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Does the Liquidity of a Debt Issue Increase with Its Size? Evidence from the Corporate Bond and Medium-Term Note Markets

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ABSTRACT

To investigate the liquidity of large issues, this study tests for yield differences between corporate bonds and medium-term notes (MTNs). In the sample, MTNs have an average issue size of $4 million, compared with $265 million for bonds. Among MTNs that have the same issuance date, the same maturity date, and the same corporate issuer, we find no relation between size and yields. Moreover, bonds and MTNs have statistically equivalent yields. Thus, rather than suggesting that large issues have greater liquidity, these findings indicate that large and small securities issued by the same borrower are close substitutes.

THE OBJECTIVE OF THIS STUDY is to test for a relation between the size of corporate debt offerings and their yields. If investors value large offerings for their greater liquidity, then large issues will have lower yields than small issues. Alternatively, if investors view securities of the same borrower as close substitutes, there may be no relation between issue size and yields. To investigate whether issue size is a significant determinant of liquidity, we test for yield differences between medium-term notes (MTNs) and bonds of the same corporate issuers. In most respects, MTNs are similar to corporate bonds. However, MTNs have an average issue size of around $5 million; in contrast, most offerings in the bond market raise at least $100 million. Thus, if liquidity increases with issue size, bonds will have lower yields than MTNs, and large MTNs will have lower yields than small MTNs.

The data we use consist of 4,182 MTNs and 68 bonds offered by four large borrowers between October 1987 and December 1992. The issues in the sample range in size from $102,000 to $1.2 billion, a disperse distribution that allows us to make reliable inferences about the relation between issue size and yields. To test for a size effect within the MTN market, we create subsamples of MTNs that have the same issuance date, the same maturity date, and the same corporate issuer. MTNs in these subsamples are identical, except for their yields and size. On average, yields on large MTNs in the subsamples are 0.35 basis point higher than yields on small MTNs, a finding that is inconsistent with the liquidity hypothesis. We also test for a yield difference between bonds

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and MTNs of the same issuer. The yield difference averages −0.44 basis point, a difference that is not statistically significant. Thus, this evidence does not suggest that large issues enjoy a yield advantage due to their perceived greater liquidity.

In previous studies, researchers have estimated the illiquidity premium of small issues by regressing yields (or yield spreads) on issue size and other explanatory variables.[1] Typically, the illiquidity premium is estimated from a sample of bonds offered by a cross-section of borrowers. This regression approach has two major shortcomings. First, issue size may proxy for borrower characteristics, such as borrower capitalization. Thus, finding that bonds with large face amounts have low yields may merely indicate that large firms have lower information costs than smaller firms, which are more likely to issue small bonds. Our study eliminates this potential bias by analyzing securities that have *identical* borrower characteristics but *different* issue sizes. A second shortcoming of the regression framework is that the parameter estimates for the variables that determine yield spreads are fixed over the entire sample period. Implicitly, the regression methodology assumes that yield spreads do not vary over time.[2] In our study, we estimate a dynamic pricing model that allows the parameters on the determinants of yield spreads to evolve over time.

Our study focuses on only one aspect of liquidity: the relation between issue size and yields in corporate debt offerings. Research on the Treasury market, in contrast, has examined other aspects of liquidity. For example, Warga (1992) finds that recently issued, "on-the-run" Treasury securities have lower returns than "off-the-run" issues, a result suggesting that the greater liquidity of on-the-run issues is positively priced. Similarly, Sarig and Warga (1989) find that a bond's liquidity tends to decrease with its age. In an examination of the transaction costs aspect of liquidity, Amihud and Mendelson (1991) find a positive correlation between yields and liquidity, measured by bid-ask spreads. In a study of yield differences between identical Treasury notes and bills, Kamara (1994) finds that the liquidity premium increases with both interest rate volatility and the turnover ratio in the note market relative to that of the bill market. Because the Treasury market studies have focused on aspects of liquidity other than the size effect, their findings are not inconsistent with the evidence in this study.

A second difference between this study and the Treasury market studies is that the latter examine secondary market data, while we analyze new issue yields. In a rational expectations framework, the yield on a newly issued security will carry an illiquidity premium to cover transaction costs if primary investors have a nonzero probability of selling the security in the secondary

[1] In a study of the cost differences between public and private bonds offered between June 1979 and December 1983, Blackwell and Kidwell (1988) find no significant relationship between issue size and new issue yields. However, in analysis of bank loans made between January 1987 and May 1989, Booth (1992) shows that loan size is negatively related to loan spreads.

[2] Evidence that yield spreads vary over the business cycle is given in Bernanke (1983, 1991), and Stock and Watson (1989). Yield spreads also vary in response to changes in a borrower's credit quality (see Hand, Holthausen and Leftwich (1992))

market before maturity (Amihud and Mendelson (1986), (1991)). Thus, if liquidity affects yields in the secondary market, the effect should also be evident in primary market yields, unless confounding effects are present. In our analysis, we attempt to remove any possible confounding effects by selecting issues that are identical except for their size.

