The impact of market liquidity in times of stress on corporate bond issuance

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Abstract

This paper investigates the impact of liquidity shocks on the composition of firms that enter the corporate bond market. When liquidity is at a premium, larger bonds by better known firms are much more prominent, which squeezes smaller issuers and the high-yield market, in particular. This paper shows that bond size is a liquidity factor, at least for some corporate debt, and that both pricing and issuance are impacted by market liquidity.

1. Introduction and motivation

In the wake of the Russian default and the Long-Term Capital Management crisis in 1998, the corporate bond market was plagued by a lack of liquidity. Trading dried up, price quotes were reportedly difficult to come by, and positions could not be liquidated either to stem losses or to meet cash demands (see, for instance, BIS (1999) or Wall Street Journal (1998a,b)). This liquidity shock had a significant and persistent impact on the corporate bond market and on the ability of firms to raise funds in that market.

Faced with an illiquid market in the autumn of 1998, bond issuance fell dramatically from a May peak of over 150 bonds per month to less than 40 per month in September and October (Exhibit 1). While issuance bounced back following the Federal Reserve's emergency October rate cut and the subsequent narrowing of spreads, the downward trend in bond issuance that was begun in September did not reverse direction until early 2001 when interest rates plummeted following aggressive easing by the Federal Reserve.

The picture in Exhibit 1 is, of course, only suggestive. Rising interest rates and heightened risk concerns also helped damp issuance following the 1998 liquidity crisis, confounding the identification of any effect from illiquidity. Furthermore, while there would seem to be little room for argument about the presence of a break in the series in autumn 1998, one might examine the issuance rebound in early 1999, or even late 1998, and argue that there was no lingering impact. To this extent the relatively quick rebound in issuance potentially hides lingering effects in the *composition* of issuers, rather than in the number of issuers or amount of issuance.

This paper, in part, documents the impact of liquidity shocks on the composition of firms that enter the corporate bond market. One difference is evident from Exhibit 1, which is that the share of investment grade issuance rose relative to high-yield ("junk") issuance. Throughout 1997 and 1998 the share of junk issuance climbed, and after August 1998 the share fell significantly (and the gap between the moving average of total issues and high-yield issues widened). While credit concerns certainly played a roll in the decline of high-yield issuance, I am going to argue that the bigger compositional effect was via the market's emphasis on issue liquidity - in particular on issue "size" and "familiarity". When liquidity is at a premium, larger bonds are much more prominent.

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Exhibit 2 suggests a spike in the relative issuance of larger bonds after the LTCM crisis, and that there was some persistence in this change in composition. I will show that this shift was driven, at least in part, by a demand for liquidity by investors and underwriters and distinguish it from various alternatives that could also account for the change. Of course, since large bonds are more likely to be issued by larger companies, it could well be that issuer characteristics rather than issue characteristics prompted the shift to larger bonds. This explanation is not really independent of my liquidity hypothesis, since the liquidity of an issue may be influenced by multiple factors, including issuer characteristics. For instance, the size and "familiarity" of the issuer may matter for liquidity because investors have done more research on these companies and there is potentially less private information.

While it is difficult to measure "familiarity", one proxy in the context of the debt markets is the amount of debt that the firm has issued. Not only is past issuance evidence of past (and ongoing) investor scrutiny, but it may also suggest some substitutability between bonds of the same issuer which could generate liquidity. Exhibit 3 is suggestive of some impact from the LTCM crisis onto the debt outstanding of bond issuers at the end of 1998.

The paper proceeds by reviewing the literature establishing that bond size could be a factor in the amount of trading activity, and therefore liquidity. Then, using multivariate regressions to control for observable issue and issuer characteristics, I establish that issue size, and certain measures of familiarity, are priced liquidity factors. In particular, the price depends crucially on whether the economy is experiencing an illiquidity shock. Moreover, the estimated effect is likely to understate the true effect as the sample of bonds issued tends significantly towards bigger bonds in times of illiquidity.

This new evidence that bond size is a liquidity factor contributes to our understanding of liquidity in the corporate debt markets. First, it helps establish that both issuer *and* issue characteristics matter for an asset's liquidity. The fact that first issues, issues by private firms and issues into the 144a (private) market are all more expensive suggests that information problems are priced at issuance. Likewise, the fact that multiple issues and large issues are discounted suggests that the prospects of wider ownership translate into more trading and more liquidity for the securities. Both of these are consistent with theories of liquidity. Second, it seems clear that the effects of liquidity, or illiquidity, go beyond market pricing and extend to the composition of who is in the market. From the perspective of market watchers, this is a hidden cost of heightened illiquidity.

The paper continues in Section 2 with a discussion of the previous theoretical and empirical literature on the sources of liquidity as well as some extensions to thinking about the corporate bond market. Sections 3 and 4 present the empirical tests of size and other liquidity factors. Section 5 then concludes.

2. Previous literature and the plausibility of issue characteristics as liquidity factors

2.1 Previous theory

The market microstructure theory from equity markets provides a basis for hypothesising that size matters. In general the bid-ask spread, which proxies for liquidity, has been modelled as dependent on three factors: order processing costs, inventory costs and adverse-selection costs (see, for instance, O'Hara (1995)). Empirical work on the contribution of these three factors to the bid-ask spread vary tremendously (see, for instance, Stoll (1989), George et al (1991) and Huang and Stoll (1997)), although both the theoretical and empirical literature has come to emphasise the roll of information problems (adverse-selection costs). But the relevant point here is that the same factors can be thought of as operating in the debt markets. While it is not necessary, it can clearly be argued that issue size could impact relative costs across any of those three dimensions.

