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To squeeze or not to squeeze? That is no longer the question

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Abstract: This paper provides an investigation into an anomaly called a short squeeze, in the CBOT T-Bonds Futures Market, for the period spanning January 1985 to September 2014. A short squeeze occurs when market manipulations cause the cheapest-to-deliver bond to be in short supply, resulting in significant price distortions. The incentive for market manipulation, or squeeze potential, is evaluated over the last 30 years and is related to documented episodes of the CBOT futures market. The squeeze potential is associated to the imperfections of the conversion system. It is observed that conditions are presently very favorable to the occurrence of short squeezes.

Key Words: Futures, treasury bonds, short squeeze, liquidity, cheapest-to-deliver.

Résumé : Cet article présente une analyse empirique d'une anomalie appelée congestion ou "short squeeze" sur le marché des contrats à terme sur bons du Trésor du Chicago Board of Trade (CBOT), durant la période allant de janvier 1985 à septembre 2014. Une telle congestion se produit lorsque des manipulations du marché réduisent la disponibilité de l'obligation "moins chère à livrer", causant ainsi des distorsions importantes dans les prix des contrats à terme. Nous proposons une mesure de l'incitatif à de telles manipulations et relions cette mesure aux épisodes de congestions documentés sur le marché du CBOT au cours des 30 dernières années. Nous associons cet incitatif aux imperfections du système de facteurs de conversion du CBOT et constatons que les conditions actuelles sont très favorables à de telles manipulations.

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1 Introduction

The proper functioning of the financial system relies heavily on U.S. Treasury securities. A first reason for this is their role as a fixed-income benchmark, as they are used by the financial sector to price other securities and as collateral in other financial instruments. A second reason is that Treasury securities act as a safe haven, to which investors move money in times of financial turmoil. And a final reason is that U.S. Treasury securities are the underlying instrument for Treasury futures contracts, which are crucial hedging vehicles for investors and traders in government bonds, mortgage-backed securities, corporate bonds and other fixed-income investments. Because of these important roles, U.S. Treasury issues have an impact on the smooth functioning of other debt, derivatives and equity markets, and any liquidity problems in these government securities can affect all participants in the financial system.

This paper analyzes the impact of some of the features of U.S. Treasury futures contracts on market delivery anomalies and on associated price distortions in the underlying Treasury securities market. Futures contracts written on long-maturity Treasury bonds (T-bonds in the sequel) and traded on the Chicago Board of Trade (CBOT) are widely used in the U.S., largely because of their ability to hedge long-term interest-rate risk. Since the notional underlying security (presently a T-bond with a maturity of 20 years and a coupon rate of 6%) is hypothetical and generally not traded in the marketplace, the CBOT offers the short trader the option to choose which issue to deliver among a set of deliverable bonds (this is called the choosing or *quality* option). To make the delivery fair for both parties, the price received by the short trader is adjusted according to the quality of the delivered issue. This adjustment is made via a system of conversion factors that tend to put all deliverable bonds on roughly equal footing by scaling the futures price up or down to reflect higher or lower coupons (compared to the reference coupon rate). Since the CBOT's conversion system is not perfect,[1] the short trader will always find some issues more profitable or less costly to deliver than others (see e.g. Ben-Abdallah et al. (2009) and Oviedo (2006) for a discussion of the bias in the CBOT conversion factor system). The security that is the most profitable for the short trader to deliver is called the cheapest-to-deliver (CTD). The actual delivery day within the delivery month is also at the option of the short trader (this is known as the *timing* option). These delivery privileges given to the short trader have been the subject of considerable research (see for instance Burghardt et al. (2005) for an extensive description of delivery options embedded in T-bond futures).

In the U.S. T-bonds futures market, the delivery process generally performs well. This is basically thanks to the existence of a large basket of bonds eligible for delivery, to the possibility of delivering at any time during the month, and finally, to the high liquidity of the underlying U.S. government securities. The futures contract design, which originally aimed at alleviating the demand initiated by the futures market on a single issue, has however created some market delivery anomalies called corners or *squeezes*. The U.S. Commodity Futures Trading Commission (CFTC hereafter) defines a squeeze as "*A market situation in which the lack of supplies tends to force shorts to cover their positions by offset at higher prices.*" The term *congestion* is also used to refer to a market squeeze. According to the CFTC, congestion is "*A market situation in which shorts attempting to cover their positions are unable to find an adequate supply of contracts provided by longs willing to liquidate or by new sellers willing to enter the market, except at sharply higher prices.*" In general, a short squeeze develops when the obligations of short traders to cover their positions in a particular issue exceed the amount of the issue available to trade, resulting in an increased delivery cost. More specifically, in the U.S. T-bond futures market, a short squeeze occurs when the outstanding amount of the underlying CTD is insufficient to meet all the delivery requirements; a classic manipulative squeeze consists of acquiring a substantial long position in the futures contract and a sizeable fraction of its CTD bond issue, possibly via repurchase agreements.

Several of these major anomalies have occurred in the past and resulted in significant and severe distortions in futures prices, thus reducing their hedging effectiveness. In such cases, the underlying securities become illiquid and usually trade *on special* in the reverse repo market. This "specialness" increases the short traders' cost of delivery and can even result in significant losses, especially if the reverse repo rate on the special issue goes negative. Short traders could then be unable or unwilling (depending on the amount of the penalty)

[1] According to the CBOT conversion factor system, bonds are equally attractive only if the term structure is flat at the level of the notional coupon rate.

to fulfill their futures obligations, resulting in a delivery failure. It is worthwhile mentioning that a cascade effect in delivery failures can be created if, for instance, the issue purchased in order to fulfill a short position in a futures contract serves as collateral in another trade (repurchase agreement), causing this last trade to fail as well.

