Strategic Trading Behavior, Price Distortion and Market Depth
in a Manipulated Market: Anatomy of a Squeeze

by

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Abstract

This paper investigates the trading behavior of major market participants during an attempted delivery squeeze in a bond futures contract traded in London. Using the cash and futures trades of dealers and customers, it provides empirical evidence on the strategic trading behavior of market participants in a market manipulation setting. It shows how learning takes place in the marketplace and how squeezes are accompanied by severe price distortions and market depth erosion. It also shows how the marked differences in the penalties for settlement failures in the cash and futures markets create conditions that favor squeezes. To minimize such incidents, it recommends that exchanges mark-to-market the specifications of their contracts more frequently, and that regulatory reporting requires flagging of possession oriented trades like forward term repos that straddle the futures contract delivery period.
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1. Introduction

History is filled with instances of individuals and corporations manipulating securities markets and attempting to generate high private returns from acquiring and exercising market power in securities trading. Well-publicized major manipulation episodes have occurred in bond markets,\(^2\) in commodity markets and their futures contracts,\(^3\) and also in equity markets.\(^4\) Manipulative grabs for pricing power are neither uncommon, nor even have the appearance of impropriety, in self-regulated over-the-counter markets like the government bond markets of the United Kingdom and the United States. For example, a UK or US bond dealing firm might acquire a large position in a particular issue and then partially restrict its availability in the market. Such an action could turn the issue “special” so that the firm could generate trading profits on its bond inventory and/or obtain disproportionately good financing rates using the bond as collateral.\(^5\)

Even though there have been innumerable cases of often serious market manipulations reported in securities markets worldwide, surprisingly little is documented about the trading behavior of major players in manipulated markets. Earlier empirical research on market manipulation is largely confined to the study of the May 1991 Salomon squeeze (Jegadeesh, 1993, and Jordan and Jordan, 1996) and the price distortion of the 30-year US Treasury bond in 1986 (Cornell and Shapiro

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\(^3\) There have been innumerable alleged attempts to corner commodities, for example episodes in the oil (Exxon, 1996), tin (1980-81 and 1984-85), silver (the Hunt family, 1979-80), and soybean (the Hunts again, 1977) markets, to name a few. See Pirrong (1995) for numerous episodes of market manipulation at the Chicago Board of Trade and other US and international exchanges, and the shortcomings of self-regulation by the exchanges.

\(^4\) Jarrow (1992) relates a collection of early references on attempted corners in individual common stocks. Lefebvre’s (1994) lively *Reminiscences of a Stock Operator* contains several discussions of manipulations. A casual web search also throws up a large number of press reports of market manipulation in equity markets. In particular, in the US, in battles involving corporate insiders, it is not uncommon for these insiders to coordinate with shareholders to engineer short squeezes, i.e., situations in which short-sellers are forced to cover their short position due to their not being able to borrow shares because these shares have been withdrawn from the share lending market.

Our paper is the first to investigate both the price distortions as well as trading positions of market participants during a major market manipulation episode. We analyze the six-month period of an attempted delivery squeeze in the March 1998 long-term UK government bond futures contract traded on the London International Financial Futures and Options Exchange (LIFFE).

A classic manipulative delivery squeeze in a bond futures contract takes place when a manipulator acquires a substantial long position in the futures contract and a sizeable fraction of its cheapest deliverable bond issue. The squeezer attempts to profit by restricting the supply of the cheapest deliverable issue. This action increases the price of the original cheapest-to-deliver issue and simultaneously forces holders of short futures contract positions to either deliver more highly valued bond issues or else buy back their futures contract positions at inflated prices.

Futures market participants, futures exchanges, and futures markets regulators are all very concerned about delivery squeeze attempts since they distort prices, hamper price discovery and create deadweight losses (see Pirrong (1993)). In particular, squeeze-generated sustained price distortion erodes the beneficial economic role of futures markets by significantly reducing the effectiveness of the contract for hedging (see, e.g., Figlewski (1984), Merrick (1988)). Moreover, because of the high volume of futures trading, a much larger market population feels the adverse impact of delivery squeezes relative to a cash market squeeze in any particular issue. Importantly, as the scale of futures trading can be a large multiple of trading in any individual cash market issue, bond futures contracts provide a feasible way of acquiring more than 100% of the cheapest deliverable issue’s supply. Judicious choice of different execution brokers and clearing accounts can help cloak the manipulator’s accumulation of a major position.6 Unfortunately, while extensively

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6 Such accumulation is perfectly legal. In contrast, in the May 1991 Treasury squeeze, Salomon Brothers accumulated a sizeable fraction of the target issue via illegal bidding activity in a Treasury auction. For a discussion of squeeze-related issues in the context of auctions, see Nyborg and Sundaresan (1996), Nyborg et al ((2001) and Nyborg and Strebulaev (2001a,b). Although important, this literature has limited implications for squeezes that arise during the course of trading of a futures contract (see section 6.6 below). In the popular press, hedge funds have often been accused of market manipulation. For academic investigation of this allegation and hedge funds’ risk exposures, see Brown et al (1998), Fung and Hsieh (2000), Fung, Hsieh and Tsatsaronis (2000), and Agarwal and Naik (2002).
acknowledged, there has been no investigation of strategic trading behavior of market manipulators during delivery squeezes.\(^7\)

Our joint examination of price distortions and inventory positions of market participants is based on a rich dataset consisting of the cash and futures trades reported by individual bond dealers and the Exchange to the UK Financial Services Authority (FSA), the chief government regulator. First, we document the extent of price distortions, i.e., the deviations of the cheapest to deliver bond’s price from its discounted cash flow value derived from the prevailing term structure. Following Kyle’s (1984) model of a squeeze, we also compare the price of the futures contract with its full-squeeze and no-squeeze values (derived from the discounted cash flow values of the first and the second cheapest deliverable bonds) and estimate the risk-neutral squeeze probability implied by the futures price. Following industry practice, we also compute butterfly yield spreads where the ‘center’ is the cheapest deliverable issue and the ‘wings’ are two other bond issues with adjacent maturities. Using these metrics, we identify different phases of the squeeze.

Second, we track the positions of all dealers and their customers across the different phases of the squeeze. From these inventory positions, we identify two dominant and opposing trading “styles” among the market participants active in the squeeze: the “squeezers” and the “contrarians.” Squeezers are market players who initiate the squeeze and those who reinforce the squeeze. Contrarians are market players who aggressively speculate that the squeeze attempt would not succeed.

Third, we identify three main ways used by squeezers to build up their long positions in the cash market. The first is the purchase of the cheapest deliverable issue. The second is the purchase of bond futures contracts. And, the third is through forward repurchase agreements. These agreements involve a simultaneous forward purchase of the cheapest deliverable issue for settlement prior to, and a companion forward sale for settlement after, the futures delivery date. These forward repurchase trades are extremely important from the perspective of the squeeze as they provide control of the cheapest deliverable issue across the futures contract delivery date.

\(^7\) The only research that relates, albeit indirectly, to delivery squeezes is Jordan and Kuipers (1997) who trace the appearance of negative option value in a callable US Treasury bond to its cheapest-to-deliver status against the CBOT Treasury bond futures contract. Academic attention on the distorting influences of futures trading on pricing in the cash markets has focused on volatility effects (e.g. Figlewski, 1981).
Fourth, in the context of the information content of the order flow, we document the relation between the proprietary trades of individual dealers and their customers, specifically learning and concerted action, and also how information about a potential squeeze got disseminated to the market-at-large.

Fifth, in the context of market microstructure literature, we examine whether market depth is adversely affected by the strategic trading behavior of market participants. We also examine whether trading flows between different groups of traders are consistent with the notion that differences in opinions generate trading. In particular, we examine the proportion of trading that takes place between the squeezing-group and the contrarian-group, and within the squeezing-group and the contrarian-group.

Finally, and importantly from a regulatory perspective, we show how the squeeze attempts are facilitated by the marked differences that exist between cash bond market, bond repo market and futures market conventions in relation to settlement nonperformance. Futures exchanges levy heavy fines on contract shorts that fail to deliver against an outstanding short position. No such fines exist for traders who “fail” in the cash bond and bond repurchase agreement markets. We show that this has important implications for cross-market cash-futures arbitrage pricing relation, since arbitrageurs cannot use repos to fund their cash positions in the presence of a squeeze. Consistent with this expectation, and contrary to what one would expect from the “specialness” of the cheapest deliverable issue, we show that LIBOR replaces the general collateral rate as the marginal implied funding rate as the risk of strategic fails increases. In this context, we also document how a narrowly targeted temporary change in repo market policy announced by the Bank of England successfully ended the squeeze.

This investigation of price distortions and trading positions of participants is of significant interest to both academics and market regulators. From an academic perspective, this paper provides, inter-alia, empirical evidence on how learning takes place in the market place and on the strategic trading behavior of major market participants (both dealers and customers) in a market-manipulation setting. From a regulatory perspective, this paper has several messages. First, regulators and exchanges need to be very concerned about ensuring that squeezes do not take place, since they are accompanied not only by severe price distortions but also by significant erosion of market depth. Second, exchanges should mark-to-market the specifications
of their contracts more frequently, so that the term structure which underlies the calculation of conversion factors does not become dramatically different from the prevailing term structure. Third, regulatory reporting should require flagging of trades like forward term repos that provide control of key deliverable issues against the futures contracts: these trades can go unnoticed under current reporting systems. These trades may also slip through the internal controls of dealers as they do not change net duration risk exposure limits of individual traders. Finally, regulators should take notice of the fact that the marked asymmetry in penalties for settlement failures between cash and futures markets create conditions that favor squeezes.