The paper is organized as follows. The next section discusses the transaction and information costs of large and small issues, focusing on how these costs may give rise to a liquidity premium. Section II describes the MTN market and the data on MTN and bond offerings. Section III constructs matched sets of MTNs and bonds with similar issuer and term characteristics, and tests for a relation between issue size and yields. Section IV presents the dynamic linear model of yield spreads, and Section V uses the model to test for differences between MTN and bond yields. The final section gives concluding remarks.

I. Liquidity, Transaction Costs, and Issue Size

In most debt markets, transactions are handled by bond dealers, mainly investment banks, who provide a specialized service of standing ready to buy and sell securities in the secondary market. Transaction costs arise because buy and sell orders do not arrive simultaneously; rather, dealers hold securities in inventory until they can arrange placements with investors. Transacting is costly because dealers must raise capital to finance an inventory of securities and because dealers face uncertainty about the time required to place securities with investors (Demsetz (1968)).

The more difficult it is for investors to process and evaluate information about a security, the longer a dealer will expect to hold the security in inventory, and the greater will be the cost of transacting. The information that investors analyze can be divided into two categories: (1) information that is specific to the *borrower*, and (2) information that is specific to the *issue*. Investors analyze a variety of types of information about a borrower, such as its leverage ratios, cash flow, management expertise, litigation risk, credit ratings, cyclical risk, and industry risk. Investors may demand a large illiquidity premium on the securities of borrowers that are difficult to analyze. Features that are specific to the issue include its face value, maturity, covenants, seniority, and option and redemption features. Other factors held constant, issues with standard features will have low information costs because they are relatively easy to evaluate. Conversely, a complicated issue may have low liquidity and high information costs, even if other securities issued by the same borrower are highly liquid.

In this study, we examine whether issue size is an independent, issue-specific factor that determines the liquidity of a security. An issue with a large face value may have low information costs because it is likely to trade frequently and because a relatively large number of investors own or have analyzed its features. In contrast, a small issue may have high transaction costs because information about it is less broadly disseminated among investors. As a result, if small issues remain in dealers' inventories for a longer period than large issues, small issues will carry an illiquidity premium. However, if investors view large and small issues of the same issuer as close substitutes, yields on large and small issues may not differ significantly.

II. Data and Sample Selection

A. Description of the Medium-Term Note Market

MTNs are highly flexible debt instruments that are offered continuously or intermittently, primarily through investment banks and other broker-dealers acting as agents. Over the past decade, the MTN market has emerged as a major source of funding for investment-grade corporations. Outstandings of MTNs grew from less than $1 billion in 1981 to $176 billion in 1992. Moreover, the number of companies that raised funds in the MTN market increased from 12 in 1983 to 402 by 1992. The MTN market began its rapid growth after the passage of SEC Rule 415 in 1982. Rule 415 permits delayed or continuous issuance of so-called "shelf" registered corporate securities, such as MTNs.[3] At most investment banks, MTNs and corporate bonds are traded side-by-side on the same trading floor, and both securities are sold primarily to institutional investors, such as mutual funds, insurance companies, and pension funds (Crabbe (1993)).

To establish an MTN program, the borrower files a shelf registration for the amount of total debt (generally between $100 million and $3 billion) that it plans to issue over the next two years. Because MTNs are issued under a single registration document, their indenture provisions do not vary from issue to issue. However, MTNs issued from a single shelf registration may have a variety of face values, coupons, maturities, and other features. For example, most MTN programs allow borrowers to issue debt with fixed or floating rates, a significant volume of MTNs include customized options, and some pay interest and principal according to unusual formulas. Furthermore, most shelf registrations allow borrowers to issue MTNs with maturities that range from nine months to 30 years, or longer. In the early 1980s, when the auto finance companies dominated the market, most MTNs had maturities in the 2–4 year range. In the mid and late 1980s, as new borrowers entered the MTN market, average maturities lengthened. Thus, the name "medium-term" has become something of a misnomer that reflects the market's origins, rather than a legal limit on the maturity of note offerings.[4]

In the MTN market, investors have the ability to design customized securities with desirable risk features through a process known as a reverse inquiry. In a reverse inquiry, the investor's demand for a customized security is relayed to an MTN issuer through an investment bank or dealer. For example, the

[3] Several studies have found that underwritten bonds sold under shelf registration have lower yields than nonshelf offerings, *ceteris paribus*. See Kadapakkam and Kon (1989), Kidwell, Marr, and Thompson (1984), and Blackwell, Marr, and Spivey (1990).

[4] In July 1993, Walt Disney Company issued a note with a 100-year maturity off its MTN shelf registration.

investor might have a demand for an MTN with payments tied to a foreign exchange rate. In most cases, the note that the investor desires will not exist in the secondary market. If the MTN issuer finds the terms of the reverse inquiry sufficiently attractive, it may agree to the transaction, even if it had not planned to offer the notes that the investor desires. In general, when an issuer agrees to issue a customized security, it will also negotiate a swap or derivative transaction in order to eliminate its exposure to the customized terms of the note structure. These transactions, in which the issuer sells a customized note and simultaneously enters into a swap, are known as structured MTNs (Crabbe and Argilagos (1994)).