This paper examines the factors contributing to the likelihood of a manipulative squeeze in the CBOT T-bond futures market. This is done using an adaptation of the pricing model proposed in Ben-Abdallah et al. (2012) to evaluate the *squeeze potential* by measuring the possible profit arising from such a manipulation; contrary to previous works in the literature, this evaluation accounts for the delivery options embedded in the contract, as well as the stochastic nature of interest-rates. An empirical investigation of anomalies in the futures price along with this measure of the squeeze potential is then performed, over the period of March 1985 to September 2014. The likelihood measure proposed in this paper is remarkably linked to the historical occurrence of squeezes, and can be related to the relationship between the interest-rate term structure and the characteristics of the notional security used by the CBOT. This leads to the conclusion that the CBOT reference rate is presently too high, fostering the occurrence of squeezes and market manipulations.

These results are important because congestion effects in bond and futures markets are likely to be exacerbated in the future, as governments worldwide cut down debt issuance while the trading volume in futures markets keeps growing. Possible distortions in futures prices should be seriously considered, as hedgers, arbitrageurs and speculators have a keen interest in the fair pricing of futures contracts. These findings are also useful to futures exchanges in developing contract specifications and conversion factor systems in order to reduce the risk of market manipulation and the likelihood of short squeezes, thus improving the hedging effectiveness of interest-rates futures.

This paper is organized as follows. Section 2 presents a brief review of the literature analyzing incentives and consequences of market manipulation and recorded short squeezes in the history of futures markets. Section 3 presents the model and data used to evaluate the likelihood of manipulative squeezes. Results are analyzed and related to recorded episodes of price distortions and market manipulation in Section 4, where a strong empirical link is found between the squeeze potential and controllable features of the futures contracts, namely, the difference between the notional coupon and the short-term interest rate. Section 5 concludes that the squeeze potential is presently very high, and advocates a reduction in the rate of the notional underlying security of the CBOT T-bond futures.

2 Manipulation of futures markets

The seminal paper by Kyle (1984) proposes a formal futures pricing model that can take into account market manipulations by traders of commodity futures. The model is developed in the framework of a game of asymmetric information between different types of agents operating in the market. The author also examines the effectiveness of regulatory policies aimed at countering squeezes, such as cash settlements, position limits, or the modification of delivery differentials. He essentially finds that the incentive to manipulate the futures market cannot be completely eliminated. This publication gave rise to an important stream of papers presenting models of market manipulation based on strategic interactions between market participants, and suggesting mitigation measures for the regulator. Among them are Vila (1988) who proposes extensions to Kyle's model of manipulation by informed insiders; Jarrow (1992) who considers large players that can influence prices through their trades; Cooper and Donaldson (1998) who analyze a dynamic game where the manipulating player exploits the forcible delivery feature of a futures contract, thereby restricting the availability of the commodity and increasing its price above its fundamental value; Kumar and Seppi (1992) who show that market manipulation can occur even with cash settlements and uninformed manipulators; and Pirrong (2001) who shows that, depending on delivery differentials, cash-settled contracts may be more vulnerable to manipulation than delivery-settled contracts, while the latter are more vulnerable to manipulations by large short sellers.

On the specific subject of supply manipulation in T-bond markets, two main issues have been studied in the recent literature. In a first stream considering structural issues, Schinasi et al. (2001) examine the financial implications of the shrinking supply of U.S. Treasury securities. Blanco (2002) also addresses this question by comparing the impact of the reduction in government bond supply in the U.S. and European markets on yield curves as well as on market operation. A second set of papers study futures price distortions and their relation to embedded option prices. Among them, Jordan and Kuipers (1997) examine these distortions in the U.S. T-bond futures market and show that the value of the put option embedded in the futures contract can be negative due to the bond's CTD value. Järvinen and Käppi (2004) propose measures of relative mispricing in the 10-year German government bonds (Bund) and Bund futures markets following short squeezes, and examine the implied value of the quality option embedded in the futures contract and the cost of choosing the second-cheapest-to-deliver Bund. Their results show some evidence of occasional squeezes in the Bund futures market. Merrick et al. (2005) investigate an attempted delivery squeeze in a bond futures contract traded on the London International Financial Futures and Options Exchange (LIFFE) and relate price distortions to the quality option embedded in the contract, and to asymmetries in penalties on failures to deliver in the cash, futures and repo markets. Sihvonen (2008) examines the dynamics of the premium of the Bund that are CTD for EUREX-traded futures contracts. He finds evidence that short-selling the current CTD against a non-deliverable bond using cash and repo markets generates statistically significantly positive profits. The author also empirically shows that the main factors governing the CTD premium are relative cheapness in delivery, amount of physical deliveries and special repo rates.

Finally, one can find reports and detailed analyses of major episodes of market manipulation and price distortions in the U.S. and Euro areas in various academic and professional publications. Here is an overview of such publications, showing that market manipulations occurred many times and in a variety of markets over the last thirty years:

- Seeman (1986), Burstein (1987), Cornell and Shapiro (1989) and Burghardt et al. (2005) on the 1985–1986 U.S. T-bond squeeze by Japanese institutions.
- Jegadeesh (1993) and Jordan and Jordan (1996) on the 1991 U.S. two-year T-notes squeeze by Salomon Brothers.
- CFTC (1996) on the June 1993 ten-year U.S. T-notes futures squeeze by Fenchurch Capital Management Inc.
- Latter (1998) on the squeeze of the LIFFE September 1997 futures contract on Italian Government Bonds (BTP) due to the predictability of its CTD. This short squeeze led both the LIFFE and the Italian futures market (MIF) to decrease the notional coupon rate on five- and ten-year BTP futures contracts (see FRB 1997), and the LIFFE to change the composition of the deliverable basket.
- Jeanneau and Scott (2001) on the Eurex five-year German government note contract (bobl) short squeeze by a small number of European banks. This lead the Eurex to introduce position limits on open interest of market participants and to lower penalties for delivery failures.
- Jeanneau and Scott (2002) on a squeeze in the cash market of the two-year German government notes (schatz) that was the CTD of the Eurex March 2002 contract.
- Morgenson (2005) and Bhaktavatsalam (2010) on the squeeze of the U.S. June 2005 10-year note contract by the Pacific Investment Management Company (Pimco).
- Clouse (2006) on the 2005-2006 period of questionable trading practices and squeeze attempts among primary dealiers in the secondary market for U.S. Treasury securities.
- CFTC (2009) on the U.S. September 2005 T-note futures contract squeeze by EMF Financial Products.