The remainder of this paper is organized as follows. Section 2 analyzes the theoretical and institutional framework relevant for delivery squeezes. Section 3 describes the data. Section 4 documents the conditions that generated the potential for the squeeze we investigate. Section 5 examines different metrics of price distortions to identify the different phases of the squeeze. Section 6 investigates trading flows and trader behavior during the squeeze. Section 7 analyzes the impact on squeezes of settlement nonperformance conventions in cash and futures markets. Section 8 offers concluding remarks.

2. Theoretical and institutional framework

2.1 Delivery convergence for conversion factor-based bond futures contracts

Bond futures contracts typically allow shorts to deliver any one from a predetermined basket of deliverable issues during the contract delivery month. By basing the contract on a basket of potentially deliverable issues, rather than on a single issue, the exchanges aim to reduce the incidence of market manipulation. Since the market values of the alternative deliverable bonds differ, exchanges apply “conversion factors” in an attempt to make the different bonds equivalent in value for delivery purposes. The LIFFE, like the CBOT, calculates the conversion factor for each bond

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8 On CBOT, the T-bond futures contract makes all issues with maturity or date to first call greater than 15 years eligible for delivery. On LIFFE, for the March 1998 Long Gilt contract, eligible gilts include those issues with between 10 years to 15 years to maturity. The short decides which bond to deliver (the quality option), and also when to deliver during the delivery month (the timing option). There is an extensive literature on these quality and timing options. See, for example, Kane and Marcus (1986), Boyle (1989), Hemler (1990) and Barnhill (1990). Chance and Hemler (1993) provide a review. However, from the perspective of this paper, it is important to note that the quality option is unlikely to be important at the time of a squeeze, since squeezes typically take place only if there is a significant difference between the cheapest to deliver bond and the next cheapest to deliver bond. The timing
by discounting the individual bond’s remaining cash flows using the assumption that the spot yield curve is flat at the level of the notional coupon defined in the futures contract. Clearly, if the level of the spot yield is significantly different from the defined notional coupon, or if the slope of the yield curve differs significantly from zero, the conversion factors defined by the exchange will not equate the net delivery costs of all eligible deliverable issues. In particular, one bond issue will become the cheapest deliverable issue (hereafter \( \text{cdi1} \)). The presence of arbitrageurs will imply that futures contract is priced off the price of \( \text{cdi1} \). This will also mean that the futures buyers can effectively acquire a position in \( \text{cdi1} \) that is greater than the issue size of that bond.

Let \( P_i \) be the delivery date price of the \( i^{th} \) deliverable issue, \( cf_i \) be the conversion factor for the \( i^{th} \) issue, and \( F^{ns} \) be the last futures price prior to delivery under normal market conditions (i.e., under a no-squeeze scenario). The ‘basis,’ which equals the short’s loss-on-delivery of the \( i^{th} \) issue, is defined as:

\[
Basis_i = P_i - cf_i F^{ns} = \text{Loss on delivery}
\]  

\( \text{cdi1} \) is the bond that minimizes at the time of delivery the difference between the market price and invoice price of the delivered bond. The futures price at contract maturity under a no-squeeze scenario is given by the zero profit condition:

\[
F^{ns} = \frac{P_{\text{cdi1}}}{cf_{\text{cdi1}}} = \min_i (P_i / cf_i)
\]  

The no-squeeze cash market price for the \( i^{th} \) issue with \( n_i \) periods to maturity equals the present value of its cash flows \( C_{i,t} \) using the default-free discount factors, \( h_t \):

\[
P^{ns}_i = \sum_{t=1}^{n_i} C_{i,t} h_t
\]

2.2 Pricing during a squeeze

Cash and futures contract market pricing can be distorted by the actions of a strategic investor (or a group of investors). The strategic investor acquires a large long position in the futures contract, in \( \text{cdi1} \), and in repo agreements on \( \text{cdi1} \) written over the futures delivery date. The futures-cash-repo strategy increases the quantity of contracts that must settle through physical delivery and reduces the supply of \( \text{cdi1} \) available for delivery.

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option can continue to be important even in a squeeze setting; however Boyle’s (1989) simulations show that the value of the timing option is much smaller than the value of quality option.
Consider a case where the strategic investor accumulates a large long futures position at a fair price (i.e., a price consistent with a no-squeeze scenario given in equations (2) and (3) above). The aim of the manipulative short squeeze strategy is to force at least some fraction of the outstanding futures contract shorts to acquire and deliver what would normally be the second cheapest deliverable issue, i.e., cdi2. Let \( P_{cdi2} \) denote the delivery date price of the cdi2. Then under a squeeze scenario, cash and futures prices increase. In case of a full squeeze, both cdi1 and cdi2 become equally cheap to deliver, and the futures price rises to the converted price of cdi2:

\[
F' = P_{cdi2} / cf_{cdi2} = \text{Min}(P_i / cf_i) \tag{4}
\]

The futures price reflects the marginal cost of making delivery of cdi2 and a competitive short is willing to pay up to \( F^s \) to liquidate the short futures position.\(^9\) Concomitantly, the price of cdi1 rises until the following condition is satisfied:

\[
F' = P_{cdi2} / cf_{cdi2} = P_{cdi1} / cf_{cdi1} \tag{5}
\]

where \( P_{cdi1}^s \) denotes the price of cdi1 under a full squeeze scenario.\(^11\) The price of the squeezed issue, \( P_{cdi1}' \), no longer conforms to the level consistent with pure discounted cash flow valuation, \( P_{cdi1}^ns \):

\[
P_{cdi1}' = (cf_{cdi1} / cf_{cdi2}) \sum_{i=1}^{n} C_{2,i} h_i > \sum_{i=1}^{n} C_{1,i} h_i = P_{cdi1}^ns \tag{6}
\]

In trades for post-delivery settlement, the cash price of cdi1 reverts to its normal discounted cash flow value. Clearly, one useful measure of the squeeze potential is given by:

\[
\text{Squeeze Potential} = F^s - F^{ns} \tag{7}
\]

In the spirit of Kyle (1984), one can relate the futures price \( F \) with \( F^s \) and \( F^{ns} \), and infer an implied risk-neutral probability \( \pi \) of the success of the squeeze:

\[
\pi = \frac{F - F^{ns}}{F^s - F^{ns}} \tag{8}
\]

\(^9\) See Kilcollin (1982) for biases that conversion factor systems of this type introduce into the delivery mathematics and Garbade and Silber (1983) for a more general discussion of penalty versus equivalence systems for quality adjustments on contracts with multiple varieties.

\(^10\) As in Kyle (1984), the final futures price rises to make the second issue equal in delivery value with the first issue even if only a fraction of deliveries take place with the second issue. See Salant (1984) for a comment on Kyle’s (1984) stylized model of a squeeze.
3. Data and salient features of UK government bond market

Trading in UK government bonds (known as “gilts”) takes place in a competitive over-the-counter dealership environment where about 15 to 20 dealers compete with each other to execute the order flow. These dealers are typically major investment houses, or their subsidiaries or affiliates (see Table 1 for an illustrative list of dealers during 1997-98). Each dealer is required to report all trades in each bond issue and in all futures contracts to the Financial Services Authority, the chief government regulator. These reports (running from September 1997 through March 1998) form one major source of the data used in this study.

Our data include all trades of each dealer and their affiliates in the March 98 Long Gilt futures contracts and the key 9% 2008 deliverable issue. We analyse the transactions of seventeen dealers and their customers. The data provide the name of the security, identities of buyer and seller, transaction price and quantity, date and time of the transaction, trade settlement date, whether the transaction was a dealer buy or sell, dealing capacity of buyer and seller (principal or agent) and any special conditions. These data enable us to calculate, for each dealer and each customer, the running inventory positions – par value of bonds and whether long or short – in the deliverable issue and the number of contracts – long or short – in the March 98 futures contract.

We also use data from two other sources. Firstly, we use Lehman Brothers’ proprietary daily cash gilt bid-side prices marked at the close of futures trading. We use these cash gilt marks to analyze basis-trading opportunities. We also use the daily gilt market discount factors derived from the closing “spot rates” computed by the Bank of England to arrive at the discounted cash flow value of different cash bonds.

4. Initial conditions and the squeeze potential

4.1 Notional coupon of the bond futures contract and the level of yield curve

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11 If only one issue has been squeezed, the cash price of the cd1/2 issue remains at its normal discounted cash flow value. If the manipulator’s positions are large enough relative to the sizes of cd1 and cd1/2, then even the third- or fourth- cheapest to deliver issues can also get “squeezed in.”
13 See Anderson and Sleath (2001) for a description of the Bank’s spline-based term structure model (as adapted for the Gilt market) used in the estimation of these discount factors.
Figure 1a plots the 15-year zero-coupon bond yield relative to the 9% flat yield curve assumed by LIFFE in the calculation of conversion factors. As can be seen, until early 1997, the long-term yields were relatively close to 9%. However, thereafter they decreased steadily to about 7% by September 1997 and about 6% by March 1998. It is well known that under such conditions the lowest duration deliverable bond becomes the cheapest deliverable issue (see Kilcollin (1982)).

Table 2 illustrates the potential profitability of a squeeze for the special case of a 6% flat zero-coupon yield curve with the conversion factors used by LIFFE. There are five issues eligible for delivery. In view of the short’s timing option, the last delivery date is the last day of the month except for the 9% 2008 issue, for which the last delivery date is March 9, 1998. Given the three business-days delivery invoicing process, the price for March 9\textsuperscript{th} delivery has to be based on the price on March 4, 1998. The upper panel of Table 2 illustrates our calculations. The 9% 2008 issue is clearly the \textit{cdi1}. The 8% 2009 issue is the rather unattractive second choice (\textit{cdi2}). A delivering short would lose nearly 2% of par value (2 full price points) by delivering \textit{cdi2} instead of \textit{cdi1}.