The basic idea motivating size as a liquidity factor is that large issues will trade more frequently. Information costs may also be reduced, not only by more trading activity, but because investors will be more knowledgeable about a larger issue because it is more widely held and analysed - it is more transparent (these are the same motivations offered in Crabbe and Turner (1995)). Trying to distinguish between what is issue-specific and issuer-specific liquidity is one of the goals of the paper.

2.2 Intuition for liquidity in the corporate bond market and the LTCM effect

In the Appendix I propose a stylised model of trading in the corporate bond market to help think about the rise of liquidity problems and its effect on the market. In the model illiquidity is the result of an information problem about the correct market prices, which generates a lemons problem in the sense of Akerloff (1970). The lemons problem, in this case, is mitigated by "informed" traders because they compete with each other for trades (rather than with the market-maker, as in the equity microstructure literature (see O'Hara (1995)), which instead generates the lemons problem when there are too many, not too few, informed traders). Thus, the extent of liquidity is determined by the availability of "informed" traders in what amounts to a search framework. *Liquidity is therefore linked to size* because larger bonds will be more widely held and disseminated, leading to more informed traders, and more liquidity, in bigger bonds.

Informed traders may also be determined by their "familiarity" with the bond being traded, or with close substitutes - close substitutes may be other bonds issued by the same issuer. Both paths lead to more informed traders, and more liquidity, for larger bonds. This secondary market phenomenon can translate into reduced issuance during illiquid times because firms (issuers) may not want to pay a large liquidity penalty. Underwriters are also less likely to bring small deals due to the same lemons problem. Underwriters must take the bonds into inventory and then sell them to investors, and during illiquid times they are less likely to do that. They must also be willing to act as dealers and make a market in the bond to help ensure liquidity.

Underwriters (dealers) do not like to hold unhedged inventory (particularly over quarter-end, and especially over year-end) because inventory is risky and firm capital must be set aside to account for that. But if the inventory can be easily hedged, dealers' positions are protected. When dealer willingness to take positions is reduced and/or the cost of hedging climbs, then dealers will not provide liquidity - they will simply be another informed investor. This distinguishes dealers from market-makers, of course, since they are not required to take the other side of trades.

In 1998, dealers suffered a shock across three related dimensions. Bond trading positions suffered losses, and dealer hedges blew up. This gave dealers losses on their positions and on their hedges while also dramatically increasing the cost of hedging. Trading losses led Wall Street firms to cut all positions, including dealer positions that were not necessarily related. At the same time the dealers' own losses gave them an incentive to reduce inventory exposure.

In 1998, the typical way for corporate bond dealers to hedge inventory was with a short position in the 10-year Treasury security. When that hedge proved ineffective - corporate prices fell while a flight to quality drove up Treasury prices - the cost of hedging climbed. Hedges that protected against spread risk were required, and since corporate bond futures and options are non-existent the swap market was the only alternative.[2] Swap spreads skyrocketed and thus so did the cost of hedging. Dealer inventories were slashed and new bond issuance was curtailed.

The importance of inventory for liquidity is an old idea. Demsetz (1968) views inventory costs, and thus the bid-ask spread, as dependent upon "waiting costs" which depend on the frequency of transactions. Thus bonds that trade more often have lower costs and spreads - they are more liquid. Demsetz (1968) shows that the specialist ends up taking more positions in slow-trading stocks - consistent with the specialist taking on more inventory and hence setting higher spreads. Dealers' sensitivity to inventory is also pursued by Ho and Stall (1981), who show that if dealers accumulate too much inventory they will lower their offer price and increase the bid-ask spread to accumulate trades on the other side. The assumption that dealers will want to reduce exposure to inventory is similar to theirs derived from a maximisation problem. That is, one could imagine dealers (and other informed investors) incrementally widening spreads as too many sell orders arrive. Spulber's (1996) search model for bid-ask spreads is similar.[3] He has no "explicit costs of search", rather the search time is the transactions cost, but it yields each "dealer" some local monopoly power. Grossman and Miller's (1988) analysis also focuses on liquidity as the "price of immediacy". Routledge and Zin (2001) instead emphasise the role of the hedge available to the market-maker.

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2 Hedging strategies related to short positions in the asset would require selling the asset and thus put the dealer in the same position as everyone else.

3 Hall and Rust (2001) extend Spulber (1996) to show how dealers and market-makers can coexist.

2.3 Previous empirical evidence

Surprisingly limited previous empirical examination exists on liquidity in debt markets, although the LTCM collapse and declining supply of Treasury debt has sparked recent interest (see, for instance, Fleming (2001)). Studies of the corporate debt market have been even rarer, presumably because of the lack of trading-level data.

Much more analysis has occurred on equity markets, where the availability of "tick" data and market quotes exists. The equity literature speaks a bit to the question of the relation between liquidity and issue size. In the equity market literature it is well established that small stocks are more subject to non-trading effects (Lo and MacKinlay (1990)) and to larger relative bid-ask spreads (see, for instance, Campbell et al (1997), Section 3.2). Less liquid stocks have also been shown to be more sensitive to trade size (Hausman et al (1992)).

The same has been assumed to be true for bond markets. For instance, Fenn (2000, p 397), in discussing a regression with spreads as the dependent variable, asserts that the "expected sign on issue size is negative, as larger issues are thought to be somewhat more liquid". Fenn (2000) indeed, in an analysis of 144a issues, finds significant results consistent with this expectation. Blackwell and Kidwell (1988), however, in a comparison of public and private bonds, find no significant link between issue size and yield. Crabbe and Turner (1995), in a narrower investigation of the MTN market, also find no significant link between issue size and yield.

