling for various measures of data measurement error. Consequently, it is legitimate to investigate whether stripping and reconstitution is driven by differences in the relative values of STRIPS and the underlying Treasury note or bond.

IV. Stripping and Reconstitution Activity

In this section, we examine the extent to which stripping and reconstitution activity can be explained by the various hypotheses described earlier.

A. The Explanatory Variables

Each of the alternative hypotheses suggests potential explanatory variables.

Valuation Differences. If stripping and reconstitution activity is driven by the response of investors to perceived differences in the values of the STRIPS portfolio and the underlying note or bond, then positive valuation differences should be followed by stripping, and negative values should be followed by reconstitution.

Market Completion. If market participants use the STRIPS program to create securities that make the market more complete, then stripping activity should be greatest at maturities for which discount bonds are most difficult to synthesize using alternative methods. To capture this, we define the market-completion dummy variable to have value one if the maturity date of the bond is later than 2006, and to have value zero otherwise.

Tax and Accounting Motivations. To examine these motivations, we include both the coupon rate and price of the bond as explanatory variables. Including the coupon rate controls for the possibility that coupon income is either tax advantaged or receives a favorable accounting treatment for some investors. Similarly, the price of the bond, when controlling for the coupon rate, captures the effect of shifts in the term structure. As the term structure shifts, the market price of securities may differ from their tax basis and create tax-trading strategies involving the stripping or reconstitution of securities. Alternatively, as the term structure shifts down, investors may choose to inflate accounting income by defeasing existing bonds with discount bonds and refinancing at lower coupon rates. This would tend to make stripping more prevalent when market interest rates decrease.

Liquidity. As discussed, Treasury notes and bonds generally become less liquid as they age. Hence, the amount of stripping and reconstitution activities may be related to the age of the underlying Treasury note or bond if liquidity is important to investors. In order to be able to isolate the specific effect of age, we also include the maturity of the underlying bond as a separate explanatory variable in the regression since age and maturity are correlated.

Dynamic Properties of Stripping and Reconstitution. A number of the hypotheses imply that the entire issue should either be stripped or reconstituted; simultaneous stripping and reconstitution should not be observed. This all-or-nothing implication is particularly applicable to the hypothesis that stripping and reconstitution are driven by the actions of arbitrageurs exploiting valuation differences.

To explore the dynamic behavior of investors in stripping and reconstituting securities, we include the percentage of the issue reconstituted during the month as an explanatory variable in the regression for the percentage stripped during the month, and vice versa. Intuitively, if stripping and reconstitution activities are driven by some simple motivation such as exploiting valuation differences, then an increase in stripping during the month should be associated with a decrease in reconstitution during the month, and vice versa. If there are nonarbitrage-related motivations for stripping and reconstitution, however, investors may not strip or reconstitute the entire issue. For example, life insurance firms may demand long-maturity discount bonds for the purpose of immunizing fixed-maturity liabilities. The demand in any period, however, will be a function of the amount of new liabilities generated. This would lead to an ongoing pattern of securities being stripped in response to demand, and may help explain why stripping and reconstitution occur at the same time. To examine the persistence of stripping and reconstitution activities, we include the amount stripped and reconstituted during the previous month as explanatory variables. Finally, since little new stripping can occur when most of the issue has been stripped, or similarly, little reconstitution can occur when only a small fraction of the total issue has been stripped, we include the total percentage amount stripped at the end of the previous month as an explanatory variable for current activity.

B. Methodology

Since we include the percentage reconstituted as an explanatory variable in the regression for the percentage stripped, and the percentage stripped as an explanatory variable in the regression for the percentage reconstituted, the regressions must be estimated as a simultaneous system in order to obtain consistent results. Accordingly, we use a standard two-stage least squares approach to estimate the regressions. As in Section III, we include only observations in the sample where the total amount of bonds held in stripped form and the remaining unstripped amount exceeds $500,000,000. As in Table III, we report both the standard two-stage least squares *t*-statistics as well as the *t*-statistics from a bootstrapped two-stage least squares regression that includes date dummies. The bootstrap controls for cross-correlation by sampling months with replacement as discussed for the regresssion in Table III.[15]

[15] In addition to the regressions reported in the paper, we also run regressions in which a separate dummy variable for each bond is included. The objective of these regressions is to determine whether the time-series relationships in the data are the same after controlling for the panel nature of the data. The regression results for the time-varying explanatory variables

C. Empirical Results for Stripping

Table IV reports the results for the regression of the total amount stripped each month on the explanatory variables. The hypothesis that stripping activity is driven by valuation differences receives no support from the data; the bootstrapped t-statistic for the variable is 0.81. Furthermore, the economic impact of this variable is small; a valuation difference of 10 cents only translates into an increase in the amount stripped of 0.067 percent of the total issue size.