3 Model and data

One of the rationales behind the futures contract allowing for the delivery of any bond in a basket of eligible bonds is to limit the incidence of a market manipulation restricting the supply of the deliverable issue. The conversion factor system aims at making all eligible bonds equivalent for delivery. The CBOT conversion factors are computed by assuming that the spot yield curve is flat at the level of the notional coupon of the futures contract. As expected, when the spot yield curve differs significantly from these assumptions, all bonds are not equal for delivery, and the short traders will want to deliver the CTD. The CTD is not the bond with the lowest market price amongst the deliverable grades, but is rather the bond that maximizes the theoretical net return of a short hedge in the futures market, i.e., the return on buying the cash bond, carrying the bond to delivery and delivering the bond into the futures contract.[2] Accordingly, the theoretical price of the futures contract is obtained by making the values to both parties equal to 0, assuming that the CTD will be delivered. When there is a significant difference between the return of a short hedge using the CTD and the next cheapest-to-deliver bond, then there is an opportunity for a squeeze, for instance by acquiring large long positions in the futures contract and reducing the supply of CTD available for physical delivery in the cash and repo markets, thus forcing some short traders to deliver another issue of the deliverable basket.

3.1 Squeeze potential measure

As pointed out in Kyle (1984), when the CTD becomes in short supply, the price of the futures contract and the price of the CTD both rise to make the second issue equal for delivery with the CTD. The potential for a squeeze therefore depends both on the composition of the deliverable basket and on the shape and level of the interest yield curve. A measure of the squeeze potential is used in Merrick et al. (2005) as the difference between the prices of theoretical forward contracts on the CTD and the second-cheapest-to-deliver issue. However, one of the consequences of the delivery options embedded in the CBOT T-bond futures contract is that the CTD (and its delivery date) cannot be determined easily in advance (recall that one of the reasons for the 2005 T-note squeeze was the fact that the CTD was predictable long in advance).

The pricing model in Ben-Abdallah et al. (2012) is used here in order to measure the squeeze potential more precisely. This model accounts for all the delivery features of the contract (quality option, delivery sequence, end-of-month and wild-card timing options) and for payments in the marking-to-market account, under a stochastic interest-rate assumption. Accordingly, the fair settlement price of the futures contract (making the value for both parties equal to 0) is computed by backward recursion on each day of the delivery month, under the assumption that the CTD is available, and under the assumption that the short seller has to deliver the next cheapest issue.[3] Starting from $t =$ the last day of the delivery month until $t = 1$, the algorithm can be summarized as follows:

Algorithm 1

1. Find the CTD and the actual loss on delivery for the short trader at notice date $t + 1$ (at 5:00 p.m.) as a function of the current short-term interest rate and futures price.
2. At the corresponding position date t (at 8:00 p.m.), determine if it is better to issue an intention to deliver or to wait at least until the next position date, on the basis of the expected value of the loss on delivery vs. either the expected value of the interim payments at the next marking-to-market date (when trading takes place) or the expected value of the contract (during the last seven business days of the delivery month). This yields the value of the contract at the position date for the short trader, as a function of the interest rate and futures price.
3. At the settlement date t (at 2:00 p.m.), compute the fair settlement price as a function of the short-term interest rate, making the expected value of the function computed at step 2 equal to 0. This yields the fair futures price as a function of the interest rate at the settlement date t .
4. If $t > 1$, set $t = t - 1$ and return to Step 1.

The result yields the futures price, as a function of the current interest rate, on the first day of the delivery month, assuming that the CTD is available for delivery at all possible delivery dates. One can then apply a similar procedure while assuming, in Step 1, that the short trader has to deliver the second-cheapest issue (at any delivery date). The resulting futures price will be higher on each day of the delivery month because the loss on delivery of the short trader at each possible delivery date will be higher, and futures prices will adjust at each settlement date to make the expected value of the contract equal to 0.

[2] This theoretical net return is called the implied repo rate; differences between this theoretical return and the actual return are generally very small because of the approximately offsetting effects in the futures and cash markets since the bond is financed through the repo market (see for instance Burghardt et al. (2005) for a discussion of these offsetting effects).

[3] Notice that the CTD is not a known single bond; it depends on the current date, on the current interest rate and on the interest term structure.

The difference between the two possible values (according to the availability or not of the CTD) of the futures price on the first day of the delivery month is used as a measure of the squeeze potential. This measure depends on the composition of the deliverable basket, but also on the stochastic behavior of the interest rate via the computation of expected values, and it accounts for the delivery options in the CBOT futures contract. It represents the expected profit, on the first day of the delivery month, from having a long position in the futures contract when the CTD is unavailable and the second-best variety is delivered by the short trader.

Clearly, there are other ways to detect a squeeze, namely, when the price of a CTD bond becomes higher than the discounted value of its future cash flows, or when it becomes unavailable in the repo market, trading on special low repo rates. However, the focus here is in rather measuring the potential for such events to occur, possibly before a squeeze is attempted. The empirical analysis is done using the squeeze potential on the first day of the delivery month, but the squeeze potential measure can be computed at any time from the inception to the maturity of a futures contract.