Research on Treasury market liquidity has been more extensive than for the corporate market, but still limited relative to equities. Analysis of the Treasury market has focused on *measures* of liquidity, such as trading volume, trading frequency, trade and quote size, bid-ask spreads and the on-the-run/off-the-run spread, and the effect of liquidity on prices (see, for instance, Fleming (2001)). Little work has focused on the factors causing liquidity in the bond market, except for going off-the-run. In one exception, Sarig and Warga (1989) show that the age of the bond is a liquidity factor. The link between age and liquidity is assumed to be that bonds eventually end up in buy-and-hold portfolios and so cease to trade. If true, this also supports the contention that size is a liquidity factor, since the amount outstanding to be traded should be proportional to size.

3. Existence of a large bond liquidity premium

If large bonds are indeed more liquid then this liquidity should be priced by the market. One standard, and relatively clean, way to test this is to put bond spreads at issuance as the dependent variable of a regression and determine if the liquidity factor affects bond spreads in the predicted direction (as in Fenn (2000) and Blackwell and Kidwell (1988)). That too is the approach taken in this paper. Spreads at issuance are, in fact, preferable since they are typically quite accurately observed.

To test the hypothesis that issue size is a liquidity factor I use data on all US non-financial straight bond issuance from 1994 to 2001. The spread is calculated as the issue's yield to maturity over that of the nearest on-the-run Treasury. The data source is SDC's New Issues database. Restricting the sample to straight debt simplifies the comparisons, since yields on convertibles are misleading without accounting for the equity piece. Pass-throughs, floaters, medium-term note programmes, asset-backed, lease- or mortgage-related, equipment trusts, and bonds with guarantees are all eliminated. That leaves 2,639 bond issues in the full sample.

The key to specifying this test is to control for the macroeconomic, issue and issuer characteristics that will also move the spread. Within this framework we can also control for alternative hypotheses regarding what drives liquidity or for why size might matter for non-liquidity reasons. For instance, a prominent alternative explanation for why size might matter for spreads is that it is a default risk factor. Therefore the independent variables include: (1) variables for testing the size-liquidity hypothesis, (2) variables measuring issue characteristics, (3) variables measuring market conditions, and (4) variables measuring issuer characteristics. The main variable used to test the size-liquidity hypothesis is the issue size. I also use the time since previous issue or a dummy variable for previous issuance within the year. Other liquidity measures include a dummy variable for multiple issues on the same day and a dummy variable for first bond issue in sample. The first issue dummy uses issuance back to 1993, but earlier issuance is excluded, so if a firm issued a bond in 1992 and 1994 the 1994 issue would be counted as a "first issue" in my analysis. I also use the total debt outstanding from Compustat as a potential measure of liquidity via "familiarity".

The macroeconomic controls include the 10-year constant maturity Treasury yield, the yield curve premium defined as 30-year minus five-year Treasury, the on-the-run premium between the on-the-run Treasury and the fitted synthetic off-the-run yield curve, the spread between BBB-rated and AAA-rated bonds, and the spread between AAA-rated bonds and Treasuries. The last two are important because I give them additional interpretation. The BBB-AAA spread I consider to be the credit spread, since it reflects the reward for the risk differential between those two classes. The AAA-T spread I consider to be the liquidity spread, since short-maturity AAA bonds have essentially zero credit risk. The liquidity spread will be dependent on flight-to-quality and other moves that push investors into Treasuries. While these two spreads are positively correlated, that correlation is only .34, suggesting that they are indeed independent sources of information.

Issue characteristics include the rating notch, coded on a continuum from AAA=1 to CCC=20, so that a higher grade means greater risk (Fenn (2000) shows that a single rating variable fits the data as well as individual dummy variables), the issue maturity, whether the issue had a put or call option, whether the issue was subordinated, and whether it was issued in the 144A market. Issuer characteristics include industry dummy variables and whether the issuer was a private firm. The data are then merged with Compustat to add other issuer characteristics such as firm leverage and coverage, in a more constrained sample.

3.2 Empirical results

Exhibit 4 reports results for the basic spread regression outlined above. Column 1 presents the baseline model. The coefficients on the macroeconomic variables are all significant in the expected direction. Increases in the on-the-run premium increase the spread, presumably due to a decline in market liquidity. A 1 basis point increase in the premium is estimated to raise issuance spreads by 1.3 basis points. Increases in the 10-year Treasury yield also increase the spread, perhaps due to their directional link with overall economy via monetary policy. A 100 basis point increase in the 10-year Treasury is estimated to raise issuance spreads by nearly 14 basis points. The slope of the yield curve, which is well known to flatten before recession and steepen before recovery, affects spreads inversely - a 10 basis point increase in the term structure reduces spreads by 4 basis points. Both the credit spread and liquidity spread push up issuance spreads. A 10 basis point move in the credit spread boosts spreads by 11 basis points, a nearly one-for-one effect, while a 10 basis point move in the liquidity spread boosts issuance spreads by nearly 5 basis points.

Skipping over (for now) the variables for the size-liquidity hypothesis, the other issue and issuer variables are all significant in the expected direction. The coefficient on rating indicates that, conditional on everything else, a one-notch downgrade adds 22 basis points to the spread. The estimated coefficient on maturity indicates that every additional year of length costs .8 of a basis point. Including an embedded put option, which is protection for the bondholder, reduces the spread by 44 basis points, while having an embedded call option, a cost to the bondholder, only increases the spread by 7 basis points and, as seen in later regressions, is one of the few non-robust estimates. The value of the call option appears to be captured by the interest rate and other issuer characteristic variables.[4] A bond issued by a private firm is estimated to pay nearly 62 basis points extra, a subordinated issue to pay an extra 86 basis points, and a 144A issue to pay an extra 65 basis points. The private-firm and 144A market effects may both reflect a penalty paid by firms which may not have to provide as much disclosure, or relatedly, a liquidity penalty by less well known firms. The industry dummies are not broken out for presentation, but they are jointly significant.