The maturity of an MTN also may be customized to make it attractive to a specific investor. For example, an investor with a demand for a note with a maturity of four years and five months may be able to obtain it in the MTN market through a reverse inquiry. Because investors place greater value on customized securities, MTNs with customized maturities will likely have lower yields than MTNs and bonds with standard maturities.

B. Sample Selection and Descriptive Statistics

To investigate the correlation between issue size and yields, we construct a sample of primary transactions by four large borrowers: General Motors Acceptance Corporation (GMAC), Ford Motor Credit Company (FMCC), General Electric Capital Corporation (GECC), and Merrill Lynch & Co., Inc. (ML). These four borrowers accounted for 24 percent of corporate MTNs outstanding at year-end 1992. Data on MTN issues are available from a one-page pricing supplement that the borrower files with the SEC, stating the sale date, the rate of interest, maturity, and other features of the MTN.

In the sample, all the securities were sold in the U.S. public market between October 1987 and December 1992. All the securities are senior, unsecured, fixed-rate, and noncallable, with maturities ranging from one to five years. We eliminate MTNs with long maturities because the four borrowers concentrate more than 95 percent of their issuance in short and intermediate-term maturities. We also restrict the sample to institutional offerings that raised more than $100,000. Although the four borrowers sometimes issue MTNs with face amounts of $100,000 and below, small issues are usually targeted to "retail" investors and the total funds raised from these issues is relatively small. As noted, many MTNs have terms that are customized to investor demand. Because investors may be willing to pay more for customized MTNs than for standard MTNs, we exclude MTNs with floating rates, options, and other unusual features. We also screen for MTNs with nonstandard maturities by eliminating issues that do not mature at an annual interval from the date of the offering, plus or minus ten days. This restriction eliminates 580 MTNs, most of which have maturities of one and one-half years. As a result of these selection criteria, the features of the MTNs in the sample do not differ from those of standard corporate bonds.

Panel A of Table I presents statistics for the sample of 4,182 MTNs offered by the four borrowers. The most striking feature of the data is the wide variation in face amount, which ranges from $102,000 to $130 million. The distribution of face amounts is skewed toward smaller offerings: the average issue size is $4 million, while the median issue size is $500,000. For each issue, we calculate a yield spread as the yield on the MTN minus the yield on an on-the-run Treasury security of comparable maturity on the same day. All

Table I

Sample Statistics for MTNs and Corporate Bonds Sold by Four Large Financial Companies

The sample consists of medium-term notes (MTNs) and corporate bonds offered between October 1987 and December 1992 by four large borrowers: General Motors Acceptance Corporation (GMAC), Ford Motor Credit Company (FMCC), General Electric Capital Corporation (GECC), and Merrill Lynch & Co., Inc. (ML). The yield spread is calculated as the yield on the MTN minus the yield on an on-the-run Treasury security of comparable maturity on the same day. All yields are measured on a 30-day month, 360-day year corporate basis. In the sample, all the securities are senior, domestic, public, fixed-rate, and noncallable, with maturities ranging from one to five years and a face amount greater than $100,000. Securities with floating rates, options, and other unusual features are excluded from the sample. The sample excludes offerings with nonstandard maturities by eliminating issues that do not mature at an annual interval from the date of the offering, plus or minus 10 days. Data on MTN issues are available from pricing supplements filed with the SEC, and the data on corporate bond offerings are obtained from *Corporate Financing Week, Investment Dealers' Digest,* and *Moody's Bond Survey.*

	Issuer				
Characteristic	GMAC	FMCC	GECC	ML	All Four Issuers
Panel A: Medium-Term Note Offerings					
Number of offerings	1718	1343	335	786	4182
Face amount ($ million)					
Mean	5.304	3.821	2.133	2.995	4.239
Median	0.402	0.500	0.900	0.500	0.500
Minimum	0.102	0.102	0.200	0.105	0.102
Maximum	100.000	130.000	45.000	100.000	130.000
10th percentile	0.150	0.150	0.250	0.200	0.150
90th percentile	25.000	10.000	5.000	5.000	11.600
Yield spread (basis points)					
Mean	79.61	74.72	36.34	80.15	74.67
Median	76.00	68.00	35.00	71.90	70.00
Minimum	11.37	11.77	7.15	31.90	7.15
Maximum	186.00	165.00	75.00	182.78	186.00
Yield (percent)					
Mean	8.29	8.48	7.45	8.47	8.32
Median	8.60	8.75	7.73	8.45	8.57
Years to maturity					
Mean	2.82	3.03	3.28	1.36	2.65
Median	3.00	3.01	3.01	1.01	2.01
Total proceeds ($ billions)	9.113	5.132	0.714	2.354	17.313