3.2 Data

3.2.1 Futures contracts

The analysis considers 119 futures contracts traded in the period between January 1, 1985, and September 30, 2014, representing the quarterly delivery cycles of the nearby futures contracts. Futures prices are obtained from the Chicago Board of Trade. Notice that, prior to March 2000, the notional bond coupon rate was equal to 8%, and has since then been reduced to 6%.

The basket of deliverable bonds until 2010 is determined based on the information about the issue dates of the 15- to 30-year U.S. Treasury bonds, which is available on the TreasuryDirect web site. On January 11, 2010, the CME Group launched the Ultra Treasury Bond futures contract, so that, effective with the March 2011 expiry, the deliverable basket includes bonds with remaining terms to maturity of between 15 to 25 years. Figure 1 presents the number of eligible bonds for the 119 lead futures contracts considered in this paper.

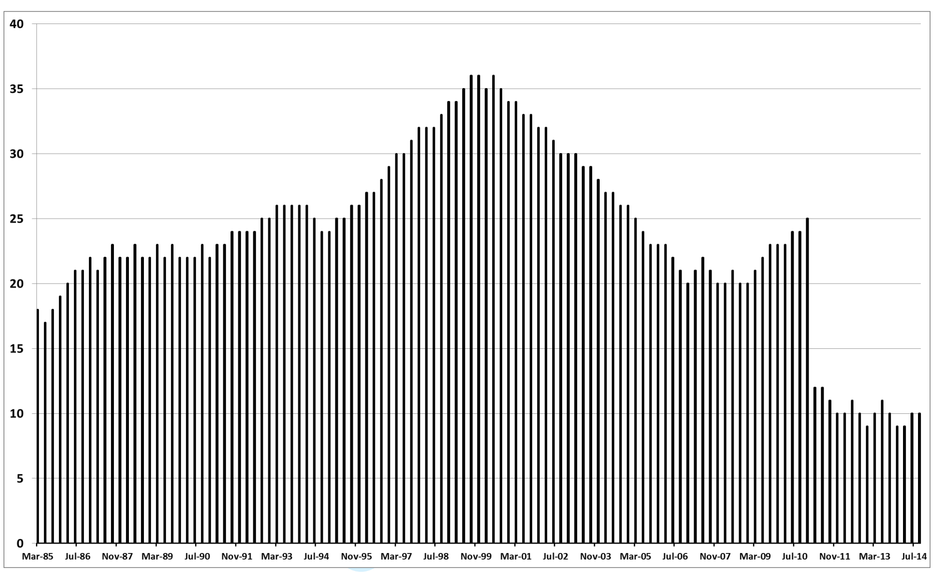


Figure 1: Deliverable basket size (number of eligible bonds) over time.

3.2.2 Interest rates and yield curves

The model used for the instantaneous spot interest rate is the Hull and White (1990) continuous-time model

$$dr_t = \kappa\left(\overline{r}(t) - r_t\right)dt + \sigma dB_t, \quad t \geq 0,$$

where $\{B_t, t \geq 0\}$ is a standard Brownian motion, κ is the mean reversion speed, σ is the volatility, and $\overline{r}(t)$ is the long-term mean expressed as a deterministic function of time in order to fit the model to the observed yield curve. The resulting long-term mean is then given by

$$\begin{aligned}\overline{r}(t) &= f(t) + \frac{1}{\kappa}f'(t) + \frac{\sigma^2}{2\kappa^2}\left(1 - e^{-2\kappa t}\right)\\ f(t) &= \gamma_0 + \left(\gamma_1 + \gamma_2\frac{t}{\gamma_4}\right)e^{(-t/\gamma_4)} + \gamma_3\frac{t}{\gamma_5}e^{(-t/\gamma_5)},\end{aligned}$$

where $f(t)$ is the instantaneous Svensson Nelson and Siegel (SNS) forward-rate curve (see Svensson (1994) and Björk and Christensen (1999)) and $(\gamma_0, \gamma_1, \gamma_2, \gamma_3, \gamma_4, \gamma_5)$ are fitting parameters. The six SNS model parameters, as well as the mean reversion speed and the volatility of the Hull-White model are estimated on the first day of the delivery month of each futures contract considered in this study. Mean reversion speed and volatility are obtained using maximum likelihood to calibrate the Vasicek (1977) model to the short-term interest-rate data over the period ranging from January 1, 1982, to the evaluation date of each contract. The estimates of the SNS parameters at the evaluation date of each contract are provided by Gürkaynak et al. (2007); these are posted and updated periodically on the website of the Federal Reserve.[4]

The interest-rate data consists of 3-month-maturity Treasury-Bill rates covering the period from January 1, 1982, to September 30, 2001, and 1-month-maturity Treasury-Bill rates covering the period from October 1, 2001, to September 30, 2014, obtained from the Federal Reserve Statistical Release. The frequency is monthly (381 observations). These rates are interpreted as proxies for the instantaneous riskless interest rate (Chapman et al. 1999). The observed term structure consists of Treasury yield curves for maturities ranging between 3 months and 30 years for the period between January 1, 1985, and September 30, 2014, which are also obtained from the Federal Reserve Statistical Release.

Figure 2 shows the estimated spot-yield surface computed on the first day of the delivery month of the nearest-expiring futures contract during the period of study. Notice that this surface is generally upward-sloping during the period.

4 Empirical investigation

4.1 Results

Figures 3 and 4 compare the observed and theoretical futures prices of a nominal \$100 contract obtained using Algorithm 1, on Day 1 of the delivery month of each futures contract traded between January 1985 and September 2014. Pricing differences are generally small, and on average negative, which is consistent with the empirical financial literature (market futures prices are lower than what they should be when the term structure is upward sloping).