3.3 Tests of liquidity and size

The overall fit of the basic regression seems good, suggesting that it is a reasonable model for testing what premium investors attach to issue size, as well as to other liquidity indicators. All of the included liquidity variables are highly significant in column 1. First issues pay a 14 basis point penalty, while multiple issues get a 14 basis point reward. The size of the bond issue has a significant coefficient of

[4] Call options appear in almost 30% of the bonds. It may be that different types of calls receive different valuation, but, in general, they receive little apparent value.

-0.034, so that the estimated effect of increasing a bond offer by $100 million is to reduce spreads by 3.4 basis points. One standard deviation for issue size in the cross section is about $277 million, yielding an estimated spread change of nearly 10 basis points.

Adding the time, in years, since the issuer's previous issue, shown in column 2, barely changes the results. The coefficient is marginally significant and each additional year since issuance is estimated to add 2.5 basis points to the spread. Including that variable adds a small boost to the size coefficient, and lowers the coefficient and significance of both the call option dummy and the on-the-run premium variable. Adding, instead, a dummy variable for whether the issuer issued a bond previously within the last year, shown in column 3, changes the estimates even less (from column 1). The coefficient on the recent issuance dummy is also marginally significant, implying that a recent bond issue reduces spreads by 7.5 basis points.

Finally, in columns 4 and 5, the Compustat data are added. Both leverage (debt-to-assets) and coverage (interest expense-to-operating income) ratios are significant in the expected direction. Firms with weaker balance sheets and weaker cash flow must pay higher spreads. Total debt outstanding, however, is not significant. This casts doubt on the robustness of the "familiarity" argument, at least as proxied for by that variable. For instance, it is insignificant even when the time-since-last-issue variable is excluded (column 4).

Moreover, the estimated size effect is also weakened. In the reduced sample with the presence of the leverage and coverage variables the estimated effects for a number of the other coefficients are altered and standard errors are larger due to the smaller sample size. For instance, the on-the-run premium and Treasury yield effects are eliminated, the liquidity spread effect is weakened, and the 144a effect is weakened.

Hence, the general conclusion from Exhibit 4 must be that liquidity factors are important for bond pricing, and that issue size appears to be rewarded with lower spreads, but the result is not completely robust. However, in ongoing research (Harrison (2002)) I show that these results change when one includes an interaction between issue size and the liquidity spread to test the hypothesis that the pricing of liquidity during illiquid times is the most sensitive. The effect of size on spreads is completely altered by adding this interaction term. It now appears that the effect of size by itself actually has a positive impact on spreads - that is, pays a liquidity penalty. This is plausible since larger issues must find more buyers for them. One way to attract more investors and to keep the deal from languishing in the underwriter's inventory is to raise the spread.

However, the liquidity premium on size is dependent upon the amount of liquidity in the market, as measured by the liquidity spread. Harrison (2002) shows that the more illiquid the period, the greater the premium on large bonds. The estimated coefficient is robustly significant, suggesting that bond size matters more during illiquid time periods.

4. Bond issue size and liquidity

As discussed in the introduction, since issue size is not exogenous it is very likely that the selection of bonds issued during illiquid periods is biased toward large bonds. This question is pursued in Exhibit 5, which puts the size of bond issuance as the dependent variable and then determines how the macroeconomic liquidity influences (or "determines") the bond size. The results are striking. In particular, the divergence between the investment grade and high-yield results is suggestive. The size of high-yield issues appears to be extremely sensitive to the state of illiquidity. A change in the liquidity spread from 0.74 to 1.34, such as after the LTCM blow-up, is estimated to increase the average bond size by $200-300 million, a more than doubling of the average size. For investment grade firms, the estimated effect is either insignificant or even in the opposite direction.

Notice, however, that the investment grade results on bond size are very sensitive to the credit spread measure, while the high-yield bond size is not at all. This is true even if the high-yield spread is used as the measure of credit risk. This suggests a link between bond size and credit quality for investment grade firms and between bond size and liquidity for high-yield firms. The credit risk channel for investment grade firms may reflect a disclosure-related mechanism that is actually due to the size of the issuer, rather than the issue. The liquidity risk channel for high-yield firms appears to be something specific about the *bond* size. In the Compustat sample the amount of long-term debt that the firm has outstanding is the only significant indicator for bond issue size, which may be a liquidity factor or simply something else related to firm size.

Other liquidity measures besides size are also potentially influenced by the state of illiquidity. Importantly, rating grade is not, suggesting that the changing quality of the sample is not driving the findings related to issuer size. Rating grade matters in every regression, but it does not appear to be systematically moving with illiquidity. This is consistent with recent anecdotal history. For example, in the aftermath of the LTCM liquidity crisis, the first issuers back in the high-yield market were the speculative telecoms firms. The market's appetite for high-risk and low-rated telecoms debt would not sate until the sector's overcapacity became apparent in 2000.