In contrast, the market-completion dummy variable is positive and statistically significant. The regression coefficient for the market-completion dummy implies that the monthly percentage stripped for these bonds exceeds that of the other bonds by more than two percent of the total issue size, which is a significant difference in economic terms as well. This provides solid support for the market-completion hypothesis. Note that in the regressions, we control for the maturity of the underlying bond. Hence, the market completion variable is not simply capturing investor preferences for long duration or highly convex cash flows. This result is important since it provides one of the first direct empirical confirmations of a well-known theoretical argument for the existence of derivative securities—namely, that derivatives are used by investors to make markets more complete.

The tax and accounting explanations also receive some support from the data. The regression coefficients for the coupon rate and the price of the note or bond are both positive, although only the coupon rate is significant based on the bootstrapped t-statistics. Thus, holding the price of the bond fixed, stripping activity increases with the coupon rate. Although there are many possible tax and accounting stories consistent with these results, this finding suggests that investors' behavior may be influenced by tax- or accounting-induced frictions.

The regression results for age run counter to the liquidity hypothesis. The age variable is highly significant but negative in sign. This implies that as a bond ages, the amount of stripping activity decreases. Traders and market participants, however, often argue than the reason older bonds become illiquid is that they are eventually absorbed into the portfolios of investors who tend to follow buy-and-hold strategies. Hence, the effective supply of bonds available in the market tends to decline over time. This rejection of the liquidity hypothesis is consistent with the existence of a clientele that places less value on liquidity.

The regression results also have a number of implications for the dynamic behavior of stripping activity. As shown, stripping activity is positively related to the amount of contemporaneous reconstitution activity. Thus, rather

(e.g., valuation difference, price, fraction stripped, etc.) are very similar to those reported in the paper. Similarly, we also run the regressions with date dummies to control for pricing errors that might be correlated across bonds at a given point in time. The results are again very similar to those reported. Finally, we run the regressions monthly using a standard Fama–MacBeth (1973) methodology to compute t-statistics. The results are again similar.

Table IV

Two-Stage Least Squares Regression Results from Regressions of Monthly Percentage Stripped and Monthly Percentage Reconstituted on the Explanatory Variables

Valuation difference is the difference between the price of the STRIPS portfolio and the price of the Treasury note or bond at the beginning of the month. Market complete is a dummy variable taking value one for bonds with maturity dates later than 2006. Coupon is the coupon rate of the security. Price is the full price of the security. Maturity and age are measured in years. Lagged stripped and lagged reconstituted are the respective percentages for the previous month. The total number of observations is 1,886.

	Constant	Valuation Difference	Market Complete	Coupon	Bond Price	Maturity	Age	Percentage Reconst	Lagged Stripped	Total Stripped	Adj. R^2
Stripping regression											
Coefficient	0.0001	0.0067	0.0214	0.0013	0.0002	−0.0012	−0.0031	1.0852	−0.0568	−0.0151	0.553
t-statistic	0.01	1.61	3.52	1.63	1.65	−3.84	−5.73	9.86	−1.32	−4.15	
Bootstrapped *t*-statistic	0.23	0.81	2.04	4.20	0.15	−1.96	−5.18	5.35	−0.91	−3.79	
Reconstitution regression											
Coefficient	0.0166	−0.0050	−0.0246	−0.0015	−0.0003	0.0012	0.0032	1.1778	−0.0677	0.0166	0.450
t-statistic	1.39	−1.17	−3.58	−1.67	−2.64	3.78	5.71	9.78	−1.29	4.09	
Bootstrapped *t*-statistic	1.13	−0.17	−2.24	−3.34	−1.30	2.00	4.39	4.49	−0.93	3.51	

than being negatively correlated, the evidence suggests that stripping and reconstitution activities tend to occur at the same time. For example, an increase of one percent in the amount reconstituted is associated with a 1.0852 percent increase in the amount stripped. This puzzling relation argues against the hypothesis that stripping and reconstitution activities are driven by the actions of arbitrageurs or investors responding to valuation differences. The coefficient for the lagged amount of stripping activity is not significant. Finally, the regression coefficient for the percentage of the total issue stripped is negative and significant. This is intuitive since additional stripping activity cannot occur if the issue has already been largely or completely stripped.[16]

D. Empirical Results for Reconstitution

Table IV also reports the results from the regression of the total amount reconstituted each month on the explanatory variables. The results generally parallel those of the stripping regression. For example, reconstitution activity is not significantly related to the valuation difference in either statistical or economic terms. This again provides evidence against the hypothesis that the STRIPS program is primarily used to exploit differences in the prices of the securities.

The market-completion dummy variable was highly significant in explaining stripping activity in the earlier regression. Similarly, the coefficient for the market-completion dummy is significantly negatively related to reconstitution activity. In particular, the coefficient for the market-completion dummy implies that the monthly amount reconstituted for these bonds is more than 2.4 percent of the total issue size less than for the other bonds. Thus, investors are less likely to reconstitute STRIPS when the STRIPS fulfill some market spanning function. Note, however, that the market completion hypothesis does not explain why investors reconstitute securities, since reconstitution only serves to make the market less complete in the sense that there is a decreased supply of STRIPS.