Table I—*Continued*

Characteristic	Issuer				All Four Issuers
	GMAC	FMCC	GECC	ML	
	Panel B: Corporate Bond Offerings				
Number of offerings	19	19	13	17	68
Face amount ($ million)					
Mean	308	249	350	172	265
Median	300	250	250	150	250
Minimum	200	100	200	100	100
Maximum	500	500	1,200	300	1,200
10th percentile	250	125	200	100	125
90th percentile	400	300	500	300	400
Yield spread (basis points)					
Mean	84.30	81.96	40.91	100.38	79.37
Median	77.70	71.00	32.50	86.00	76.00
Minimum	53.20	45.00	12.00	63.00	12.00
Maximum	140.30	130.00	75.00	168.00	168.00
Yield (percent)					
Mean	8.78	8.67	7.49	8.07	8.32
Median	8.79	8.87	8.27	8.50	8.63
Years to maturity					
Mean	4.11	4.38	2.47	2.79	3.54
Median	4.01	5.00	4.02	3.02	3.03
Total proceeds ($ billions)	5.850	4.725	4.550	2.925	18.050

yields are measured on a 30-day month, 360-day year corporate basis. Yield spreads on MTNs of GMAC, FMCC, and ML average between 75 and 80 basis points, while those of GECC average 36 basis points. These differences in yield spreads are to be expected, given that GECC was rated triple-A throughout the sample period, while the other borrowers had double-A, single-A, or Baa ratings. Yield spreads for all four borrowers vary widely over the sample period. For example, GMAC's spreads range from 11 basis points to 186 basis points. In part, this variation in spreads reflects differences in note maturity, as longer-term securities typically have wider yield spreads. However, holding maturity constant, spreads nevertheless display considerable variation over time, reflecting changes in investors' perceptions of the credit risk of the borrowers.

To analyze price differences between MTNs and corporate bonds, we obtain data on bond offerings by the four issuers from *Corporate Financing Week, Investment Dealers' Digest,* and *Moody's Bond Survey.* In constructing the sample of bonds, we use the same criteria as we use for the sample of MTNs: each bond is a noncallable, U.S. public offering, with a fixed coupon rate and a maturity between one and five years. Between October 1987 and December 1992, the four companies issued 68 bonds that met these criteria. Panel B of Table I shows that the size of the bond issues ranges from $100 million to $1.2 billion and averages $265 million, or 63 times larger than the average MTN issue.

III. Tests for a Size Effect Using Matched Sets

A. Do MTNs with Large Face Amounts Have Lower Yields Than MTNs with Small Face Amounts?

To test for a size effect in the MTN market, we create 605 matched sets of MTNs issues. By construction, the MTNs in a matched set are identical, except for their face amounts and, possibly, their yields. MTNs are assigned to a matched set if they have the same issuance date, maturity date, and corporate issuer. For example, the four MTNs with two-year maturities issued by GMAC on February 2, 1990 are members of one matched set. Most of the matched sets have only a few MTNs. Indeed, 393 of the 605 matched sets contain only two MTNs, and 134 contain only three MTNs.

For each matched set, we calculate the yield difference between the MTN with the largest face value and the MTN with the smallest face value. Under the null hypothesis that there is no correlation between issue size and yields, the yield difference will equal zero. If liquidity increases with issue size, then the yield difference will be significantly negative. Strikingly, the yield difference is exactly equal to zero in 457 of the 605 matched sets (Table II). Thus, large and small MTNs that were issued on the same day, by the same corporation, and with the same maturity usually had equivalent yields. Among the 148 matched sets in which the yield difference does not equal zero, 89 have positive yield differences and 59 have negative yield differences. This finding does not agree with the prediction of the liquidity hypothesis. Moreover, the average yield difference between the largest and smallest MTNs is positive (0.35 basis point).

A *t*-test for statistical significance may be inappropriate, given that the distribution of yield differences is concentrated at zero. Indeed, a Shapiro-Wilk (1965) test rejects the hypothesis of normality at the one percent level of significance. To evaluate the statistical significance of the yield difference, we use the three step bootstrap method outlined in Efron and Tibshirani (1986). First, we create 10,000 bootstrap samples of size 605 by drawing randomly with replacement from the actual sample of yield differences. Second, we calculate the mean yield difference for each of the bootstrap samples. Third, we use the bootstrap sample means to estimate a standard deviation and confidence interval. The standard deviation estimated from the bootstrap samples is 0.24 basis point, suggesting that the yield difference does not differ from zero (p-value = 0.15). Bootstrap standard deviations are also estimated for the four subsamples of individual borrowers. The average yield difference for MTNs of GECC is negative and statistically significant at the five percent level, a finding that supports the liquidity hypothesis, but this result should be interpreted with caution because the sample contains only 15 matched sets of GECC MTNs with non-zero yield differences. Among the other three borrowers, the average yield differences are positive, and for FMCC the difference is statistically significant at the five percent level. Overall, within the MTN market, the evidence from the matched sets tests does not suggest a negative correlation between issue size and yields.