5 Discussion

Recent experience shows that a severe liquidity shock (1998) is in some ways as bad for the corporate bond market as a severe credit quality shock (2000-01). In both cases credit spreads widen, even though in the case of the credit quality shock spreads widen more. But issuance was more strongly curtailed in the case of the liquidity shock (1998). This shuts some firms out of the public debt market, and thus makes it more difficult for them to obtain financing. However, the reality is that most firms do not need to come to the bond market very often, and thus a temporary closing of that financing venue (even for a period of three months) does not pose serious consequences to the underlying economy.[5]

Rather, this finding simply emphasises that the effect of liquidity on the corporate bond market goes well beyond the secondary market by also affecting the primary market. The impact of illiquidity on investors, and on trading activity, may well be more troublesome than the impact on issuance. Nonetheless, problems in the primary market reflect the problems in the secondary market. Central bankers interested in monitoring liquidity can therefore also look to the primary market. Of course, liquidity problems in US fixed income markets were mitigated by emergency Federal Reserve rate cuts in both October 1998 and January 2001.

Examining the primary market provides additional insights into what issue and issuer characteristics may be fundamental liquidity factors. This study, in particular, focuses on the roll of issue size and its sensitivity to illiquidity. By looking for liquidity factors in market prices, I am assuming that the market recognises and prices liquidity. Identifying fundamentals therefore only helps in our understanding of how liquidity works and what attributes are valued by the market. This could be helpful in building "liquidity" portfolios and identifying liquidity returns. Merrill Lynch, for instance, tracks a corporate bond index of the 175 most active high-yield bonds, as well as both "large cap" and "small cap" high-yield indices. Such evidence is also useful for theoretical considerations of the sources of market liquidity.

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5 For instance, I find that only between 5 and 10% of high-yield firms issue bonds in a given quarter, and only around 10% will issue additional bonds within a year.

Appendix
Stylised model of liquidity in the corporate bond market

Model set-up

The true market value of a bond is uncertain. It is distributed uniformly on an interval +/- Φ around P*, with E(P) = P*. Investors go to the market to buy or sell and must search for a partner to trade with. The search is random but costly. The partner can be either informed or uninformed. Informed traders exist in the population in the proportion $\forall$, to be described later. Uninformed traders are (1-$\forall$) likely. Assume that the seller is informed. Informed traders know the correct price, P^I, a draw from the interval around P*.

Consider a seller who solicits an offer from an uninformed trader. Ignore the search costs for now. What offer does the uninformed trader make? The expected price is P*, but to offer P* is not optimal since it invites trades from an informed seller only when $P^I < P^*$. To avoid this adverse selection the uninformed traders must offer $P^{LO} = P^* - \Phi$. This is the lemons problem in the corporate bond market. If there are only uninformed traders (except the seller) then no trading occurs, unless the seller must sell for other reasons - in which case P^{LO} prevails.

Now consider a seller soliciting an offer from an informed trader, again ignoring the search costs. The informed trader offers P^I, since to offer anything lower than that is to lose the difference to the next informed trader that the seller can find. The informed partner only has monopoly power up to the cost of searching for the next informed trader, and thus this is the extent of the price concession that they can extract from an informed seller. (For the sake of bargaining, imagine that it is costless to refresh a previous offer.)

Assume that the cost of searching is $\exists$, for now take it as a fixed cost, but it can also be a variable cost, which may be important for sellers needing to sell off a particularly large position. Since it costs $\exists$ to replace a partner, each offered uninformed price will actually be P^{LO}-$\exists$; due to the search costs even the uninformed trader can extract rents. For the offered informed price it still costs $\exists$ to find a new price, but the informed partner is more difficult to replace since they are rare, and the offered price will be P^I-$\exists/\forall$. This follows from the decision rule of the seller: search again as long as the expected benefit from searching exceeds the cost. Which gives the strategic partner the optimal policy of setting the price right at this cutoff point.[6] The haircut is intuitive: if there is a 50% chance of finding an informed partner then the price concession can be twice as big.

The analysis of the decision rule is identical if the offer is made by an uninformed partner. The uninformed partner will not set the haircut so as to deter the seller from searching for an informed trader because they do not know P^I (and the optimal informed offer price). To attempt this would lead them to increase their price, which they will not do, since it would result in them being the victim of adverse selection. But they are strategic in discounting the price by $\exists$.

This generates the expected price to the seller of: $(1-\forall)*(P^{LO}-\exists) + (\forall)*(P^I-\exists/\forall)$. We can see that having informed investors mitigates the lemons problem, up to a point. The smaller $\forall$, the larger $\exists$, and the smaller P^I, the more likely that the benefit from finding an informed trader does not meet the cost and both types of partners (informed and uninformed) will offer the same P^{LO}-$\exists$ price.

The preceding assumes that the seller is small relative to the market. Now allow the seller's impact relative to the market to vary. We do this by assuming that 8 is the probability of receiving a sell shock. The amount of selling therefore becomes important if 8 is big - so that many investors are receiving the shock. To see this consider the probability of finding an informed trader, which ex ante is $\forall$. But if each

6 The decision rule is to search again if [expected (benefits) > costs]. If the investor searches again then the probability of improving is $\forall$ which generates benefits of (P^I-P^{OI}) where P^{OI} is the price offered by the informed partner, with probability (1-$\forall$) the investor is worse off and will revert back to P^{OI}, the previous offer. In this case the investor will execute the same decision rule on whether to search again, facing the same costs and benefits. Along this branch of the tree, then, there is $\forall$ probability of benefit (P^I-P^{OI}) and (1-$\forall$) of continuing. Due to this structure, regardless of whether it is viewed as a multi-period or one-period problem, the solution for maximising P^{OI} for the strategic partner is the same: $P^{OI} = P^I-\exists/\forall$.

informed trader has a probability 8 of being a seller too, then it becomes more difficult to find a trade, now equal to ∀*(1-8) instead of simply ∀. If 8 > ½ it follows that not all trades can be filled at the informed price. Some must be executed at the lemons price.[7] Bonds where there are more informed traders always have a smaller lemons premium, but there is always a 8 such that no trading occurs and the uninformed price is offered by everyone.