The lower panel of Table 2 describes a manipulator’s trading target. Under a two-issue full-squeeze scenario, the contract shorts would be forced to deliver \textit{cdi2}. The price of \textit{cdi1} and the March 98 futures would then rise. The \textit{cdi1} could gain 2% of par value (2 full price points) from 123.28 to 125.28. The March 98 futures contract would also gain a similar amount. The squeezer would generate marked-to-market paper profits. The realized profits, however, would depend on the price at which the squeezer manages to unwind the positions.

4.2 Changes in squeeze potential over the sample period

Figure 1b shows how the spot yield curve changed over the sample period from September 1, 1997 (the first day of trading in March 98 futures contract) to March 4, 1998. Although the short-term yield remained at about 7%, the long term yields fell from 7% in early September 1997 to a little under 6% in mid-February 1998. In the context of these changes in the term structure, Figure 1c plots the squeeze

\footnote{LIFFE does not permit deliveries of bonds during their ‘special ex-dividend period’ - a period of 21 calendar days prior to the ex-coupon date.}
\footnote{March 4, 1998 is the last day to purchase a cash gilt issue for regular settlement in time for a March 9\textsuperscript{th} futures delivery given the futures exchange’s three business day delivery invoicing process.}
potential, i.e. the difference between $F^s$ and $F^{ns}$, over the life of March 98 futures contract, where $F^s$ and $F^{ns}$ are the converted forward delivery date prices of the cdi2 and cdi1 respectively.\textsuperscript{16} As can be seen, the squeeze potential of the March 98 contract increased substantially over the sample period and peaked at 2.35% of par value (2.35 price points) in February 1998. This increase reflects the fall in the level of the yield curve, and the fact that the yield curve changed from being flat to being downward sloping. Both these factors exacerbated the contract’s conversion factor bias and increased the potential profitability of a successful squeeze.\textsuperscript{17}

5. Price distortions during the squeeze

5.1 Mispricing of the cheapest-to-deliver issue relative to fundamental value

The difference between the market value of the bond and its discounted cash flow value (as per equation (3)) on any particular date can be interpreted as an issue-specific price distortion or mispricing. Transient issue specific effects can be due to liquidity trading or can potentially be “noise,” but consistent differences between the market price and the discounted cash flow value for cdi1 will arguably reflect squeeze-related price distortions. Figure 2a plots the difference between the market value of cdi1 and its discounted cash flow value from September 1, 1997 to March 4, 1998. Based on this mispricing, we identify six different phases of the squeeze:

- Phase I is from September 1\textsuperscript{st} to October 15\textsuperscript{th}. During this phase, the average mispricing (i.e., price distortion of cdi1) was flat at about 0.075% of par value.

- Phase II is from October 16\textsuperscript{th} to November 4\textsuperscript{th}. During the early part of this phase, i.e., up to October 29\textsuperscript{th}, the mispricing rose steadily to 0.24% and then from October 30\textsuperscript{th} to November 4\textsuperscript{th}, it rose sharply to 0.77%.

- Phase III is from November 5\textsuperscript{th} to January 9\textsuperscript{th}. During this phase, the mispricing was largely steady at an average level of about 0.67%.

\textsuperscript{16} The forward prices are based upon the bond’s discounted cash flow value under Bank of England’s daily discount factor series and net financing costs.

\textsuperscript{17} LIFFE responded \textit{ex-post} to the market distortions generated by the March 98 contract squeeze by lowering the notional coupon of its June 98 bond futures contract, for the first time since 1982, from 9% to 7%. This change dramatically reduced future squeeze potential for contracts maturing June 98 and beyond. It also reduced part of the abnormal value that the 9% 2008 bond – the cdi1 for both March 98 and June 98 contracts – would have in forward trading after March 1998. However, since the March 98 contract was already trading, its terms remained fixed.
• Phase IV is from January 12th to January 27th. During this phase, the mispricing jumped sharply to its maximum level of 1% of par value.

• Phase V is from January 28th to February 13th, the last business day before the Bank of England’s repo policy announcement. During this phase, the mispricing fell steadily to about 0.67%.

• Phase VI is from February 16th to March 4th, the last day of delivery of cdi1. During this phase, the mispricing fell to about 0.24%.

5.2 Cash-market butterfly spreads and futures-market calendar spreads

Practitioners often use “butterfly” trades – position switches from one “center” issue into a combination position in two “wing” positions in issues of longer and shorter duration – as a repositioning strategy among three securities.\(^{18}\) Figure 2b plots the “butterfly yield spread,” i.e., the difference between the average of the yields-to-maturity of the 7.25% 2007 and the 8% 2009 (the “wings”), and the yield-to-maturity of cdi1 i.e., 9% 2008 (“the center”).\(^{19}\) As can be seen, the butterfly yield spread metric portrays a picture of mispricing that is qualitatively very similar to that identified using the discounted cash flow approach.

Practitioners also use futures contract calendar spreads to get an indication of changes in pricing relations over the trading life of the contracts. When we examine the calendar spreads between the December 97 and March 98 contracts and also between the March 98 and June 98 contracts, we find spread changes that mimic the price distortion of cdi1 reported in figures 2a and 2b.\(^{20}\) Since neither cash market butterfly nor futures market calendar spread analyses requires sophisticated analytical tools, we believe that the shift in the pricing of cdi1 would have been observable to all bond market participants around mid-October 1997.

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\(^{18}\) See Garbade (1996), Chapter 14, for an analysis of cash market bond butterfly trades.

\(^{19}\) The butterfly yield spread is the “basis point pick-up” that a switch from cdi1 into a combination of the 7.25% 2007 and the 8% 2009 would generate. Although the average yield differential of this type does not index true relative value as precisely as the discounted cash flow approach, practitioners track such spreads closely because the bond triplet position implicit in such spreads provides a low risk trading strategy to exploit relative value mispricings. Note that this particular butterfly is reasonably symmetric, since the modified duration differences between the center issue and each wing are approximately equal (about 0.5 years in each case as computed in November 1997).

\(^{20}\) In particular, we find that the March-December spread increased sharply from a discount of 1/32nds to a premium of 6/32nds by October 30, 1997. It further widened to 12/32nds by November 3rd, 18/32nds the following day and peaked at 27/32nds on November 25th before contracting and stabilizing for most of December at about 16/32nds. Similarly, the March-June spread appreciated by 12/32nds from Phase III to Phase IV, slipping back in Phase V, and to more normal levels by the end of February 1998.
5.3 Implied squeeze probability

Figure 2c plots $\pi$, the implied squeeze probability calculated from equation (8). The identifiable phases in Figure 2c are virtually identical to the phases found in Figure 2a. Figure 2c reveals that virtually no thoughts of a squeeze were priced into the market until mid-October 1997. After this time, the implied squeeze probability rose sharply, averaging about 35% in November and December 1997, and 40% in January 1998. In the first half of February 1998, the implied squeeze probability fell back to an average of 30%. Change in the implied probability of the squeeze on February 16, 1998 stands out. On this day, the Bank of England announced a change in its repo market policy and the implied probability fell sharply from 27% to 14%. During the second half of February, the implied squeeze probability dropped even further.

5.4 Open interest and delivery experience

Table 3 summarizes the open interest and delivery history of the LIFFE Long Gilt futures contract for maturities from March 95 through March 98 (source: LIFFE and Bloomberg). For Long Gilt futures contracts maturing from March 97 to March 98, the peak open interest is about one-and-a-half to two times the par value size of the associated $cdi1$. However, the size of the delivery for March 98 contract stands out. It is nearly double the size of the largest reported prior delivery and about six times the average delivery amount against March 95 to December 97 contracts. It also represents 82.4% of the total outstanding par amount of $cdi1$, as against an average of only 11.3% for March 95 to December 97 contracts. The March 98 delivery is also 47.7% of the contract’s peak open interest as against an earlier average of 8.7%.

6. Squeeze-related trading flows

In this section, we examine the positions and the trading behavior of seventeen dealers (together with firms affiliated with them) and their customers during the life of the March 98 futures contract. In particular, we compute the sum of their end-of-day positions (in par value) in the $cdi1$ and in the March 98 futures contract.\footnote{We construct the inventory positions by adding the net value of trades over a day to the position at the end of the previous day. We assume that the participants start with a zero inventory on September 1, 1997, about eight weeks before the first signs of the abnormal price distortions became evident (see}
an overnight net position in excess of 300 million (about $0.5 billion) on any day.
We find that there are twenty such market participants (nine dealers and eleven customers). We examine their individual inventory series more closely.

6.1. Can any of the market participants be characterized as “squeezers”? We find that ten market participants (six customers and four dealers) had large long positions consistent with those of a squeezer, and we hereafter address them as squeezers. We label the squeezing customers from SC1 to SC6 and the squeezing dealers from SD1 to SD4, where the numbering is generally in the order in which they took up their positions. We report their positions in Figures 3 and 4.

Figure 3a shows that the first players in this squeeze were clearly customers SC1 and SC2. As can be seen SC1 rapidly built up a large position in $cdi1$ in phase I (second week of September 1997). The size of the position of SC1 and SC2 was about 1.5 billion through phase I (amounting to 27% of the outstanding size of $cdi1$). They took some profits in phase II (reducing their position to about 0.9 billion), and subsequently retained a position of about £1.1 billion through the rest of the sample period. Interestingly, even though the initial trades of SC1 and SC2 were intermediated by several dealers, their build-up of positions seems to have gone unnoticed and had no price impact. Squeeze related price distortions started only in phase II, about 30 days after these positions were built up. SC3 and SC4 became squeezers towards the end of phase I and accumulated a total position of about 0.5 billion by the end of phase II (see Figure 3b). SC5 and SC6 started building up their long positions only in middle of phase III with positions totaling to about 1.2 billion by the end of December 1997 (see Figure 3c).