Table II

Matched Sets Tests for a Relationship between MTN Issue Size and Yields

MTNs are assigned to a matched set if they are issued on the same day, have exactly the same maturity date, and are issued by the same corporation. For each matched set, the yield difference is calculated as the difference between the yield on the MTN with the largest face value and the yield on the MTN with the smallest face value. In the analysis, all the matched sets have at least two MTN issues. The sample used to create the matched sets consists of 4,182 MTNs that were issued between October 1987 and December 1992 by General Motors Acceptance Corporation (GMAC), Ford Motor Credit Company (FMCC), General Electric Capital Corporation (GECC), and Merrill Lynch & Co., Inc. (ML). Bootstrap standard deviations and p-values are estimated from 10,000 samples drawn randomly with replacement from the actual sample of matched sets. The tests suggest that yields on large MTNs do not differ significantly from yields on small MTNs.

Yield Difference between Large and Small MTNs (basis points)	Issuer				All Four Issuers
	GMAC	FMCC	GECC	ML	
Mean	0.536	0.304	−2.115	0.565	0.353
Standard deviation	0.510	0.146	1.151	0.422	0.242
Bootstrap standard deviation	0.511	0.148	1.140	0.412	0.241
(p-value*)	(0.285)	(0.036)	(0.041)	(0.181)	(0.151)
Median	0	0	0	0	0
Number of matched sets	253	196	26	130	605
Number of matched sets in which the yield difference is:					
Positive	49	16	6	18	89
Negative	35	7	9	8	59
Zero	169	173	11	104	457
Shapiro-Wilk test for normality	0.764**	0.475**	0.761**	0.493**	0.622**

* Two-tailed significance level of a test that the yield difference equals zero.
** Test for normality is rejected at the 1 percent level of significance.

B. Do Bonds and MTNs Have Different Yield Spreads?

To test whether investors value bonds for their large size, we create matched sets that contain one bond offering and at least one MTN issue with similar term and issuer characteristics. We first tried to create matched sets in which the bonds and MTNs have the same issuance date, maturity date, and issuer. The sample contains no matched sets that fit these criteria, however, mainly because the bond and MTN markets have different maturity conventions. Bonds usually mature on the first or fifteenth day of the month. By contrast, MTNs may mature on any day of the month. As a result, if a corporation issued a two-year bond and a two-year MTN on January 13, 1990, the bond would typically mature on January 15, 1992, and the MTN would likely mature on January 13, 1992. Thus, only rarely will an MTN and a bond have the same issuance date and maturity date. To create matched sets, we select MTNs that are issued on the same day as the bond and mature within ten days of the bond maturity date. However, this selection criteria results in only five matched sets. To increase the number of matched sets, we expand the selection criteria

Table III

Matched Sets Tests for Differences between Bond Yields and MTN Yields

Each matched set contains one bond offering and at least one MTN offering. MTNs and bonds are assigned to a matched set if they are issued by the same corporation, if they are issued within a five day interval around the bond issuance date, and if they mature in a ten day interval around the bond maturity date. For each matched set, the yield difference is calculated as the difference between the bond yield spread and the average yield spread on MTNs in the matched set. The sample used to create the matched sets consists of 4,182 MTNs and 68 bonds that were issued between October 1987 and December 1992 by General Motors Acceptance Corporation (GMAC), Ford Motor Credit Company (FMCC), General Electric Capital Corporation (GECC), and Merrill Lynch & Co., Inc. (ML). Bootstrap standard deviations and p-values are estimated from 10,000 samples drawn randomly with replacement from the actual sample of matched sets. The tests indicate that yield spreads on bonds do not differ significantly from spreads on MTNs.

Difference between bond yield spreads and MTN yield spreads (basis points)	Issuer				All Four Issuers
	GMAC	FMCC	GECC	ML	
Mean	1.060	−2.854	−0.494	0.826	−0.437
Standard deviation	2.336	2.165	4.628	3.319	1.372
Bootstrap standard deviation	2.248	2.106	4.226	3.134	1.359
(p-value*)	(0.659)	(0.179)	(0.465)	(0.844)	(0.755)
Median	0.437	−2.109	2.204	−0.645	−1.442
Number of matched sets	16	15	6	10	47
Number of matched sets in which the yield difference is:					
Positive	8	3	3	5	19
Negative	8	12	3	5	29
Shapiro-Wilk test for normality	0.942	0.932	0.911	0.904	0.965

* Two-tailed significance level of a test that the yield difference equals zero.

to include MTNs that are issued within five days before or after the bond is issued. This increases the number of matched sets to 47.