Furthermore, once a trade occurs, if the price is observable, investors can update their prices. Uninformed investors can infer P^I from a trade not at the low price and update their information to offer the informed price. In this case ∀ is equivalent to one, all investors are informed. Conversely, if a trade is executed at the low price then informed investors will infer that they can extract additional rents from a desperate partner and so will update their information to offer the lemons price. In which case the price is not informative and trading dries up, except for the most desperate sellers. In this case ∀ is equivalent to zero, all investors are uninformed and a lemons market results. The model offers no dynamics, but it is intuitive that trades at the low price will lead investors to lower the offer price even more.

Let the number of potential traders (ie market participants) be N. Assume a minimum holding size of M (for instance, $1 million). (Alternatively, we can assume that holdings are diffuse but only those holding the largest positions are informed.) Then the number of holders of a given security is H = G/M where G is the amount issued. The number of holders of a close substitute is R = O/M where O is the amount of closely substitutable debt that is traded (think of other debt issued by the same company within recent history). Thus ∀ = (R+H)/N. The point is that ∀ is constructed to depend on R and H - the size of the issue and the amount of other debt the firm has recently outstanding. Later we offer extensions so that ∀ depends on the amount of trading.

This model can generate a loss of liquidity as a result of large price declines

In this model a loss of liquidity is not arbitrarily assumed, rather it is generated by large price declines. Large price declines increase 8 as investors are forced to sell to eliminate losing positions (or meet margin calls) and/or to meet redemptions. This reduces liquidity. Similarly, price declines reduce dealers' willingness to make a one-sided market since they want to reduce not build inventory (and also since hedging costs have increased), which can have a large effect on liquidity since, if they pull back, the probability of a trade falls from 1 to ∀*(1-8).[8]

Extensions

There are two additional intuitive predictions which could be generated from this framework. The first is to show how shocks can be transmitted from one asset to another as sellers (and dealers pulling back) drain liquidity from each market in turn - since a seller will rather sell a different bond than be forced to sell at the lemons price. If the selling is strong enough, the lemons price (which could be different) will result in each market.

Second, additional insight into liquidity can come from a richer view of investor type. "Mark to market" investors (hedge funds and mutual funds) are subject to "sell" shocks when prices fall (but not when they rise). Hedge funds suffer a "sell" shock when prices fall since they must mark to market and meet margin calls. Mutual funds are assumed to be unlevered, but face redemptions. "Buy and hold" investors (insurance companies and pension funds) do not face sell shocks. They never sell, but they are not informed, therefore as they accumulate bond share the liquidity of that bond dries up. Thus, liquidity for a bond diminishes over time as buy-and-hold investors accumulate share and reduce trading.

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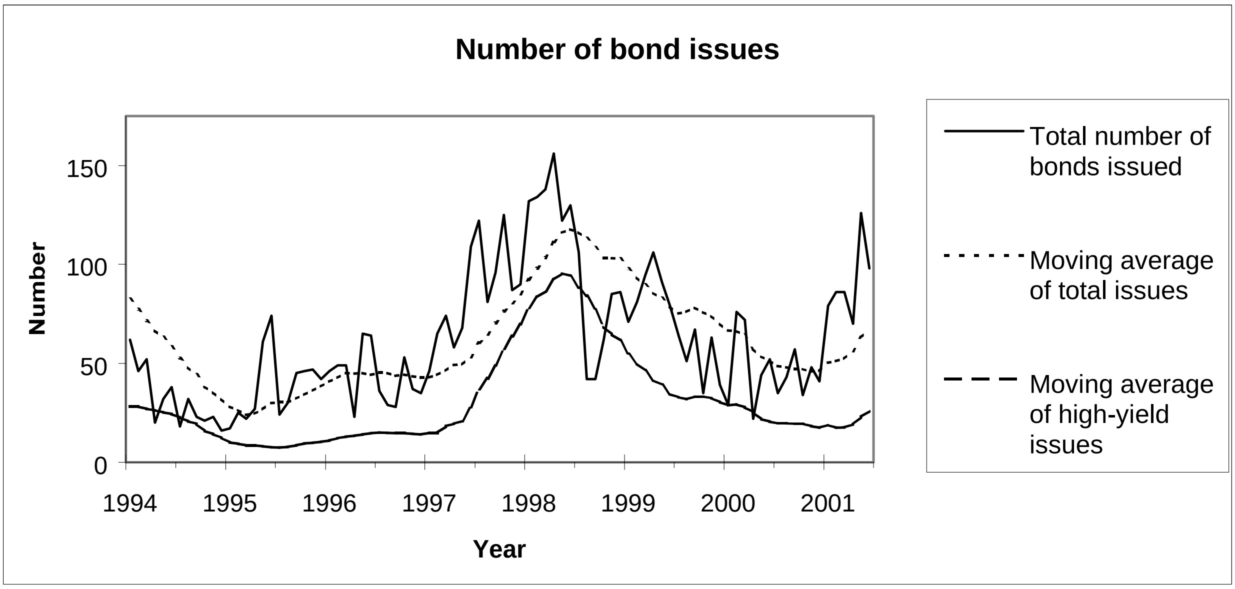
7 This would be similar if a seller has to move a particularly large amount of bonds. Or, if the penalty is increasing in the quantity, then it would be more likely to get a trade done at the lemons price.

8 Price increases reduce 8 and so increase liquidity. If positive "buy" shocks were also possible the resulting symmetrical illiquidity of "too much" buying is eliminated by dealers' willingness to stay in the market (as opposed to on the downside) and by their willingness to bring a fresh supply of new bonds. Unfortunately, when the market needs to sell, the issuers have not typically entered the market to retire their debt. Of course, that probably would be an optimal outcome, if the firm had cash on hand.