Finally, Figure 5 plots the proposed measure of the squeeze potential, that is, the difference between theoretical futures prices according to the availability or not of the CTD for delivery during the delivery month. The squeeze potential is expressed in percentage points of par (ppp) for a nominal \$100 contract.

Notice that the squeeze potential indicates the potential significance of gains from short squeezes, and does not necessarily correspond to actual episodes of market manipulation. On the other hand, significant positive differences between observed and theoretical futures prices represent price distortions that most probably correspond to market manipulations. The correlation between the squeeze potential and pricing differences series is 0.61; a simple linear regression shows that the squeeze potential is highly significant to explain price distorsions (p-value is 10^{-13}).

[4] http://www.federalreserve.gov/econresdata/researchdata/feds200628_1.html

Figure 2: Spot-yield surface.

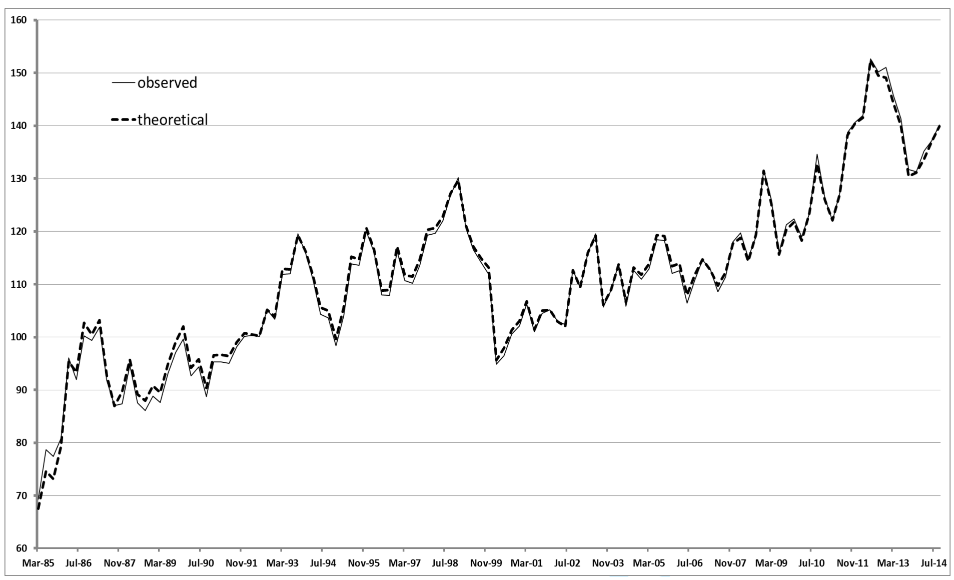


Figure 3: Observed vs. theoretical futures prices (in US $) on Day 1 of the delivery month.

4.2 Analysis

This section analyzes the large pricing distortions and squeeze-potential measures observed over the period of study, and relate them to events that influenced the CBOT T-bond futures market.

4.2.1 March 1985–March 1986

The largest price distortion in the period of study occurs in March 1985–March 1986, culminating in a price difference of $4.27 in September 1985. During this period, four of the largest squeeze-potential evaluations are obtained, ranging from 42 ppp to 58 ppp. This episode coincides with the most dramatic squeeze in the history of U.S. basis trading.

In 1985, Japan's trade surplus reached more than US$50 billion and Japanese securities firms aggressively expanded their presence in the fixed-income U.S. market. Japanese investors invested massively in U.S. Trea-

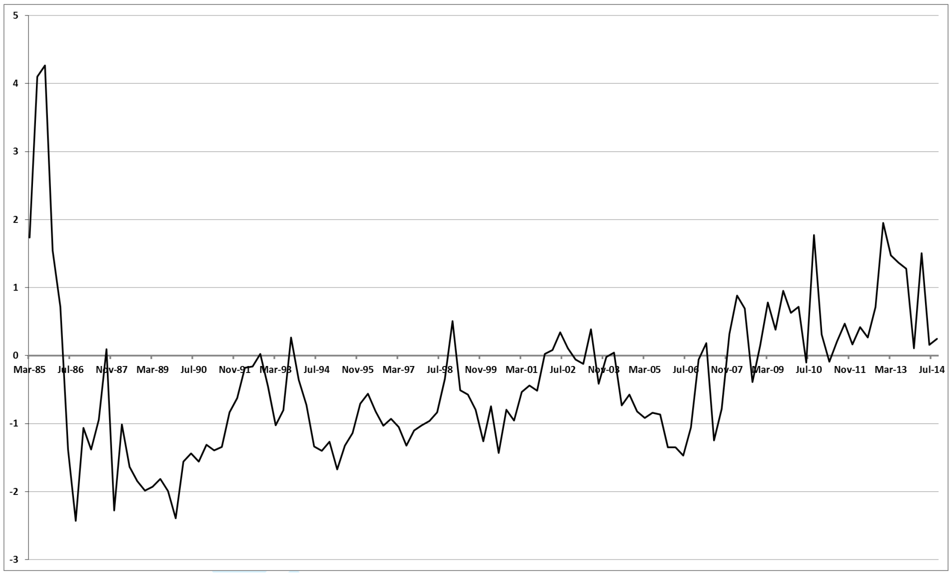


Figure 4: Difference (in US $) between observed and theoretical futures prices on the first day of the delivery month.

