Are Investors in Treasury Note Futures Informed?

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ABSTRACT

This paper examines the price impact associated with trades in 10-year U.S. Treasury Note Futures, for the period July 2002 to June 2004. Using a proprietary data set that includes a Customer Type Indicator (CTI), the issue of whether a particular category of investors are informed is explored. This paper extends the existing literature in three main ways. First, it investigates an unresolved empirical issue, as existing research into interest rate futures markets is virtually non-existent. Second, the availability of this proprietary data set allows price effects associated with different investor types to be accurately estimated, without need for a proxy. Finally, analysing the motivations of different investors may help to explain the increasing importance and popularity of interest rate futures contracts. Results indicate that trades by institutional investors contain information, while trades by all other investors contain no information. Additionally, there is a pronounced asymmetry in the price impact of purchases and sales; there is a significant continuation following purchases, while there is almost a complete reversal following sales. This asymmetry is attributed to an upward bias in returns during the sample period, as a result of falling interest rates. Price impacts are also estimated on an intra-day basis and during periods where interest rates are moved or remain unchanged, with results indicating that the only informed investors are institutions. These results are further confirmed using alternative estimation techniques.

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1. INTRODUCTION

Subrahmanyam (1991) states that there are two broadly defined motives for trade in financial markets; information and liquidity. Informed traders trade on the basis of their private information, while liquidity traders trade for reasons not directly related to the future payoffs of financial assets, but due to their need for immediacy. Numerous price impact models show that informed trades contain more information than liquidity trades and are associated with a greater price impact.[1] Empirical studies examining price impact in equity markets, using large trades as a proxy for informed trades, find that these transactions incur a significant permanent price impact.[2] Further empirical evidence, using institutional trades as a proxy for informed trades, confirms that there are significant information effects associated with individual transactions and trade packages in equity markets.[3]

Comparable studies examining the price impact associated with trades in futures markets provide mixed results.[4] Further, none of these studies are able to directly estimate the price impact associated with specific groups of traders. Thus, the question of whether there are informed traders in futures markets is an unresolved empirical issue. This paper addresses this gap in the literature by providing

[1] See Grossman and Stiglitz (1980), Kyle (1985), Glosten and Milgrom (1985) and Easley and O'Hara (1987).
[2] See Kraus and Stoll (1972), Hasbrouck (1988, 1991), Ball and Finn (1989), Seppi (1992) and Daley, Hughes and Rayburn (1995).
[3] See Chan and Lakonishok (1993, 1995) and Chakravarty (2001).
[4] For example, Frino and Oetomo (2005) and Frino, Kruk and Lepone (2006) find no evidence that trades in stock index and interest rate futures contain information, while Berkman, Brailsford and Frino (2005) document that trades in stock index futures contain a small, yet significant, amount of information.

evidence on the price impact associated with different categories of investors in Treasury Note Futures markets.

Treasury Notes are debt instruments issued by the U.S. government that are actively traded in the secondary market. Interest rate futures were pioneered by the Chicago Board of Trade (CBOT) in 1975 and Treasury Note Futures were among the first to be introduced. Similar to S&P 500 futures, whose value depends on the expected future value of the stocks contained in that index, the value of Treasury Note Futures is determined by the market's expectation about the future trading price of Treasury Notes. However, as expected, the factors that influence the values of equities and interest rate products are significantly different.

The value of equities are influenced by market-wide and firm-specific factors; consequently, the value of S&P 500 futures is influenced primarily by market-wide factors as the firm-specific component is diversified away due to the large number of stocks contained in the index (Subrahmanyam, 1991). While it may be possible for an investor to obtain inside information on the value of a specific stock, or even a number of different stocks, it is unlikely that they would use this information to trade in S&P 500 futures as this reduces their competitive advantage due to diversification.

The value of Treasury Note Futures, on the other hand, is essentially determined by expectations about future interest rates. It appears unlikely, although not impossible, that investors may possess inside information about the actions of the

U.S. Federal Reserve. However, it is possible that some groups of traders are able to process macroeconomic information more efficiently than others. This implies that certain investors may possess an informational advantage about future interest rate movements, although, at present, there are no studies that address this issue.