Exhibit 1

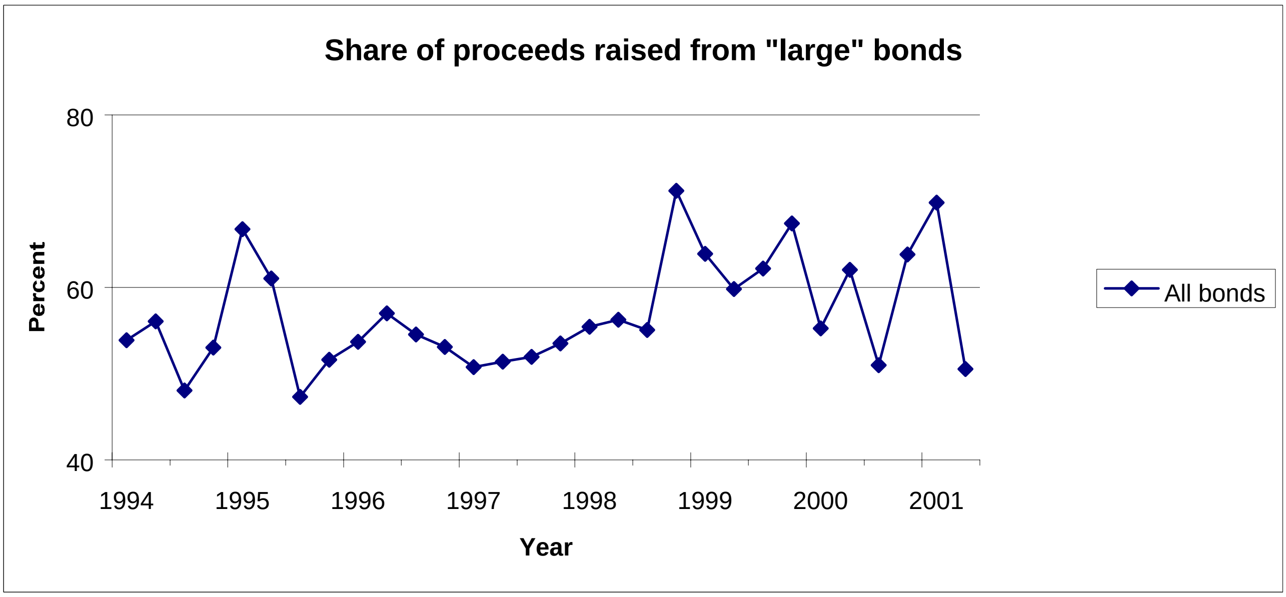
The effect of the LTCM crisis on amount of US non-financial bond issuance



Note: Data are author's calculation from SDC issuance data. US dollar bonds only, issued by US domiciled firms (ie excluding euros and yankees). Non-financial firms only, excluding asset-backed, mortgage-related, and issuance from MTN (medium-term note) programmes.

Exhibit 2

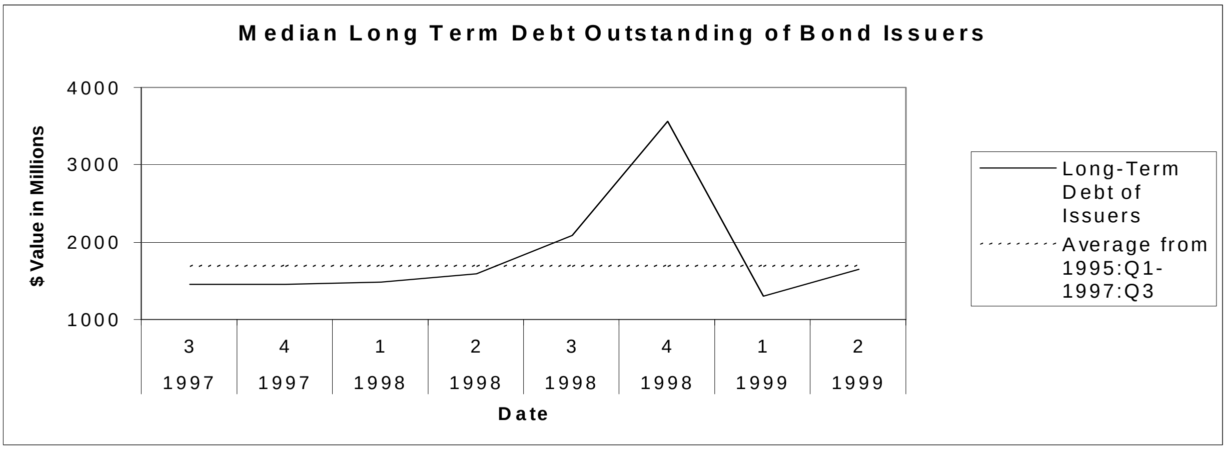
The effect of the LTCM crisis on the amount of "large" bond issuance



Note: Bond sample as in Exhibit 1. "Large" is defined as the upper size quartile as determined by the prior year of issuance.

Exhibit 3

The effect of the LTCM crisis on the amount of "name" bond issuance



Note: Bond sample as in Exhibit 1. The amount of long-term debt outstanding of the issuer is taken from Compustat for the quarter of the bond issue.