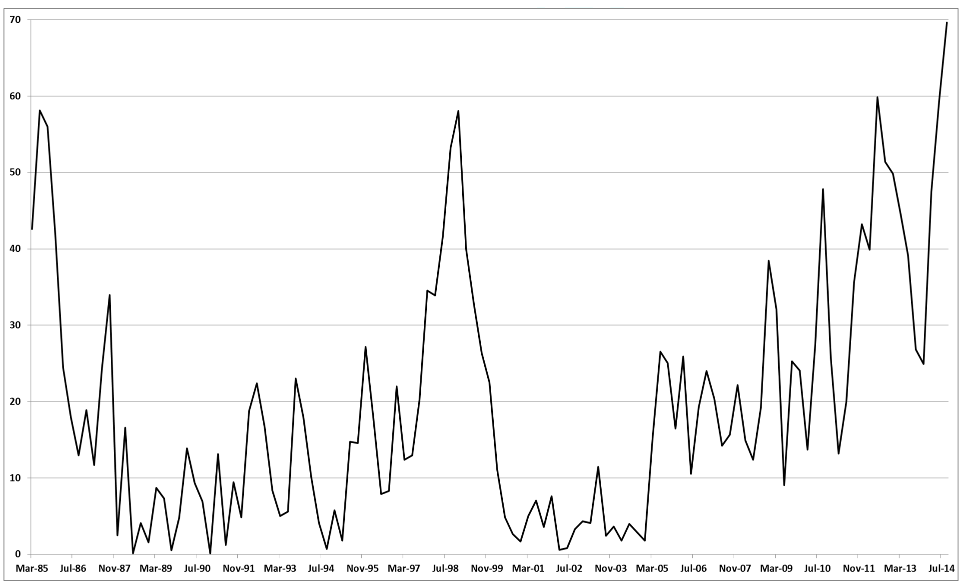


Figure 5: Squeeze potential on the first day of the delivery month (ppp).

sury bonds, which were not made available on the repo market as Japanese institutions were not accustomed to repo transactions. Specifically, in May 1986, the Japanese were withholding the CTD of the June 1986 futures. This squeeze went on for some time until Nomura Securities stepped in to ease the crisis by obtaining $500 million in U.S. bonds from its Japanese clients and making them available to American dealers. One can refer to Seeman (1986) and Burstein (1987) for a detailed discussion of the 1985-1986 Japanese investment strategies in the U.S. fixed-income market as well as the resulting short squeeze in May 1986.

4.2.2 September 1993

In September 1993, the prices of T-bond futures reached their highest value since they began trading in 1977. This can be explained by the 1993 "bond rally," as a wide range of market participants had taken sizeable leveraged bond positions on the assumption that the increasing price trends prevailing in the bond market through 1993 would continue. The squeeze potential was relatively high, at 23 ppp at the beginning of the September 1993 futures delivery month, and at that time a corresponding \$0.26 overvaluation of the futures price is observed. The futures price and squeeze potential then fell sharply in 1994 as the Federal Reserve raised the federal funds rate, and bondholders were forced to liquidate their long bond positions in order to limit their losses. For a detailed description of 1993-1994 developments in the bond market, see to Dini (1994).

4.2.3 March 1998–September 1999

The squeeze potential measure is very high during this period, averaging 41 ppp and reaching 58 ppp for the December 1998 contract. At that time, yields were substantially below the notional coupon level (8%), favoring delivery of the lowest-duration bond. Also, the T-bond maturing in February 2015 and offering a coupon rate of 11.25% retained the status of CTD grade almost without interruption during that period, while the second CTD was significantly more expensive. Observation of Figure 4 shows a sizeable price distortion in December 1998, where the futures was trading at \$0.51 above its theoretical price, indicating that a squeeze probably took place at that time.

4.2.4 2000–December 2004

The squeeze potential was consistently small during that period, averaging 4 ppp and falling as low as 0.6 ppp in March 2002. In mid-1999, the Treasury announced a buy-back program and a reduced 30-year bond issuance, which were implemented between mid-1999 and the second quarter of 2000, and resulted in a higher volatility and significant flattening of the long-end part of the Treasury yield curve. In addition, starting with the March 2000 contract, the notional yield of the T-bond futures contract was reduced to 6%. As a result, as of March 2000, the yield curve was nearly flat at 6%, the level of the notional coupon rate, so that bonds were approximately equivalent for delivery.

4.2.5 The 2005–2006 market squeeze warnings episode

The squeeze potential measure exhibits a sharp increase in the beginning of 2005, jumping from 1.8 ppp for the December 2004 contract to 15.2 ppp for the subsequent March 2005 contract. Relatively high values for the squeeze potential persisted during the years 2005 and 2006 with an average of more than 20 ppp. At that time, the Fed interest-rate policy, which consisted in raising short-term interest rates, resulted in what was called a "bull flattening of the Treasury yield curve." As in 1998-1999, this nearly flat term structure of interest rates favored delivery of the issue with the lowest duration, making the CTD predictable and well-known in advance for a long period of time, while delivery of non-CTD issues was relatively costly. On September 27, 2006, the Deputy Assistant Secretary for Federal Finance at the U.S. Treasury delivered a speech to inform the members of the Bond Market Association that the U.S. Treasury and the Treasury market regulatory agencies were seriously concerned about the significant increase in the number of manipulative and questionable trading practices they observed among primary dealers over the last two years in the secondary market for U.S. Treasuries. According to him, many firms held sizeable amounts of Treasury securities in order to squeeze their market, which could result in price distortions in the cash, repo and futures markets for U.S. Treasury issues (Clouse 2006). Immediately following this speech, a decline in the number of bonds in scarce supply was reported (The Economist 2006). This event also lead to the creation of the the Treasury Market Practices Group (TMPG), who released on May 11 2007 a set of guidelines and recommendations in its first best practices document that was regularly updated thereafter.

4.2.6 The 2008–2009 credit crisis

The 2008 credit crunch created considerable buying pressure on the U.S. Treasury Bond market. The so-called "flight to quality" increased the demand for Treasuries, which were considered a safe haven by investors in this period of global turmoil. Moreover, many investors tended to hold the bonds more tightly, while some of the entities with large holdings stopped lending their bonds through the repo market. This strong demand for Treasury securities and lack of liquidity resulted in large price distortions in the March 2008 and June 2008 futures contracts (respectively \$0.88 and \$0.69). It is worth stressing that the demand for Treasury bonds at that time was not the result of market manipulation and that shortages involved all types of maturities; notice that the squeeze potential was in fact a little below average during these two months.