Among the dealers, SD1 (who initially had a short position due to trades with SC1 and SC2) started building up a long position in late September 1997 (see Figure 4a). SD1 is the only dealer who seemed to have “learned” from trading with the squeezing customers. SD1 built up a significant long position of about £0.8 billion towards the beginning of phase II, just as the price distortions began (see Figure 2a). SD1 engaged in early profit-taking, closing out three-fourth of the peak position by the beginning of January 1998. SD2 built up a long position of about £1.5 billion towards the end of phase II and the start of phase III, after the squeeze became evident.

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Figure 2a). This assumption is innocuous since we know that dealers’ positions in individual UK
from price distortions (see Figure 4b).\footnote{However, as we shall see in the next section, SD2 also built up massive forward-term-repo positions from the start of Phase II.} Except for some reduction of position in January 1998, SD2 maintained that position throughout the sample period. SD3 built up a long position of about 0.65 billion by the end of phase I, engaged in limited profit-taking in late October 1997, and then aggressively built up a long position in early December 1997 that peaked at about 1.2 billion (see Figure 4c). In early January, SD3 again took profits by reducing the position to less than £0.1 billion. SD4 was a relatively late entrant and a smaller player reaching a maximum position of about 0.35 billion in mid November 1997.

There is no way of our being able to say whether these ten squeezers acted in concert. In fact, SD3’s decision to repeatedly book profits indicates a perception of ultimate squeeze success that differed significantly from those of other squeezing dealers, and that the activities of these dealers were less than perfectly coordinated.

6.2 Are there trades with unusual settlement configuration targeted at gaining possession of \textit{cdi1} around the futures delivery date?

Trades in the cash bond market are typically settled on the next trading day. There also exist a number of short-term repo trades, i.e., trades in which one participant sells to (buys from) another participant while simultaneously agreeing to buy back (sell) that same security on the following trading day or within two weeks from the trading day. We notice that a large number of trades in our sample belong to these two categories.

Interestingly, we also observe a number of extremely unusual repo trades towards the end of phase I, and all through phase II. All these trades are forward-term-repo (FTR) trades in \textit{cdi1} in which one trader/dealer buys from another trader/dealer for forward delivery on February 20, 1998 (i.e., some two weeks before the last delivery date of \textit{cdi1} against the March 98 contract), while simultaneously agreeing to sell that same security on or soon after March 20, 1998.

Figure 5 shows that the first FTR trade took place on October 7, 1997 when SC4 took up a 0.25 billion long position in \textit{cdi1} (i.e., SC4 bought 0.25 billion of \textit{cdi1} for delivery on February 20, 1998 and simultaneously sold that lot for delivery on March 20, 1998). SC4 rapidly increased the position in these FTRs on October 10,
1997 to 0.8 billion. Around the same time, on October 10, 1997, SC3 also built up a long FTR positions of 0.5 billion. The FTR trades of SC3 and SC4 were intermediated by several different dealers, and one of these dealers, SD2, “learned” about the squeeze from these trades and started trading in the FTRs. SD2 built up a large long position in these FTRs on October 15th, starting with a position of 0.5 billion, and increasing quickly to a maximum of 2 billion by the end of phase II. SD2 subsequently settled down in steps to reach a final position of about 0.9 billion. Interestingly, SD2 also took direct exposure in the squeezable bond and the associated futures contract, but did so only after building a large position in the FTRs.23

As mentioned earlier, the direct accumulation of \textit{cdi1} positions by SC1 and SC2 in September went largely unnoticed. It is the activity in the FTRs that seemed to have leaked the information about a possible short-squeeze to the market-at-large. The price distortion started in the second week of October 1997, after the first few FTR trades. The price distortion increased from about 0.05 price points on October 10, 1997 to about 0.25 price points on October 29, 1997. Over this period squeeze-related trading activity was mainly in FTR trades rather than direct purchase of \textit{cdi1}.

FTR trades generate little interest-rate risk exposure because they are offsetting forward calendar spreads. However, these FTR trades are very important from the perspective of a squeeze since they provide temporary control of the deliverable supply of \textit{cdi1} just prior to the futures delivery date. These FTR trades are relatively invisible to governmental regulators because the actual delivery is scheduled to take place several weeks/months in the future. They are also likely to escape close internal scrutiny within the dealer firm, as they do not affect the net duration-based position risk limits of individual traders.

6.3 \textbf{Can any of the market participants be characterized as “contrarians”?}

As discussed in sub-section 5.2, by first week of November 1997 all market participants would have observed the changes in butterfly yield spreads and calendar spreads and therefore would have become aware of the distortion in the prices of \textit{cdi1} and March 98 futures contract. So, if some market participants took up large short positions after the price had become abnormally high, then they can be characterized

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23 Over the period October 10-29, 1997, in addition to SC3 and SC4, several other customers also took up positions in FTRs, albeit on a smaller scale. In fact, the trading records show that SD2 also did brisk business as a “market-maker” in these FTRs after October 10, 1997.
as “contrarians.” A contrarian is a market participant whose short position is consistent with the speculation that the squeeze attempt would ultimately be unsuccessful, either because some members of the squeezing coalition would take profits and run, or because there would be external intervention by regulators or the exchange. We find that five dealers and five customers had short positions that were consistent with those of a contrarian, and we label them as CD1 to CD5 and CC1 to CC5 respectively. We report their positions in Figures 6 and 7.

CD1 initially acquired a short position when the first squeezing customers SC1 and SC2 made their trades, and CD2 initially acquired a short position in the wake of the first wave of buying in phase II. However, both CD1 and CD2 later decided to bet aggressively against the squeeze with positions in excess of 1.0 billion each (see Figure 6a). In addition to these two dealers, three other dealers (CD3, CD4 and CD5) wagered aggressively against the squeeze from the middle of phase III (after cdi1 had become significantly overpriced) with positions of at least over 0.5 billion each (see Figures 6b and 6c).

Among the contrarian customers, CC1, CC2 and CC3 had an aggregate short position of about 0.9 billion around the start of phase II, which they, more or less, maintained during the course of the squeeze (see Figures 7a and 7b). CC4 started building a short position towards the beginning of phase III reaching to about £0.9 billion towards the end of phase III and maintained it at that level. CC5 started betting against the squeeze towards the end of phase III reaching a maximum short position of about 0.3 billion in early February 1998 (see Figure 7c).

6.4 Are there any other identifiable trading styles?

We do not discern any other identifiable trading styles that are relevant to the squeeze. We found one dealer who was a classic cash-futures basis arbitrageur. This dealer took short positions in the March 98 contract paired with corresponding long positions in cdi1. However, this dealer did not take any active role in the squeeze. There were seven other dealers with positions that were too small to indicate conscious speculation in favor of or against the squeeze.
6.5 Summary of the squeeze

Table 4 presents a schematic summary of the actions of the major market participants involved in the squeeze. In early September, two customers started the ball rolling by building a position of 27% of the outstanding issue size of \( cdi1 \). Though these trades were intermediated by several dealers, the “market” largely remained unaware of a potential short-squeeze, and these trades were executed with little price impact. One dealer “learned” from intermediating these trades and became a squeezer and another dealer who was caught short when the price distortions began, became a contrarian. “Learning” in the market-at-large about the possibility of a squeeze began with the building of forward term repo positions in mid-October 1997. Although these FTR trades were intermediated by several dealers, the price impact became evident only when one of these dealers started building up a substantial proprietary position in the FTR contracts.

By early November 1997, the possibility of a squeeze became evident to all market participants. The price distortion jumped from 0.24% to 0.70% from October 30, 1997 to November 4, 1997. In December 1997, a few more customers joined the squeezers, and the total positions of the squeezers reached about 2.1 billion in FTRs and over 5.0 billion in \( cdi1 \) (see Figures 5 and 8). During December 1997 and January 1998, another group of players, the contrarians, became active. They wagered aggressively against the squeeze with short positions averaging to about 5.5 billion. The price distortion remained in the range of 0.70% to 1.00% up to late January 1998. On February 16, 1998, the Bank of England announced a narrowly targeted repo policy in \( cdi1 \) that effectively ended the squeeze. Price distortion fell from its high of 1.00% in late January 1998 to about 0.20% by early March.

6.6 Implications of squeeze related theoretical models

The literature on short-squeezing considers the extent to which “small” participants with a long position are able to free-ride on a short squeeze by a “large” long participant. For example, Kyle (1984) argues that the small long participants will be able to unwind their entire position well above the competitive price before the large squeezer will be able to sell any of its units. Cooper and Donaldson (1998)
formalize this notion and consider a case where all players are strategic. Nyborg and Strebulaev (2001b) while studying auctions present a generalized short squeezing model which nests the models of Dunn and Spatt (1984) and Cooper and Donaldson (1998) as special cases. Some implications of their model are as follows. First, some market participants free ride on the efforts of the squeezers, and earn more on a per unit basis than the large squeezers. This is supported by the trading of SC3, SC4 and SD4 in our data (see Figures 3 and 4). These traders build up their long position after the initiation of squeeze, and due to their early profit taking, make more money than the larger squeezers (who do not manage to unwind their long position). Second, their model implies that the volatility after a squeeze will be higher compared to a no-squeeze scenario. If one thinks of volatility as arising from fundamental (term-structure related) factors and the squeeze factor, then the price distortion graphs in Figure 2 clearly indicate that the squeeze factor contributed to an increase in volatility during phases II to VI.