Exhibit 4

Impact of issue size and other indicators of liquidity, as well as various controls, on bond pricing

Dependent variable = spread to Treasuries	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
On-the-run premium (versus synthetic)	1.30** [2.31]	1.02* [1.89]	1.32** [2.34]	0.81 [1.18]	0.80 [1.16]
Treasury yield (10-year constant)	13.85*** [3.80]	13.77*** [3.93]	13.75*** [3.78]	5.00 [1.07]	5.27 [1.13]
Yield curve premium (30-year minus 5-year)	–42.85*** [8.37]	–42.20*** [8.55]	–42.73*** [8.35]	–48.91*** [7.07]	–48.21*** [6.97]
Credit spread (BBB - AAA)	112.44*** [16.35]	120.43*** [18.10]	113.06*** [16.43]	112.27*** [11.66]	111.36*** [11.56]
Liquidity spread (AAA-T)	48.91*** [5.25]	54.00*** [6.03]	48.86*** [5.25]	25.98* [1.90]	27.40** [2.01]
Rating grade (AAA=1, CCC=20)	21.70*** [46.20]	22.86*** [48.17]	21.59*** [45.69]	17.08*** [25.10]	17.03*** [25.01]
First issue? (1 if "yes", 0 if "no")	**13.62*** [3.70]**	**14.13*** [3.56]**	**10.65*** [2.65]**	**17.83*** [3.58]**	**22.27*** [4.05]**
Multiple issues (same day)? (1 if "yes", 0 if "no")	**–14.26*** [3.52]**	**–11.91*** [3.48]**	**–15.17*** [4.27]**	**–18.07*** [4.02]**	**–16.79*** [3.70]**
Time since previous issue(years)		**2.51* [1.71]**			**3.65* [1.90]**
Issue in previous year? (1 if "yes", 0 if "no")			**–7.51* [1.88]**		
Amount issued ($ millions)	**–0.034*** [5.38]**	**–0.037*** [6.02]**	**–0.035*** [5.43]**	**–0.011 [1.36]**	**–0.010 [1.27]**
Maturity of issue (years)	0.789*** [4.49]	0.950*** [5.63]	0.801*** [4.56]	0.850*** [3.75]	0.841*** [3.71]
Put option? (1 if "yes", 0 if "no")	–43.96*** [6.09]	–45.77*** [6.97]	–43.81*** [6.07]	–49.89*** [5.44]	–49.22*** [5.37]
Call option? (1 if "yes", 0 if "no")	7.41* [1.93]	2.81 [0.76]	6.70* [1.74]	3.13 [0.63]	2.84 [0.57]
Private company? (1 if "yes", 0 if "no")	61.52*** [6.67]	61.88*** [6.97]	61.44*** [6.67]	na	na
Subordinated issue? (1 if "yes", 0 if "no")	86.43*** [13.15]	82.88*** [12.94]	86.29*** [13.13]	103.09*** [9.97]	102.13*** [9.87]
144a issue? (1 if "yes", 0 if "no")	64.95*** [8.95]	54.78*** [7.75]	63.20*** [8.64]	24.53** [2.33]	22.50** [2.13]
Industry dummies	Yes***	Yes***	Yes***	Yes***	Yes***
Leverage (debt/assets)				61.25*** [3.93]	62.78*** [4.03]
Coverage (intx/oibd)				1.06* [1.95]	1.06* [1.95]
Long-term debt out ($ millions) (x100)				**–0.026 [0.86]**	**–0.022 [0.73]**
Number of observations	2,639	2,639	2,639	1,185	1,185
Adjusted R-square	.73	.73	.73	.68	.68

Note: Dependent variable is spread to Treasuries on issued bonds. Data are SDC newly issued bonds from 1994 to 2001, excluding financial companies, yankees, euros, asset-backed, pass-throughs, lease-related, mortgage-related, equipment trust-related, MTN programmes, and bonds with guarantees. Straight debt only. Constant term is significant but not reported. T-stats under the coefficients. ***, ** and * are significance at 1%, 5%, and 10% respectively.

Exhibit 5

Determinants of the size of a bond issue

Dependent variable = size of bond issue	Investment grade firms			High-yield firms	
	(1)	**(2)**		**(3)**	**(4)**
Treasury yield (10-year constant)	59.57** [2.38]	84.74** [2.39]		81.30** [2.58]	93.65* [1.67]
Yield curve premium (30-year minus 5-year)	46.81 [0.94]	360.79*** [4.62]		–66.16 [1.13]	–203.54* [1.82]
Credit spread (BBB - AAA)	186.74*** [3.46]	320.18*** [4.05]		–18.32 [1.05]	–21.05 [0.55]
Liquidity spread (AAA-T)	**57.82 [0.83]**	**–261.16** [2.37]**		**320.81*** [3.90]**	**509.32*** [2.75]**
Rating grade (AAA=1, CCC=20)	9.39*** [4.43]	8.46** [2.55]		–18.45*** [4.55]	–13.58 [1.42]
Maturity of issue	0.576 [1.01]	1.29 [1.48]		–1.51 [0.89]	0.73 [0.95]
144a issue? (1 if “yes”, 0 if “no”)	98.44*** [3.13]	42.95 [0.83]		–95.34*** [3.54]	–49.72 [1.04]
Industry dummies	Yes***	Yes***		Yes***	Yes***
Year dummies	Yes***	Yes***		Yes***	Yes***
Leverage (debt/assets)		14.55 [0.20]			–22.46 [0.27]
Coverage (intx/oibd)		–25.93 [0.60]			–0.30 [0.22]
Long-term debt out ($ millions) (x100)		0.83*** [7.17]			2.57*** [4.65]
Number of observations	2,026	983		612	190
Adjusted R-square	.26	.28		.22	.42

Note: Dependent variable is the size of the bond, measured in millions of dollars. SDC issuance data from 1994-2001, as in Exhibit 5. T-stats in brackets under coefficients. ***, ** and * are significance at 1%, 5%, and 10%, respectively.

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