It is worth mentioning however that a shortage in bond supply has a direct impact on the term structure of interest rates extracted from bond yields. When the long-term yield is lower thant the CBOT reference coupon rate, price increases of long-maturity bonds contribute to widen the gap between these rates even more, which increases the basket heterogeneity and the potential losses from delivering alternative bonds. This spiralling effect can be observed at the end of 2008. As a result of the credit crisis, the 30-year Treasury yields reached an all-time record low on December 18, 2008. Consequently, the squeeze potential was very high in December 2008 (38 ppp) and March 2009 (32 ppp). Futures price distortions were also very high during the whole of 2009.

Following the bull run in the Treasury bond market at the end of 2008, the Federal Reserve Bank of New York and the DTCC allowed delivery failures in order to artificially increase the supply and to depress the bond prices.[5] It is worthwhile mentioning that, as of May 1, 2009, the TMPG began charging a penalty to traders failing to deliver, amounting to 3 percentage points on each uncompleted trade.

4.2.7 September 2010 to June 2012

June 2012 marks the attainement of a new record low of 2.53% for the 30-year Treasury yield. Examination of Figures 4 and 5 shows a steadily increasing squeeze potential from January 2011 culminating with the June 2012 value of 60 ppp, and a frequent occurrence of high price distortions since September 2010. The fact that the deliverable basket was reduced in January 2011, thus increasing its heterogeneity with respect to losses on delivery, was a contributing factor to the higher value of the squeeze potential during that period, in addition to the discrepancy between the long-term yields and the notional coupon.

Both the squeeze potential and the price distorsion were very high in September 2010, but there is no record of a market manipulation for that contract in the literature. Squeeze episodes have multiplied during the period 2010-2012, and many were documented. In December 2010, purchases by the Fed contributed to a short squeeze due to a shortage of supply (see for instance Garner (2010) and Malpass and Chow (2011a), (2011b)). In May 2011, the risk of a reduction in the Treasury issuance due to the debt-ceiling problem caused an acute shortage of Treasuries and a dramatic fall in Repo rates (as low as 0.01%); at the same time, low interest rates resulted in higher T-bond and T-bond futures prices and bond QE2 purchases by the Fed in May and June contributed to a squeeze (see Brittany (2011), Capo McCormick (2011) and Malpass and Chow (2011c)).

4.2.8 The year 2014

Following a fall to the still relatively high level of 25 ppp in December 2013, the squeeze potential has increased steadily in 2014 to reach an all-time record high of 70 ppp in September 2014. Long-term yields have been consistently decreasing during the Year 2014, but most importantly the heterogeneity of the basket has increased for short-duration bonds, which are among the cheapest to deliver when interest rates are low. As time evolves, bonds with short maturities (and high coupons) are progressively removed from the set of eligible bonds. For instance, the highest coupon bond in the basket is presently a 6.25% bond maturing in May 2030; the next highest was until the June 2014 contract a 6.125% bond maturing in August 2029. In September 2014, the second highest coupon is 5.375%, which makes the second CTD much more expensive to deliver than for the preceding contracts.

It is important to stress that, in addition to the decision by the Department of the Treasury to reduce bond issuance, the announcement of new rules aiming at strengthening the banking sector and improving its safety contributed to a significant and persistent shortage of supply in Treasury securities observed as of January 2013. According to these new rules, not only large amounts of high quality collateral is required to pledge for derivatives transactions, but rehypothecation (a mechanism by which banks reuse bonds received

[5]Note that during the 2008–2009 credit crisis, the "fail to deliver" event had become so common that the industry created the acronym FTD for it.

as collateral in some lending transactions to secure their own loans) is no longer be allowed. These factors resulted in collateral scarcity, causing a dramatic drop in the overnight repo rate (reaching -3% for some Treasury bonds) as well as considerable price distortions in the cash, repo and futures markets for U.S. Treasury issues (see for instance Coy (2013) for a discussion of the Treasury shortage episodes recorded in 2013). As mentioned above, this scarcity has a spiralling impact on the squeeze potential by lowering the term structure of interest rates.

Furthermore, it is worthwhile mentioning that, in the current environment characterized by historic low interest rates, investors establishing short positions in Treasury bonds and bond futures in anticipation of higher rates are always exposed to the risk of a short squeeze if yields do not rise as expected. This was actually the case in January 2014 when interest rates started falling unexpectedly due to a flight to quality in response to some negative economic reports, while the market was generally bearish on Treasury bonds because investors were strongly convinced that the increase in interest rates observed by the end of 2013 would continue in the future. Thus, investors and traders in the Treasury bonds markets (cash and futures) were short-squeezed as they were forced to unwind their short positions at higher prices (see e.g. Eisen (2014) and Marie (2014)). Consistent with this 2014 squeeze episode, observation of Figures 4 and 5 shows that the price of the March 2014 contract is highly overvalued ($1.5). On May 2014, Gundlach (the so-called "King of Bonds") reportedly said that "If we go down [more] on Treasury yields, we will see one of the biggest short-covering scrambles of all time" (Ro 2014).

4.3 Determinants of the squeeze potential

From the way it is interpreted in this paper, the squeeze potential is related to the quality option, that is, the value for the short trader to deliver the CTD instead of another grade (here, the second CTD, which yields a conservative value for the squeeze potential since in periods of acute shortage, even costlier grades may be delivered). Pricing the quality option is a complex problem because of interest-rate stochasticity and because of the other delivery options embedded in the futures contract, making the delivery date uncertain.