The coupon rate variable is again significant. This time, however, the coefficient is negative, implying that high coupon bonds tend to be stripped more and reconstituted less than other Treasury notes and bonds. Again, the price variable is not significant based on the bootstrapped t-statistics. The results for the liquidity hypothesis parallel those for the stripping regression; the age of the bond is significantly positively related to the amount of reconstitution activity, consistent with the existence of a clientele with a strong propensity to hold aged illiquid bonds. Stripping and reconstitution

[16] As a diagnostic for potential multicollinearity problems, we examine the correlation matrix of the regression coefficients. Only the correlation between the coefficients for the completeness variable and the maturity of the bond is in excess of 0.90; all of the remaining correlations are much smaller. Since both completeness and the maturity of the bonds are significant, the correlation between the coefficients does not affect the power of the t-tests for these variables.

are significantly positively related. The lagged amount reconstituted is not significant. Finally, the regression coefficient for the percentage of the total issue reconstituted is positive and significant.

V. Conclusions

We have conducted an analysis of the determinants of stripping and reconstitution activity using data on the Treasury STRIPS program. The results suggest that little of this activity is directly related to the actions of speculators or arbitrageurs attempting to exploit profit opportunities. In contrast, market participants' use of the STRIPS program appears to be primarily for making markets more complete, and exploiting accounting and tax asymmetries.

Although our results are limited to Treasury STRIPS, these results are consistent with economic theory about the motivation for financial innovation and the creation of new derivative securities. Despite claims by critics, market participants appear to use the flexibility to create and reconstitute Treasury-derivative securities like STRIPS for fundamental economic reasons.

REFERENCES

Allen, Franklin, and Douglas Gale, 1988, Optimal security design, *Review of Financial Studies* 3, 229–263.

Amihud, Yakov, and Haim Mendelson, 1986, Asset pricing and the bid-ask spread, *Journal of Financial Economics* 17, 223–249.

Boudoukh, Jacob, and Robert Whitelaw, 1993, Liquidity as a choice variable: A lesson from the Japanese government bond market, *Review of Financial Studies* 6, 265–292.

Constantinides, George, 1983, Capital market equilibrium with personal tax, *Econometrica* 51, 611–636.

Constantinides, George, and Jonathan Ingersoll, 1984, Optimal bond trading with personal taxes: Implications for bond prices and estimated tax brackets and yield curves, *Journal of Financial Economics* 13, 299–335.

Dammon, Robert, Kenneth Dunn, and Chester Spatt, 1989, A re-examination of the value of tax options, *Review of Financial Studies* 2, 341–372.

Daves, Philip, and Michael Ehrhardt, 1993, Liquidity, reconstitution, and the value of U.S. Treasury strips, *Journal of Finance* 48, 315–329.

Duffie, Darrell, 1996, Special repo rates, *Journal of Finance* 51, 493–526.

Duffie, Darrell, and Matthew Jackson, 1989, Optimal innovation of futures contracts, *Review of Financial Studies* 2, 275–296.

Fama, Eugene, and James MacBeth, 1973, Risk, return, and empirical tests, *Journal of Political Economy* 71, 607–636.

Grinblatt, Mark, 1995, An analytic solution for interest rate swap spreads, Working paper, University of California at Los Angeles.

Jordan, Bradford, Randy Jorgensen, and David Kuipers, 1999, The relative pricing of U.S. Treasury strips: Empirical evidence, *Journal of Financial Economics*, forthcoming.

Kamara, Avi, 1994, Liquidity, taxes, and short-term treasury yields, *Journal of Financial and Quantitative Analysis* 29, 403–417.

Klaffky, Thomas, and Robert Kopprasch, 1990, Analysis of treasury zero-coupon bonds, in Frank J. Fabozzi, ed.: *The Handbook of Treasury Securities* (Probus Publishing Co., Chicago).

Livingston, Miles, and Davis Gregory, 1989, *The Stripping of U.S. Treasury Securities*, (Salomon Brothers Center for the Study of Financial Institutions, New York University, New York).

Longstaff, Francis, 1992, Are negative option prices possible? The callable U. S. Treasury-bond puzzle, *Journal of Business* 65, 571–592.

Longstaff, Francis, 1995, How much can marketability affect security values?, *Journal of Finance* 50, 1767–1774.

Ross, Stephen, 1989, Institutional markets, financial marketing, and financial innovation, *Journal of Finance* 44, 541–556.

Silber, William, 1991, Discounts on restricted stock: The impact of illiquidity on stock prices, *Financial Analysts Journal* 47, 60–64.

Shapiro, Monte, and Carol Johnson, 1990, Overview of government zero market and investment strategies, in Frank J. Fabozzi, ed.: *Handbook of Treasury Securities* (Probus Publishing Co., Chicago).

Tufano, Peter, 1989, Financial innovation and first-mover advantages, *Journal of Financial Economics* 25, 213–240.