For each of the 47 matched sets, we calculate the difference between the yield spread on the bond and the average yield spread on the MTNs. If bonds enjoy a liquidity advantage, this difference will be negative. Although the mean difference is −0.44 basis point, the standard deviation of the mean is 1.37 basis points. Thus, the t-statistic of −0.32 indicates that the difference is not significantly different from zero (Table III). A signed-rank test and a test from a bootstrap distribution also suggest that the difference between bond and MTN spreads does not differ from zero (p-values of 0.46 and 0.75, respectively). Moreover, among the four borrowers, none of the mean values differ significantly from zero. To examine the robustness of these findings, we created matched sets in which MTNs were issued in 5, 10, or 15 day windows around the bond *issuance* date, and in which the MTNs matured in 5, 10, or 15 day windows around the bond *maturity* date. For each of these combinations, the test results indicate that yield spreads on bonds do not differ significantly from spreads on MTNs.[5]

In summary, the evidence from the matched sets tests does not suggest that investors value large issues for their greater liquidity. We caution that the failure to reject the null hypothesis that size and yields are unrelated does not necessarily imply that the hypothesis is correct. Indeed, given the non-normality of the yield differences in the sample, it is important to determine whether the tests have the power to reject the hypothesis for economically meaningful differences in yields. To this end, we calculated the difference in spreads that would give rise to a rejection. In the matched pairs test, a rejection would result if the average difference between large and small MTNs was 0.55 basis point. In the matched sets test, a 2.8 basis point difference between MTN and bond yields would produce a rejection. By way of comparison, bid-ask spreads are typically three to ten basis points in the secondary market for investment-grade corporate securities. Thus, the results suggests that the tests have power to distinguish between yield differences that are economically significant.

IV. A Dynamic Model of Yield Spreads

A shortcoming of the matched set methodology is that it does not analyze all the security offerings in the sample. For example, only 47 of the 68 bonds were analyzed in the matched sets tests for differences between bond and MTN yields. To make use of all the information in the sample, we estimate a model that relates the yield spread on a new security offering to its cross-sectional determinants, such as issuer, maturity and face value. In the model, the parameter estimates for the cross-sectional determinants evolve each period (daily) according to a random walk. In the state space form, the model is:

$$y_{j,t} = X_{j,t}'\boldsymbol{\beta}_t + \boldsymbol{\nu}_{j,t}, \quad \boldsymbol{\nu}_{j,t} \sim N(0,\, \boldsymbol{\omega}), \qquad j = 1 \text{ to } J_t; \quad t = 1 \text{ to } T \tag{1.a}$$

$$\boldsymbol{\beta}_{\mathbf{t}} = \boldsymbol{\beta}_{\mathbf{t-1}} + \boldsymbol{\eta}_{\mathbf{t}}, \quad \boldsymbol{\eta}_{\mathbf{t}} \sim \mathbf{N}(\mathbf{0},\, \boldsymbol{\Omega}) \tag{1.b}$$

[5] One institutional difference between MTNs and bonds is that MTNs are usually sold at par, while bonds are often sold at discounts to par. This difference may introduce a bias in our tests because, when the spot yield curve is positively sloped, a bond selling at a deep discount should have a higher yield-to-maturity (YTM) than a par bond with the same maturity. Consequently, our tests are biased against finding a size effect between bonds and MTNs. However, for our purposes, the YTM bias is not large enough to affect our inferences because the bonds were not sold at deep discounts. Among the 68 bonds in the sample, the average price was 99.87 percent of par, and the largest discount was 99.54 percent of par. Moreover, the difference between the bonds' yields and their coupons averaged just four basis points, and the maximum difference was 15 basis points. To evaluate the significance of the bond discount, we calculated the YTM bias under an extreme case in which the spot yield curve had a 600 basis point slope from one to five years. The YTM bias is 0.16 basis point for a discount bond with a five-year maturity and a four basis point difference between its yield and coupon. The bias is 0.61 basis point for a bond with a 15 basis point difference between its yield and coupon. Thus, the YTM bias is economically small, and it is small compared to the 1.4 basis point standard deviation of the mean difference between bond and MTN yields.

where $y_{j,t}$ is the yield spread on security j offered on day t, $X_{j,t}$ is a k × 1 vector of characteristics for security j on day t, and β_t is a k × 1 coefficient vector that defines the state. In the transition equation (1.b), Ω is a k × k covariance matrix of the innovations in the state parameter estimates.[6] In the observation equation (1.a), ω is a 1 × 1 scalar that measures the variation in a yield spread that is not explained by the model's cross-sectional variables.

The key difference between the model specified by equations (1.a,b) and models used in previous research on corporate bonds is that the former is dynamic. Our model may be best thought of as a linear regression model in which the coefficients are indexed by time. That is, we allow the parameters on the cross-sectional determinants of yield spreads to vary over time. In contrast, previous research has estimated a static regression model, in which yield spreads on a sample of new issues are regressed on cross-sectional variables.[7] In addition to differing from the standard regression model, the model (1.a,b) also differs from standard time-varying parameters models in that it can be applied to unbalanced time-series data. In most applications of time-varying parameters models, the number of observations does not change from period to period; i.e., the data are balanced. In our applications, the number of debt offerings is not the same in each period; rather, on each day, a borrower may issue several new securities or none at all. As a result, equation (1.a) has two subscripts, t and j, the former indicating the day of the offering, and the latter denoting the issues that come to market on that day. On a particular day, t, the number of observations is given by J_t. In a sample of unbalanced data, J_t will vary from period to period. The total number of observations in the model is thus $n = \sum_t J_t$.