From the evaluation of this quality option under the Hull-White model for the interest-rate dynamics, an empirical investigation of the association between squeeze-potential values and their possible determinants is conducted over the period of study. Possible determinants include the yield curve level and slope, the reference coupon rate and the size and heterogeneity of the basket of deliverable bonds. The best predictor of the squeeze potential is found to be the difference between the reference coupon rate and the level of the yield curve, which explains 72% of the variations in its values. The regression equation is then

$$s_t = 7.26 + 4.82 \times (n_t - l_t)^2$$

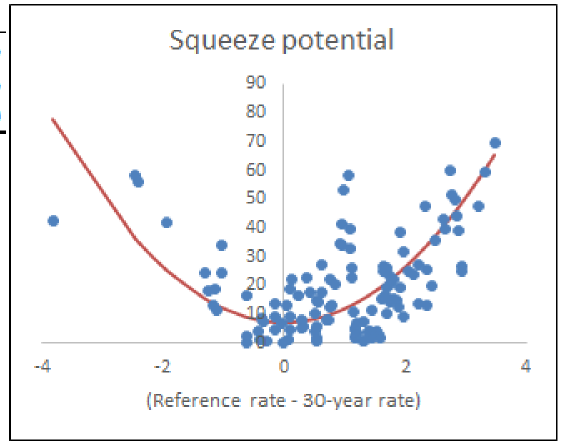
where

- s_t : squeeze potential in ppp, computed using Algorithm 1
- l_t : long (30-year) maturity rate
- n_t : reference coupon rate (%) (8 from March 1985 until December 1999, and 6 from March 2000 until Septembre 2014).

Regression results are presented in Figure 6.

Figure 7 plots the time series of the difference $(n_t - l_t)$ over the period of study. It shows that this difference is presently very large, contributing to the very high value of the quality option, and providing an incentive to squeeze the market. In fact, it is interesting to note that this difference is very close to the one observed just before March 2000 when the CBOT lowered the reference coupon rate from 8% to 6%. This large difference between the reference and actual rates is not likely to change in the short term since (according to the Fed chair Ms. Janet Yellen) rates will be kept near zero for a "considerable period" after the end of the Fed's bond-buying stimulus program, and the target federal funds rate (pinned close to zero since 2008) will not go up unless the U.S. experiences an economy recovery.

Regression Statistics	
R Squared	0,72358325
Standard Error	8,65584305
Observations	119



	Coefficients	*Standard Error*	*Student t*	*P-value*
Intercept	7,26329549	1,058844034	6,859646232	3,47928E-10
(ref.rate-30y.rate)^2	4,81784357	0,275294595	17,50068347	1,85057E-34

Figure 6: Regression results.

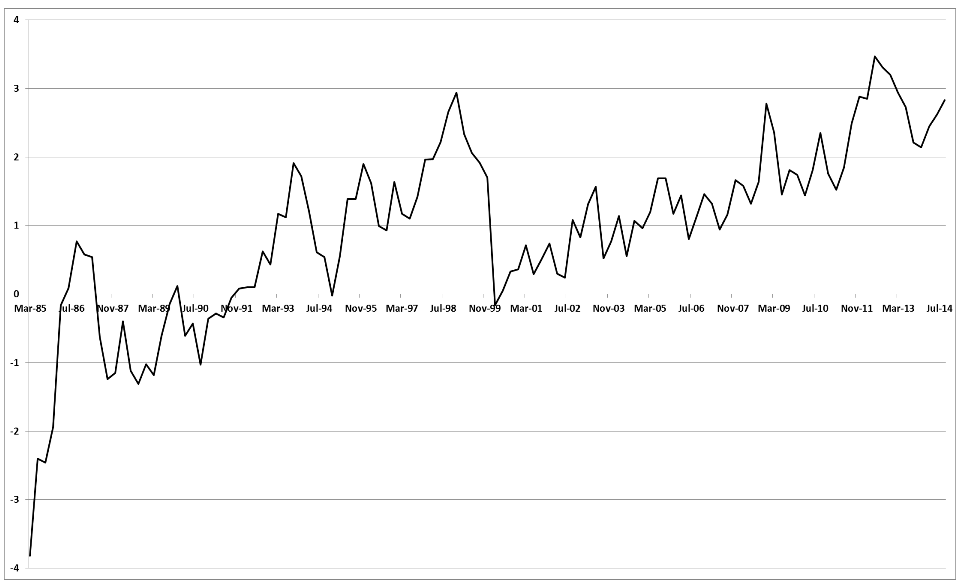


Figure 7: Difference between the CBOT reference rate and the 30-year Treasury rate.

5 Concluding remarks

This paper provides a broad empirical examination of a market manipulation called a short squeeze, in the CBOT T-bonds futures market. A short squeeze occurs when the cheapest-to-deliver bond is in short supply, resulting in the short traders having to deliver a more expensive grade, or even failing to deliver, at the expiration of the contract. These market squeezes cause significant distortions in the behavior of futures prices.

The squeeze potential is measured by computing the difference between the theoretical futures price and the price of the same contract assuming that the CTD is not available to the short trader who has to deliver a costlier grade. In order to estimate futures prices, the pricing algorithm proposed by Ben-Abdallah et al. (2012) is used under the time in-homogeneous Hull–White stochastic interest-rate model.

Pricing distortions and squeeze-potential measures obtained using this algorithm over the period covering March 1985 to September 2014 are related to documented episodes of price manipulation or scarcity problems in the T-bond futures market.

This investigation indicates that one of the very important contributing factors to the squeeze potential over the period of study is the difference between the notional reference rate and the short rate. This difference is now reaching record levels and is not likely to go down in the near future. These results indicate that the reference coupon rate of the T-bond futures is presently too high, fostering the occurrence of market squeezes.

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