6.7 The squeeze and market depth

Pirrong (1995, pp 146) argues that delivery squeezes erode market depth and randomly penalize traders who consume liquidity such as hedgers. In this context, we examine the impact of the squeeze on market depth as measured by the price impact of order-imbalances. We define market depth from the perspective of customers and examine whether customer order-flow imbalances affect price distortion in the presence of a squeeze. We also distinguish between days on which there are net customer buys and days on which there are net customer sells. If squeezers have cornered the supply, it may potentially be more difficult for customers to execute their buy orders relative to their sell orders. We examine this by running the following regression:

$$\Delta X_t = \sum_{j=1}^{6} D_{i,j} \alpha_j + \sum_{d=1,2} \sum_{j=1}^{6} \lambda_{d,j} D_{i,j} D_{d,j} \Delta I_d + \phi X_{t-1} + \xi_{t,j} \quad (9)$$

where $X_t$ is the mispricing of $cdil$ at the end of day $t$ (as measured by the deviation from its term-structure based discounted cash-flow value), $\Delta X_t$ is the change in $X_t$.

24 The ability of small participant to free-ride on the squeeze is similar to the ability of small shareholders to free-ride on the monitoring effects of large shareholder (see, e.g., Shleifer and Vishny, 1986) and is related to the notion that when there are externalities, smaller participants can do better, on
from end of day \( t-1 \) to end of day \( t \), \( D_{i,t} \) is a dummy variable for phase \( i \), \( (i = I, II, ..., VI) \), \( D_{d,t} \) is a dummy variable for the direction of order-imbalance direction \( d \) (\( d=1 \) for net customer buys and \( d=2 \) for net customer sells), \( \lambda_{i,t} \) is the market depth (similar to Kyle’s (1985) lambda) in phase \( i \), \( \Delta I \) is the net customer order-flow on day \( t \), and \( \varphi \) is the mean-reversion that would ordinarily exist in the mispricing of \( cdi \) irrespective of any squeeze related effects.\(^{25}\)

We run the regression in equation (9) for the totality of customers and report the results in Table 5. We find that \( \varepsilon \), our metric of market depth is not significantly different from zero in phase I, neither for net buys nor for net sells suggesting that the market was generally unaware of the potential of a squeeze. We also find that net customer-sells are not associated with adverse movement of prices (i.e., adverse price impact) in any phase. \( \varepsilon \) continues to be indistinguishable from zero in phase II for net customer buys.\(^{26}\) However, the situation is sharply different for net customer-buys in phase III to phase V. \( \varepsilon \) is significantly positive in phases III, IV and V, indicating that the customer-buy trades were moving the price against the buyers. In phase VI, after the Bank of England’s announcement, \( \varepsilon \) became indistinguishable from zero.

These regression results clearly demonstrate that the squeeze not only caused price distortions but also led to a significant erosion of market depth for public buys. A public trader attempting to buy \( cdi \) would have faced significantly higher market impact costs from early November 1997 to mid-February 1998. Our findings support Pirrong’s (1995) contention that delivery squeezes erode market depth and randomly penalize traders who consume liquidity.

### 6.8 Trading flows among squeezers and contrarians

In the market microstructure literature, heterogeneous beliefs are the dominant factor generating trading. In the context of the squeeze investigation, we have two groups of traders who hold diametrically opposite beliefs. The squeezers believe that the squeeze will succeed and therefore the fair price of \( cdi \) is \( F^s \) (equation (4)). In contrast, the contrarians believe that the squeeze will collapse and therefore the fair

\(^{25}\) The Mispricing series should ordinarily be stationary and mean-reverting. If mispricing deviates from zero, it would be pulled towards zero by the actions of arbitrageurs. See Yadav et al. (1994).

\(^{26}\) A per unit basis, than the larger ones (see, Olsen and Zeckhauser (1966) and Bergstrom, Blume and Varian (1986)). Also, see Dunn and Spatt (1984) for a model of short squeeze without free-riding.
price of $cdi1$ is $F^{ns}$ (equation (2)). So long as the market price of $cdi1$ lies between $F^s$ and $F^{ns}$, the squeezers would be buyers and the contrarians would be sellers of $cdi1$. Hence, the overwhelming majority of trading should take place between squeezers and contrarians, rather than among different squeezers or different contrarians.

We calculate the percentage of total trading that takes place between squeezers and contrarians, among different squeezers, and among different contrarians. We report the findings in Table 6 separately for each phase as well as for the overall sample period. We find that, on average, about 90\% of the trading takes place between the squeezers and the contrarians. This percentage is substantially higher than what one would expect if the trading was randomly distributed across different market participants. We do find that some trading takes place between squeezing dealers and squeezing customers. This happens mainly during phase III to phase VI when some squeezing dealers and squeezing customers took profits. In contrast, the trading among contrarians is virtually zero as most of them maintained their short position throughout the squeeze period. Overall, these results support the notion that differences in opinion is the dominant factor generating trading.

7. Settlement nonperformance penalties and squeeze incentives
7.1 Asymmetries in settlement nonperformance penalties: cash vs. futures

Pirrong (1993) emphasizes the role of economic frictions such as transportation and transactions costs in the delivery squeeze of physical commodities. Although neither of these costs are important for financial securities, settlement related frictions can potentially play an important role in the squeeze of financial securities. Albeit rare, there can be “settlement fails,” i.e., instances when a trade is not settled smoothly through a transfer of money and title on the contractual settlement date. Ultimately, fails are “cleaned-up” by a good settlement after some delay. In the UK and US cash bond markets, a “fail” by the seller does not alter the contractual cash flows of the originally agreed transaction. Hence, a failed-to “buyer” is still the recognized beneficial owner of the as-yet-undelivered securities in question and is responsible for paying the originally agreed invoice amount when the securities are ultimately delivered. The failing “seller” is still obligated to make the delivery of the securities, but receives only the originally agreed invoice amount, and not the

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26 For net customer-sells in phase II, the depth metric is negative indicating that these trades were
interest between the original settlement date and the actual delivery date. Hence, the failing seller is penalized through implicitly lending at 0% for the failed period.

The right to fail provides an important release valve for pressures caused by trade-processing problems, and also limits the damage a potential squeezer can cause. In a market without fails, individual traders caught with short positions in a manipulated issue would be compelled to buy back the issue in the cash market at the squeeze-inflated price, or borrow the security in the repo market to make good settlement of the shorted security. The trader who chooses to fail prefers to lend at 0% in preference to paying the squeeze-inflated cash market price. The fail system obviates the need for a “buy-in” aimed to ensure a smooth securities transfer on the original settlement date. However, if the failed-to buyer was set up to receive the bond to make delivery against a short bond futures contract position, these bonds would not be available for use in a timely futures delivery, and the buyer will consequently fail in the futures market.

Settlement date nonperformance is much more of an issue for US/UK bond futures markets than it is in the respective spot markets, because US/UK bond futures exchanges also impose substantial fines on contract shorts who fail. For example, the CBOT can fine the non-performing member up to $25,000 for the violation, and an additional $25,000 for “conduct detrimental to the exchange.” The exchange is perceived to be free to interpret this “per violation” standard as applying on a per contract basis, which makes the base $25,000 fine alone to be 25% of the bond contract’s par value. In addition, the exchange can reprimand the clearing member firm responsible for the fail, and is free to apply other sanctions. Clearly, fails in these futures markets are so punitively costly that they are virtually not an available option. The existence of such draconian nonperformance penalties dramatically alters the futures manipulator’s endgame. In particular, most futures shorts cannot wait for a potential last-minute supply-releasing pre-delivery collapse of the squeeze. In a

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27 In a “no-fail” system, the repo rate on a borrowing of the affected issue would not be floored at 0%. Indeed, the repo rate could be negative, since traders would compete to avoid being “bought-in” at the (temporarily) squeeze-inflated cash market price in order to make good settlement.

28 The exchange imposes penalties on the failing clearing member regardless of whether the failed deliveries reflect the clearing member’s proprietary positions or that member’s customer accounts. Not surprisingly, clearing members typically identify those customers with short positions in the delivery month and require such customers to position the correct quantity of deliverable bonds in their clearing accounts three-to-seven-days ahead of the last trading day. If these customers do not have the correct quantity of bonds in their account by this deadline, the clearing member offsets the relevant short
delivery squeeze showdown between a credible squeezer and contract shorts, the contract shorts have to blink first.

### 7.2 Settlement nonperformance penalties and cash-futures arbitrage

The cost-of-carry arbitrage based price of a bond futures contract $F_t$ at time $\tau$ is given by:

$$F_t = \frac{1}{cf_{cdi}} \left[ (P_{cdi,\tau} + A_{cdi,\tau}) (1 + r) \frac{T - \tau}{360} - (A_{cdi,T} - A_{cdi,\tau}) - C_{cdi} - DOV_{cdi} \right]$$

where $cf_{cdi}$ is the conversion factor for delivering $cdi_1$, $P_{cdi,\tau}$ is the price of $cdi_1$ at time $\tau$, $A_{cdi,\tau}$ is the accrued interest on $cdi_1$ on settlement date $\tau$, $r$ is the financing rate, $C_{cdi}$ is the value of coupons received (if any) between dates $\tau$ and delivery date $T$, adjusted for any riskless reinvestment income until date $T$; and $DOV_{cdi}$ is the value of the short’s delivery quality option to switch out of the initially cheapest to deliver issue and deliver an alternative issue.\(^{29}\)

Duffie (1996) and Jordan and Jordan (1998) discuss the importance of repo/reverse repo agreements in the financing of bond positions. For highly leveraged traders, like bond dealers and cash-futures arbitrageurs, the financing cost savings of accessing the preferential rates associated with collateralized lending via the repo market can be very significant, particularly when the specific bond turns “special”, and can be financed at rates even lower than the prevailing “general collateral” rates. Such a special financing rate directly affects the futures price via equation (10).