To obtain maximum likelihood estimators of ω and Ω, we use the predication error decomposition, described in Harvey (1989) and Crabbe and Turner (1993).[8] Given (1.a,b) and the estimators of ω and Ω, the Kalman filter may be

[6] Most applications of the time-varying parameters model have imposed a diagonal restriction on Ω. In our applications, we do not impose any restrictions. Intuitively, it is desirable to allow for contemporaneous correlation in the innovation variances. For example, innovations in GMAC's yields will likely be correlated with innovations in FMCC's yields.

[7] For examples of the static model of corporate bond pricing, see Fisher (1959), Allen, Lamy, and Thompson (1987), and Crabbe (1991). The static model represents a restricted, special case of our generalized modeling method because it treats the parameters as fixed over the estimation period (i.e., $\Omega = 0$). There is considerable empirical evidence that yield spreads vary over time, suggesting that the static regression model is misspecified. For example, Bernanke (1991) and Stock and Watson (1989) find that yield spreads on corporate securities vary over the business cycle. In addition, a corporation's new issue spreads will change as investors reassess the issuer's credit quality. In a study that compares the performance of the dynamic model and the static regression model, Crabbe and Turner (1993) show that the dynamic model explains about 85 percent of the variation in yield spreads, compared with only 35 percent for the static model. Most importantly, because the static model assumes that yield spreads are constant over time, it may lead to mistakes in inference.

[8] Evaluation of the likelihood requires specification of the initial state vector, β_0, and its variance. In our estimation, we use a backcasting algorithm to obtain these estimates. As a result, our estimator is an approximation of the exact maximum likelihood estimator, which could be obtained from specifying a diffuse prior for β_0. In large samples, such as ours, the approximation will be very close to the exact estimator.

used to compute optimal estimators for the state vector, β_t. We employ the fixed-point smoothing variant of the augmented Kalman filter, discussed in Anderson and Moore (1979) and Harvey (1989), to obtain optimal estimates of the state vector conditional on *all* information, past and future:

$$\hat{\beta}_t = E[\beta_t | X_0, \cdots, X_T, y_0, \cdots y_T, \omega, \Omega]. \tag{2}$$

These estimates are our primary tool in examining the relation between issue size and yields.

V. Estimation Results

To examine whether issue size effects debt yields, we estimate the following model for a sample that pooled the 68 bonds and the 4,182 MTNs of all four borrowers:

$$\log(spread_{j,t}) = GMAC_{j,t}\beta_{1,t} + FMCC_{j,t}\beta_{2,t} + GECC_{j,t}\beta_{3,t} + ML_{j,t}\beta_{4,t} + maturity_{j,t}\beta_{5,t} + face_{j,t}\beta_{6,t} + \nu_{j,t} \tag{3.a}$$

$$\beta_t = \beta_{t-1} + \eta_t, \tag{3.b}$$

where β_t is the vector of parameters $\beta_{1,t}$ through $\beta_{6,t}$. $GMAC_{j,t}$ takes on a value of one if MTN j sold on day t is issued by GMAC and zero otherwise, and the variables $FMCC_{j,t}$, $GECC_{j,t}$, and $ML_{j,t}$ are likewise defined as zero-one indicator variables. We include these variables to capture information that is specific to the borrower. The variable $maturity_{j,t}$, the years to maturity of the MTN, is included to model the term structure of credit risk. $Face_{j,t}$, the face value of the offering in millions of dollars, is included to measure the liquidity premium of large issues. $Spread_{j,t}$ is the yield spread in basis points on MTN j issued on day t. By specifying the dependent variable as the log of the spread, we ensure that expected values for the level of the spread will be non-negative. This is a desirable property of a pricing model because it guarantees that risky fixed-income securities will have higher expected yields than Treasury securities with comparable terms and features. The dynamic model has an R^2 statistic of 0.94, indicating that it explains a large part of the variation in yield spreads.[9]

Figure 1 displays the dynamic model's estimates of $\beta_{6,t}$, the state vector of coefficients for the variable *face*. If investors value large issues for their greater liquidity, then the estimates for $\beta_{6,t}$ will be negative. The estimates are negative for some of the sample period, but the point-by-point 95 percent

[9] Alternative models indicate that a large proportion of the variability in yield spreads arises because spreads vary over time. Using the same sample of 4,182 MTNs and 68 bonds, we estimated a static regression model that included *maturity*, *face*, and borrower indicator variables as explanatory variables but does not allow the parameter estimates for these variables to vary over time (i.e., $\mathbf{\Omega} = \mathbf{0}$). The static model has an R^2 of 0.34, compared with 0.94 for the dynamic model. Other diagnostic statistics, such as the log likelihood and the root mean square error, also indicate that the dynamic model completely dominates the static model.