This paper extends previous work by empirically examining the permanent price impact, which is used as a proxy for information content, associated with different categories of investors in Treasury Note Futures markets. This is achieved through the use of a proprietary data set from the CBOT, which includes a Customer Type Indicator (CTI). Results indicate that trades by institutional investors contain information, while trades by all other investors contain no information. Contrary to previous studies of futures markets, there is a marked asymmetry between the price impact of purchases and sales; purchases are associated with a significant permanent impact, while the impact of sales is largely temporary. This asymmetry appears to be caused by an upward bias in returns during the sample period, as a result of falling interest rates. It is further confirmed that institutions are informed through examining intra-day price effects, as well as price impacts during periods where interest rates are moved or remain unchanged. Price impacts are of a greater magnitude during periods when interest rates remain unchanged, although the asymmetry is still evident. Additionally, alternative estimation techniques are used to estimate price effects, which also provide consistent results.

2. DATA and METHOD

A proprietary data set, obtained from the CBOT, containing all trades in 10-year U.S. Treasury Note Futures made on the CBOT between 1st July 2002 and 21st June 2004 is examined in this paper. This is a rare and accurate source of data that is not available to the general public. The time of each transaction is reported to the nearest second as well as price, volume and contract expiry date. The direction of each trade is specified, so that trade direction algorithms, such as the tick test, are not required. The data also contains a transaction ID, which enables orders originating from the same investor to be aggregated, even though they may be executed against several different counterparties and hence reported as separate transactions. However, transaction ID's are not unique to each trader so trade packages are unable to be constructed as in Chan and Lakonishok (1995) or Frino and Oetemo (2005).

Perhaps the most unique and useful feature of this data set is that it specifies a Customer Type Indicator (CTI) for both sides of the transaction, similar to the data set used by Manaster and Mann (1996). There are four CTI categories. CTI 1 trades are market making trades for personal accounts (i.e. trades made by 'locals'). CTI 2 trades are those executed for the account of the trader's clearing member (i.e. proprietary trading by brokers). CTI 3 trades are those executed for the account of any other exchange member (i.e. brokers trading on behalf of other exchange members that may not have a pit broker). CTI 4 trades are those by external customers (i.e. institutional investors). Unlike Frino and Oetomo (2005), who exclude trades by locals in order to proxy for institutional trades, the available of CTI data allows a separate analysis to be carried out on each category of traders. Thus, slippage costs incurred by different categories of traders can be calculated and subsequently compared to determine whether any particular category of investors are informed in Treasury Note Futures markets.

Transactions are divided into quartiles according to volume and each quartile is mutually exclusive, meaning transactions with the same volume are always placed in the same size group. Contracts with different expiry dates are traded simultaneously, with those closest to expiry referred to as 'near' contracts and those that are further away from expiry referred to as 'deferred' contracts.[5] This paper focuses predominantly on near contracts as they are the most frequently traded.[6]

Additional data on the U.S. Federal Funds target interest rate is obtained from the U.S. Federal Reserve for the period July 1 2002 to June 21 2004. This sample period occurs during a time when U.S. interest rates reached historically low levels, as seen in Figure 1a. Between 2001 and 2003, interest rates in the U.S. were lowered from 6.5 percent to as low as 1 percent. Figure 1b shows that during the sample period, interest rates were lowered twice; from 1.75 percent to 1.25 percent in November 2002 and from 1.25 percent to 1 percent in June 2003.

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[5] There are numerous types of deferred contracts. The deferred contract with expiry closest to the near contract is called the 'first deferred' contract, the deferred contract with expiry next closest to the near contract is called the 'second deferred' contract, and so on.

[6] First deferred contracts are analysed separately to ensure results are robust to the type of contract analysed.