*Ceteris paribus*, the futures price on a contract whose $cdi_1$ turns special will be lower than if the issue traded in the repo market at the general collateral term repo rate (because the financing cost to delivery will be smaller).

Note however that this argument is not likely to hold during a squeeze in the context of draconian futures market non-performance penalties. This is because, during a squeeze, an arbitrageur with long-cash/short-futures position can no longer feel confident using a standard repo agreement to finance the cash market position because the repo counterparty can strategically ‘fail” on the timely return of the collateral bond. Thus, when the probability of a squeeze increases, repo dependent futures positions by buying contracts back in the market. In essence, the clearing member performs a preemptive “buy-in” to avoid the penalties for settlement fail.\(^{29}\) Clearly, squeeze potential exists largely when the value of the quality option is insignificant, and hence $DOV_{cdi} = 0$. In that case, equation (11) simplifies to pure “cash and carry” pricing.
cross-market arbitrage traders begin to leave the market in favor of traders (like commercial bank trading desks), who are not dependent on the repo market, and instead have access to uncollateralized sources of funds. In such circumstances, LIBOR should become the marginal financing rate in equation (10). Since LIBOR is higher than the repo rate, we should find that the futures price increases (rather than decreases) relative to that of the \( cdi1 \) during periods when squeeze concerns arise. Thus, evidence that LIBOR replaces repo as the relevant marginal financing rate during the squeeze episode provides a direct test of the importance in determining market behavior of the asymmetry in penalties for failed settlements between cash and futures markets.

Figure 9a plots the general collateral repo rate, the LIBOR rate, and the cash-futures arbitrage financing rate implied by the relative prices of the \( cdi1 \) and March 98 futures contract. When we measure the difference between the implied repo rate and the LIBOR rate, and the difference between the implied repo rate and the general collateral rate, we find that until January 20, 1998 the former has a mean of -0.34% (t-statistic 26.1) while the latter has a mean of -0.05% (t-statistic 4.06). After January 21, 1998 these mean differences equal -0.006 (t-statistic -0.47) and 0.45 (t-statistic 30.4) respectively. This suggests that, up to January 20, 1998, the implied financing rate was slightly smaller than but significantly closer to the general collateral rate than the LIBOR rate. Thereafter, instead of decreasing (as if the \( cdi1 \) had turned special due to futures-delivery related high demand), the implied financing rate increased and became statistically indistinguishable from the LIBOR rate. This result clearly reveals that during the latter part of the squeeze, the marginal arbitrageurs financed their cash market position using an uncollateralized source of funding rather than the repo market.

We shed light on this in another way by measuring the futures mispricing relative to \( cdi1 \) under different financing rates. Figure 9b plots the mispricing of the futures contract under the assumption that the financing rate is the general collateral rate versus the LIBOR rate. After January 20, 1998 the March 98 futures contract appears overpriced relative to the repo-based funding calculations, while it seems to be fairly priced relative to the LIBOR based funding calculation. The average daily overpricing with repo-based calculation equals 0.035% (t-statistic 11.5) while that with LIBOR equals -0.002% (t-statistic -1.35). These findings provide strong
evidence on the importance of settlement nonperformance penalties in determining the behavior of arbitrageurs and market prices.

7.3 Squeeze-ending action by the Bank of England

Interestingly, the specific action taken by the Bank of England to end the squeeze also illustrates the importance in squeeze facilitation of the differences in settlement non-performance penalties between cash and futures markets. Concerned about the distortions generated by the squeeze attempt, the Bank of England introduced an innovative non-invasive policy response. It made a temporary change in its repo policy. On February 16, 1998, the Bank of England released a press notice concerning “market developments in 9% Treasury Loan 2008 and the long gilt future contract on LIFFE.” The following is an excerpt from that press notice:

The Bank of England continues to monitor market developments in 9% Treasury Loan 2008 and the long gilt future contract on LIFFE. It recognizes that there is concern that some market participants may fail to be delivered stock due for repurchase under repo agreements and intended for delivery into the long gilt future.

In order to forestall any market disruption resulting from significant failed trades or returns, the Bank of England is prepared to make supplies of the stock available from 23 February, on overnight repo only, to any gilt-edged market maker (GEMM) who has been subject to a failed return or delivery of stock, or has a customer who has been subject to a failed return or delivery of stock. HM Treasury will issue further amounts of this stock for this purpose.... The repo rate applying to any stock made available through this facility will be 0%.

It is interesting to note the ingenuity of Bank of England’s offer. The Bank’s offer of issuing new stock and making it available at 0% overnight repo was (not an open offer but was) targeted specifically at avoiding the draconian penalties for failing to deliver in the futures market. The fact that the repo rate on the newly available quantities of Gilts was set at 0% did not change the profit or loss or other incentives for any dealer or customer versus the alternative of failing in cash market settlement. The additional new supply of bond would simply replace any quantity cornered by the squeezers through strategic repo fails. Thus, the Bank of England’s action was targeted narrowly at addressing the asymmetries between settlement non-performance
penalties in the cash and futures markets. It is this narrow specific action that successfully ended the squeeze, and as Figure 2 shows, the price distortion, the butterfly yield spread and the implied squeeze probability all fell towards their “normal” values.\textsuperscript{30} The squeezers were relying on the exceptionally high costs of failing in the futures market to force shorts to capitulate as the delivery date approached. The Bank’s narrow action removed futures delivery fail risk, eliminated the fear of the additional LIFFE delivery fail penalties, and ended the squeeze.

One small puzzle does remain. While the 9% 2008 cash issue re-priced back towards more normal no-squeeze equilibrium levels after the Bank of England's policy change, March 98 futures remained slightly overpriced relative to cash on the basis of the cash-and-carry arbitrage relationship. In Figure 9b, the deviation of the futures price from its repo-generated cash and carry arbitrage value remained about +0.02 percent of par value. We interpret this as a premium that the market was willing to pay for an option on "irrational" March 9\textsuperscript{th} delivery behavior. Recall that the 9% 2008 was no longer eligible for delivery after the March 9\textsuperscript{th} delivery date. Once the 9% 2008's eligibility ended, the price of the March 98 futures would jump 2% to reflect the new deliverable: the 8% 2009. Apparently, some market participants were willing to overpay for March 98 futures even after the squeeze threat vanished in the hope that some contract shorts would “forget” to deliver on March 9, 1998.\textsuperscript{31} However, in the end, rational delivery behavior reigned. Indeed, 92,401 contract deliveries were made using the cdil prior to the close of its eligibility window. These deliveries absorbed an amazing 82.4% of the outstanding par value of cdil. No cash market gilt fails occurred and the Bank of England's special repo facility was never used.

8. Concluding remarks

This paper examines the strategic trading behavior of major market participants during an attempted delivery squeeze in a bond futures contract traded on the LIFFE. The defining feature of this paper is that it is the first simultaneous

\textsuperscript{30} Squeeze under normal trading conditions is not that unusual. In February 2001, the one-month gold lease rates jumped from its normal level of under 1% to above 4.5% in a matter of days and the central banks had to intervene by lending additional supply.

\textsuperscript{31} Speculators on delivery irrationality were willing to pay +0.01 to +0.02 percent of par value on a lottery ticket that had a potential payoff of +2.00 percent of par value.
investigation of price distortions and trading positions of major market participants involved in the market-manipulation episode. The paper also analyzes particular institutional features that give an important endgame advantage to squeezers in futures markets.

This paper provides, *inter-alia*, empirical evidence on the strategic trading behavior of major market participants (both dealers and customers) and how learning takes place in the market place in a market-manipulation setting. It shows how prices become distorted when a group of market participants try to manipulate the market. It provides evidence consistent with the notion that the heterogeneity of beliefs is the dominant factor generating trading. It also supports the implications of theoretical short squeeze models.

From a regulatory perspective, this paper has several messages. First, regulators and exchanges need to be very concerned about ensuring that squeezes do not take place, since they are accompanied not only by severe price distortions but also by significant erosion of market depth. Second, futures exchanges should mark-to-market the specifications of their contracts more frequently, so that the prevailing market conditions do not dramatically differ from those assumed in the calculation of conversion factors. Third, regulatory reporting should require flagging of trades like the forward term repo trades that provide control through possession of key deliverable issues against the futures contracts. Under current reporting systems, these trades can go undetected. They may also slip through the internal controls within dealer firms as they do not change net duration risk exposure limits of individual traders. Finally, regulators should take note of the fact that the marked differences in the penalties for settlement failures in the cash and futures markets create conditions that favor squeezes.

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References


Table 1

This table provides an illustrative list of dealer firms in the UK government bond market during the sample period.

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<td>Morgan Stanley</td>
</tr>
<tr>
<td>National Westminster Bank</td>
</tr>
<tr>
<td>Nikko Securities</td>
</tr>
<tr>
<td>Salomon Brothers</td>
</tr>
<tr>
<td>SG Warburg</td>
</tr>
<tr>
<td>Union Bank of Switzerland</td>
</tr>
<tr>
<td>Winterflood Securities</td>
</tr>
</tbody>
</table>
Table 2

This table describes the impact of squeeze on pricing of 9% 2008 and March 1998 Long Gilt futures contract under a flat 6% spot rate term structure. It analyses two scenarios: no squeeze and full-squeeze. In view of LIFFE’s 3-business days delivery invoicing process, the last date on which the 9% 2008 bond can be delivered is March 4, 1998, which corresponds to a cash settlement date of March 5, 1998. All issues are priced on March 4th for regular settlement on March 5th. 9% 2008 issue is financed for 4 days until March 9th. The other issues are financed for 26 days until the March 31st delivery date. The assumed financing rate is the then prevailing average yield of 6%. The delivery cheapness measure is the “net basis” defined as the basis less the issue’s “carry” (coupon accrual less financing cost) over the financing period.