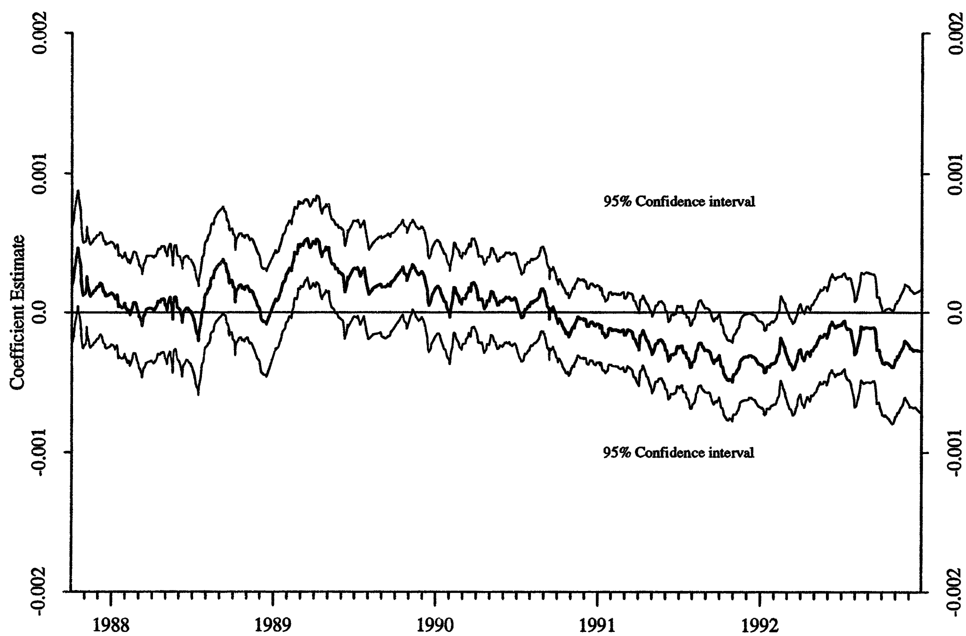

Figure 1. Parameter estimate and confidence interval for the face value variable from a model that pools MTNs and bonds of all four issuers. The estimates are derived from a dynamic linear model of yield spreads on 4,182 MTNs and 68 bonds that were offered between October 1987 and December 1992 by General Motors Acceptance Corporation (GMAC), Ford Motor Credit Company (FMCC), General Electric Capital Corporation (GECC), and Merrill Lynch & Co., Inc. (ML). In the model, the dependent variable is the log of the yield spread and the explanatory variables are the maturity of the offering in years, the face value of the offering in millions of dollars, and four indicator variables for the issuer of the security. The parameter values for the explanatory variables evolve over time according to a random walk. The figure indicates that the parameter estimates for the face value variable generally do not differ significantly from zero, suggesting that large and small issues have similar yields.

confidence interval indicates that the estimates generally do not differ significantly from zero. These estimation results are at variance with the liquidity hypothesis. To evaluate the economic significance of the results, we use the parameter estimates from the model (3.a,b) to determine the yield difference between large and small issues. Specifically, we calculate the estimated spread between \$100 million issues and \$1 million issues for each day that a borrower sold a bond or an MTN. The estimated difference between yields on large issues and yields on small issues averages −0.44 basis point for GMAC, −0.59 basis point for FMCC, −0.35 basis point for GECC, and 0.54 basis point for ML. For each of the four borrowers, the estimates of the median difference between \$100 million and \$1 million issues also are within one basis point of zero.

The estimates from the dynamic model indicate that the yield difference between large and small issues is statistically insignificant and economically small. Moreover, the results from the dynamic model agree with the inferences from the matched sets tests in Section III. In alternative specifications of the dynamic model, we also included a zero-one indicator variable for bond offerings, and we used log and quadratic specifications for the variable *face*. These alternative specifications do not give rise to different inferences about the relation between issue size and yields. In summary, the findings do not suggest that large issues enjoy a liquidity advantage; rather, they suggest that large and small issues with similar characteristics have similar yields.

VI. Concluding Remarks

This study has examined the effect of issue size on debt yields of four large borrowers: General Motors Acceptance Corporation, Ford Motor Credit Company, General Electric Capital Corporation, and Merrill Lynch & Co., Inc. We tested for yield differences between 4,182 MTNs and 68 bonds that the four borrowers issued in the U.S. market between October 1987 and December 1992. Although the bonds had an average issue size of $265 million, more than 60 times as large as that of MTNs, the yield difference between bonds and MTNs is not significant. Moreover, we found no relation between the face amount of an issue and its yield. It is important to caution that these results may not generalize to other borrowers and to other markets. Still, for the borrowers that we analyzed, these results indicate that large and small issues are close substitutes and that MTNs and bonds are also close substitutes.

Our findings shed light on how liquidity affects debt yields. In the corporate debt market, the liquidity of a security reflects both the characteristics of the borrower and the features of the security. All the securities of a particular borrower may be relatively illiquid if investors find it costly to analyze the borrower's credit quality. However, securities of a particular borrower may have differing degrees of liquidity: complicated or nonstandard securities may be highly illiquid, even if other securities of the same borrower are relatively liquid. To test the hypothesis that liquidity increases with issue size, we examined securities that had identical borrower characteristics but different issue sizes. Our results suggest that liquidity is not a function of issue size. However, the results do not necessary suggest that liquidity, itself, is not positively priced, because factors other than issue size may determine the liquidity of a security.

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