Panel A: No-Squeeze scenario

<table>
<thead>
<tr>
<th>Deliverable Issues Coupon</th>
<th>Maturity</th>
<th>Conversion Factor</th>
<th>Modified Duration</th>
<th>Assumed Yield</th>
<th>Delivery Date</th>
<th>Issue Price</th>
<th>Forward Price</th>
<th>Converted Forward Price</th>
<th>Net Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.00%</td>
<td>10/13/2008</td>
<td>0.9999442</td>
<td>7.02</td>
<td>6.00%</td>
<td>03/09/1998</td>
<td>123.28</td>
<td>123.27</td>
<td>123.27</td>
<td>0.00 CDI</td>
</tr>
<tr>
<td>8.00%</td>
<td>09/25/2009</td>
<td>0.9291579</td>
<td>7.59</td>
<td>6.00%</td>
<td>03/31/1998</td>
<td>116.50</td>
<td>116.40</td>
<td>125.28</td>
<td>1.86</td>
</tr>
<tr>
<td>6.25%</td>
<td>11/25/2010</td>
<td>0.7941347</td>
<td>8.60</td>
<td>6.00%</td>
<td>03/31/1998</td>
<td>102.19</td>
<td>102.19</td>
<td>128.68</td>
<td>4.29</td>
</tr>
<tr>
<td>9.00%</td>
<td>07/12/2011</td>
<td>1.0001748</td>
<td>8.33</td>
<td>6.00%</td>
<td>03/31/1998</td>
<td>127.29</td>
<td>127.20</td>
<td>127.17</td>
<td>3.90</td>
</tr>
<tr>
<td>9.00%</td>
<td>08/06/2012</td>
<td>1.0002554</td>
<td>8.78</td>
<td>6.00%</td>
<td>03/31/1998</td>
<td>128.68</td>
<td>128.59</td>
<td>128.56</td>
<td>5.29</td>
</tr>
</tbody>
</table>

Minimum (P/cf) = 123.27 = Futures Price

Panel B: Full-Squeeze scenario

<table>
<thead>
<tr>
<th>Deliverable Issues Coupon</th>
<th>Maturity</th>
<th>Conversion Factor</th>
<th>Modified Duration</th>
<th>Assumed Yield</th>
<th>Delivery Date</th>
<th>Issue Price</th>
<th>Forward Price</th>
<th>Converted Forward Price</th>
<th>Net Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.00%</td>
<td>10/13/2008</td>
<td>0.9999442</td>
<td>7.02</td>
<td>5.777%</td>
<td>03/09/1998</td>
<td>125.28</td>
<td>125.27</td>
<td>125.28</td>
<td>0.00 co-CDI</td>
</tr>
<tr>
<td>8.00%</td>
<td>09/25/2009</td>
<td>0.9291579</td>
<td>7.59</td>
<td>6.00%</td>
<td>03/31/1998</td>
<td>116.50</td>
<td>116.40</td>
<td>125.28</td>
<td>0.00 co-CDI</td>
</tr>
<tr>
<td>6.25%</td>
<td>11/25/2010</td>
<td>0.7941347</td>
<td>8.60</td>
<td>6.00%</td>
<td>03/31/1998</td>
<td>102.19</td>
<td>102.19</td>
<td>128.68</td>
<td>2.70</td>
</tr>
<tr>
<td>9.00%</td>
<td>07/12/2011</td>
<td>1.0001748</td>
<td>8.33</td>
<td>6.00%</td>
<td>03/31/1998</td>
<td>127.29</td>
<td>127.20</td>
<td>127.17</td>
<td>1.90</td>
</tr>
<tr>
<td>9.00%</td>
<td>08/06/2012</td>
<td>1.0002554</td>
<td>8.78</td>
<td>6.00%</td>
<td>03/31/1998</td>
<td>128.68</td>
<td>128.59</td>
<td>128.56</td>
<td>3.28</td>
</tr>
</tbody>
</table>

Minimum (P/cf) = 125.28 = Futures Price
Table 3

This table provides the details of most delivered bond issue, issue size in £millions, issue size in terms of equivalent number of futures contracts, the peak open interest in terms of number of contracts, actual delivery size in terms of number of contracts, actual delivery size (contract equivalent) versus peak open interest, actual delivery as a percentage of issue size. The **(*) indicates that the number of contracts against which a bond was delivered is significantly different from the average of March 1995 to December 1997 at 1% (5%) level. Source: London International Financial Futures Exchange (LIFFE).

<table>
<thead>
<tr>
<th>Contract Expiry Date</th>
<th>Most delivered bond issue in the spot market</th>
<th>Issue size (£’millions)</th>
<th>Issue size: equivalent no. of future contracts</th>
<th>Peak open interest No. of contracts</th>
<th>Actual delivery: No. of contracts</th>
<th>Actual delivery versus peak open interest</th>
<th>Actual delivery as a % of issue size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mar-98</td>
<td>9.00% Oct 13 2008</td>
<td>£5,621</td>
<td>112,420</td>
<td>194,223</td>
<td>92,401**</td>
<td>47.7%</td>
<td>82.2%</td>
</tr>
<tr>
<td>Dec-97</td>
<td>7.25% Dec 07 2007</td>
<td>£5,000</td>
<td>100,000</td>
<td>197,528</td>
<td>20,559</td>
<td>10.4%</td>
<td>20.6%</td>
</tr>
<tr>
<td>Sep-97</td>
<td>9.00% Oct 13 2008</td>
<td>£5,621</td>
<td>112,420</td>
<td>184,449</td>
<td>27,335</td>
<td>14.8%</td>
<td>24.3%</td>
</tr>
<tr>
<td>Jun-97</td>
<td>8.50% Jul 16 2007</td>
<td>£7,397</td>
<td>147,940</td>
<td>229,943</td>
<td>49,042*</td>
<td>21.3%</td>
<td>33.1%</td>
</tr>
<tr>
<td>Mar-97</td>
<td>8.50% Jul 16 2007</td>
<td>£7,397</td>
<td>147,940</td>
<td>203,199</td>
<td>15,424</td>
<td>7.6%</td>
<td>10.4%</td>
</tr>
<tr>
<td>Dec-96</td>
<td>7.50% Dec 07 2006</td>
<td>£11,700</td>
<td>234,000</td>
<td>168,602</td>
<td>4,230</td>
<td>2.5%</td>
<td>1.8%</td>
</tr>
<tr>
<td>Sep-96</td>
<td>7.75% Sep 08 2006</td>
<td>£4,000</td>
<td>80,000</td>
<td>152,796</td>
<td>8,031</td>
<td>5.3%</td>
<td>10.0%</td>
</tr>
<tr>
<td>Jun-96</td>
<td>9.00% Oct 13 2008</td>
<td>£5,621</td>
<td>112,420</td>
<td>127,654</td>
<td>6,650</td>
<td>5.2%</td>
<td>5.9%</td>
</tr>
<tr>
<td>Mar-96</td>
<td>8.50% Jul 16 2007</td>
<td>£7,397</td>
<td>147,940</td>
<td>148,013</td>
<td>2,359</td>
<td>1.6%</td>
<td>1.6%</td>
</tr>
<tr>
<td>Dec-95</td>
<td>7.50% Dec 07 2006</td>
<td>£11,700</td>
<td>234,000</td>
<td>114,355</td>
<td>13,115</td>
<td>11.5%</td>
<td>5.6%</td>
</tr>
<tr>
<td>Sep-95</td>
<td>7.75% Sep 08 2006</td>
<td>£4,000</td>
<td>80,000</td>
<td>110,623</td>
<td>6,171</td>
<td>5.6%</td>
<td>7.7%</td>
</tr>
<tr>
<td>Jun-95</td>
<td>7.50% Dec 07 2006</td>
<td>£11,700</td>
<td>234,000</td>
<td>107,544</td>
<td>11,529</td>
<td>10.7%</td>
<td>4.9%</td>
</tr>
<tr>
<td>Mar-95</td>
<td>9.50% Apr 18 2005</td>
<td>£4,842</td>
<td>96,840</td>
<td>111,098</td>
<td>9,302</td>
<td>8.4%</td>
<td>9.6%</td>
</tr>
</tbody>
</table>

Average (March 1995 through December 1997) 143,958 154,650 14,479 8.7% 11.3%
Table 4: Schematic Representation of Market Participants Trades

<table>
<thead>
<tr>
<th>Dates</th>
<th>Market Participant Activity in 9% 2008 Bond Issue</th>
<th>Price impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase I: September 1, 1997 to October 15, 1997</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oct 7th - Oct 15th</td>
<td>SC3 &amp; SC4 built up long FTR positions to ~£1.3 billion.</td>
<td>Initiation of price distortion</td>
</tr>
<tr>
<td>Oct 15th</td>
<td>CD4 built up short position to ~£0.8 billion.</td>
<td></td>
</tr>
<tr>
<td>Oct 16th - 23rd</td>
<td>SD1 built up a position of ~£0.9 billion.</td>
<td>Widening of price distortion</td>
</tr>
<tr>
<td>Oct 16th - 30th</td>
<td>SD2 built a long position in FTRs of upto ~£2.0 billion.</td>
<td>Price distortion increased to 0.25%</td>
</tr>
<tr>
<td>Oct 30th - Nov 4th</td>
<td>SD2 built a significant long position of ~£1.4 billion in a very short time.</td>
<td>Sharp jump in price distortion up to 0.70%</td>
</tr>
<tr>
<td>Nov 5th - January 9, 1998</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nov 28th - Dec 4th</td>
<td>CD2 &amp; CD4, contrarian dealers, built short positions of over £1.0 billion each.</td>
<td>Price Distortion remained in a band of ~0.60-0.70%</td>
</tr>
<tr>
<td>Dec 2nd - 10th</td>
<td>SC5 &amp; SC6, late entrants, took long positions of ~£1.2 billion.</td>
<td></td>
</tr>
<tr>
<td>Dec 4th - 5th</td>
<td>CC4, a contrarian, built a short position of ~£1.3 billion, increasing further to ~£2.0 billion by early January 1998.</td>
<td></td>
</tr>
<tr>
<td>Dec 29th - 31st</td>
<td>SC6, a late entrant, built a long position of ~£0.9 billion.</td>
<td></td>
</tr>
<tr>
<td>Dec 30th - 31st</td>
<td>SD3 booked profits by partly unwinding its long position</td>
<td></td>
</tr>
<tr>
<td>Jan 7th</td>
<td>SD1 rapidly built up a long position of ~£1.3 billion after limited profit taking over the entire Phase III</td>
<td></td>
</tr>
<tr>
<td>Phase IV: January 12, 1998 to January 27, 1998</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jan 12th - 27th</td>
<td>Squeezers maintain an aggregate long position at around £5.5 billion. SD2 booked profits partially during this period.</td>
<td>Price distortion increased to ~1.00%</td>
</tr>
<tr>
<td>Jan 12th - 27th</td>
<td>Contrarians increased their aggregate short position to ~£7.0 billion (reaching a max. of £7.6 billion on Jan 21st)</td>
<td></td>
</tr>
<tr>
<td>Phase V: January 28, 1998 to February 13, 1998</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jan 28th - Feb 13th</td>
<td>Contrarians continued to maintain a significantly bigger short position (<del>£6.5 billion) as opposed to the long position held by squeezers (</del>£5.5 billion)</td>
<td>Price Distortion declined to ~0.70%</td>
</tr>
<tr>
<td>Feb 16th</td>
<td>Bank of England announced a conditional buy-back policy</td>
<td>Price Distortion declined to 0.20% by Mar 4th.</td>
</tr>
</tbody>
</table>
Table 5

The regression equation used for the results in the table below is:

\[
\Delta X_t = \sum_{i=1}^{6} D_{t,i} \alpha_i + \sum_{i=1}^{6} \sum_{d=1,2}^{6} \lambda_{i,d} D_{t,i} D_{d,t} \Delta I_t + \phi X_{t-1} + \xi_{t,t}
\]

where \( X_t \) is the mispricing of \( cdil \) at the end of day \( t \) (as measured by the deviation from its term-structure based discounted cash-flow value), \( \Delta X_t \) is the change in \( X_t \) from end of day \( t-1 \) to end of day \( t \), \( D_{t,i} \) is a dummy variable for phase \( i \) (\( i = I, II, ..., VI \)), \( D_{d,t} \) is a dummy variable for the direction of order-imbalance (net buys or net sells), \( \lambda_{i,d} \) is the market depth (similar to Kyle’s (1985) lambda) in phase \( i \), \( \Delta I_t \) is the net customer order-flow on day \( t \), and order-imbalance direction \( d \) (\( d=1 \) for customer buys and \( d=2 \) for customer sells), and \( \phi \) is the mean-reversion that would ordinarily exist in the mispricing of \( cdil \) irrespective of any squeeze related effects.

<table>
<thead>
<tr>
<th>Regressor</th>
<th>Slope coefficient</th>
<th>t-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant for Phase I</td>
<td>0.011</td>
<td>0.72</td>
</tr>
<tr>
<td>Constant for Phase II</td>
<td>0.075</td>
<td>3.48</td>
</tr>
<tr>
<td>Constant for Phase III</td>
<td>0.188</td>
<td>4.96</td>
</tr>
<tr>
<td>Constant for Phase IV</td>
<td>0.268</td>
<td>5.42</td>
</tr>
<tr>
<td>Constant for Phase V</td>
<td>0.130</td>
<td>3.07</td>
</tr>
<tr>
<td>Constant for Phase VI</td>
<td>0.133</td>
<td>3.43</td>
</tr>
<tr>
<td>Customer Sells Ph I</td>
<td>-0.108</td>
<td>-0.75</td>
</tr>
<tr>
<td>Customer Sells Ph II</td>
<td>-0.301</td>
<td>-5.93</td>
</tr>
<tr>
<td>Customer Sells Ph III</td>
<td>-0.025</td>
<td>-0.30</td>
</tr>
<tr>
<td>Customer Sells Ph IV</td>
<td>0.070</td>
<td>1.42</td>
</tr>
<tr>
<td>Customer Sells Ph V</td>
<td>-0.303</td>
<td>-1.48</td>
</tr>
<tr>
<td>Customer Buys Ph I</td>
<td>0.016</td>
<td>0.13</td>
</tr>
<tr>
<td>Customer Buys Ph II</td>
<td>0.279</td>
<td>0.78</td>
</tr>
<tr>
<td>Customer Buys Ph III</td>
<td>-0.009</td>
<td>-0.14</td>
</tr>
<tr>
<td>Customer Buys Ph IV</td>
<td>0.075</td>
<td>1.82</td>
</tr>
<tr>
<td>Customer Buys Ph V</td>
<td>0.182</td>
<td>2.97</td>
</tr>
<tr>
<td>Customer Buys Ph VI</td>
<td>0.482</td>
<td>2.21</td>
</tr>
<tr>
<td>( X_{t-1} )</td>
<td>-0.305</td>
<td>-5.50</td>
</tr>
</tbody>
</table>

Adjusted R-Square : 38.2%
This table reports how the total amount of trading among squeezers (customers and dealers) and contrarians (customers and dealers) is distributed during the six phases of the squeeze: trading between squeezers and contrarians, trading among squeezers or trading among contrarians.

<table>
<thead>
<tr>
<th>Trading between</th>
<th>Squeezers and Contrarians</th>
<th>Among the Squeezers</th>
<th>Among the Contrarians</th>
</tr>
</thead>
<tbody>
<tr>
<td>During Phase I</td>
<td>97.9%</td>
<td>2.1%</td>
<td>0.0%</td>
</tr>
<tr>
<td>During Phase II</td>
<td>97.5%</td>
<td>2.5%</td>
<td>0.0%</td>
</tr>
<tr>
<td>During Phase III</td>
<td>88.1%</td>
<td>11.4%</td>
<td>0.5%</td>
</tr>
<tr>
<td>During Phase IV</td>
<td>82.2%</td>
<td>16.9%</td>
<td>0.9%</td>
</tr>
<tr>
<td>During Phase V</td>
<td>81.7%</td>
<td>15.8%</td>
<td>2.5%</td>
</tr>
<tr>
<td>During Phase VI</td>
<td>79.5%</td>
<td>19.5%</td>
<td>1.0%</td>
</tr>
<tr>
<td>Overall</td>
<td>89.5%</td>
<td>9.9%</td>
<td>0.6%</td>
</tr>
</tbody>
</table>
Figure 1

Figure 1a plots the long-term bond yields from September 1994 to March 1998. Figure 1b provides snapshots of the term structure and Figure 1c displays the squeeze value over the sample period (September 1, 1997 to March 4, 1998).
Figure 2

This figure reports the price distortion, butterfly yield spreads and implied squeeze probability during the sample period (September 1, 1997 to March 4, 1998).

2a. Price Distortion over Time

2b. Butterfly Yield Spread

2c. Implied Squeeze Probability
Figure 3

This figure plots the par value position of the six squeezing customers (in millions of Pound Sterling) in the context of the price distortion (in %) during the sample period (from September 1, 1997 to March 4, 1998).

3a. Inventories of First Three Squeezing Customers

3b. Inventory of Squeezing Customer (Active Trader)

3c. Inventories of Squeezing Customers (Late Entrants)
This figure plots the par value position of the four squeezing dealers (in millions of Pound Sterling) in the context of the price distortion (in %) during the sample period (from September 1, 1997 to March 4, 1998).

4a. Inventory of Squeezing Dealer 1

4b. Inventory of Squeezing Dealer 2

4c. Inventories of Squeezing Dealers (Profit Takers)
Figure 5

This figure plots the par value position of the forward term repo positions of two squeezing customers and one squeezing dealer (in millions of Pound Sterling) in the context of the price distortion (in %) during the sample period (from September 1, 1997 to March 4, 1998).
Figure 6

This figure plots the par value position of the four contrarian dealers (in millions of Pound Sterling) in the context of the
price distortion (in %) during the sample period (from September 1, 1997 to March 4, 1998).

6a. Inventories of First Two Contrarian Dealers

6b. Inventories of Contrarian Dealers (Late Entrants)

6c. Inventory of Contrarian Dealer 4
This figure plots the par value position of the five contrarian customers (in millions of Pound Sterling) in the context of the price distortion (in %) during the sample period (from September 1, 1997 to March 4, 1998).
Figure 8
This figure plots the par value position of squeezing customers and dealers, and contrarian customers and dealers (in millions of Pound Sterling) in the context of the price distortion (in %) from September 1, 1997 to March 4, 1998.
Figure 9

Figure 9a plots the LIBOR rate, the general collateral rate and the implied repo rate (in %) during the sample period (from September 1, 1997 to March 4, 1998). Figure 9b plots the mispricing of futures contract under two scenarios: first, when the financing rate is the general collateral rate, and second, when the financing rate is LIBOR rate during the sample period.