Figure 1a U.S. Federal Funds Target Rate, January 1 2000 to August 31 2006

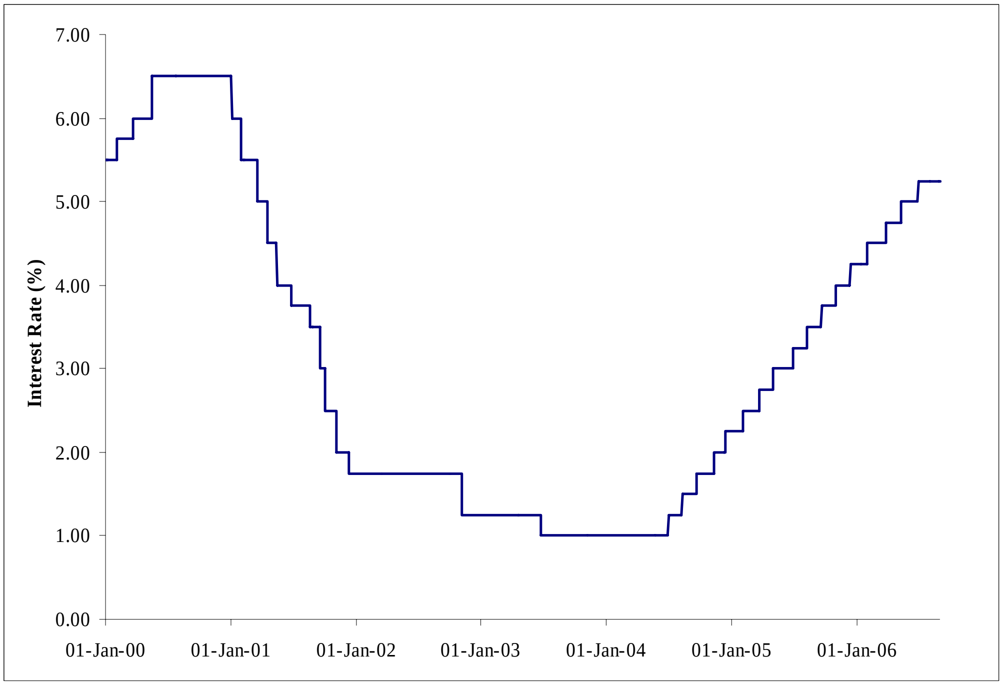
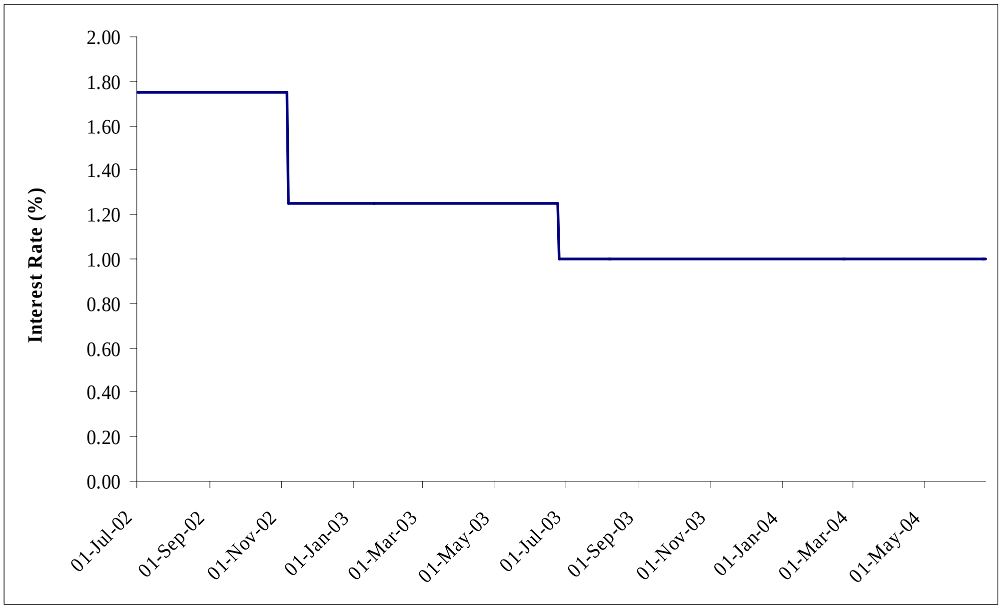


Figure 1b U.S. Federal Funds Target Rate, July 1 2002 to June 21 2004.



The method applied in this paper follows that used in Frino and Oetomo (2005), who calculate the total, temporary and permanent price impact associated with each trade. The total price impact, or ‘slippage’, is defined as the immediate movement in price as a result of executing a particular trade. The temporary price impact, or liquidity effect, measures the extent to which the price reverses subsequent to a trade being executed. Finally, the permanent price impact, or information effect, is defined as the difference between the pre-trade and post-trade benchmark prices; in other words, the underlying change in value. Consistent with earlier studies, the permanent price impact is used as a proxy for the information content of trades. These three components are expressed as follows:

$$Slippage_i = \frac{(Price_i - OpeningPrice_i)}{MinTick} \tag{1}$$

$$Liquidity_i = \frac{(ClosingPrice_i - Price_i)}{MinTick} \tag{2}$$

$$Information_i = \frac{(ClosingPrice_i - OpeningPrice_i)}{MinTick} \tag{3}$$

In the above equations, $Price_i$ is the execution price for trade *i*, $OpeningPrice_i$ is the price at the start of the 15-minute trading interval where trade *i* takes place and, similarly, $ClosingPrice_i$ is the price at the end of the 15-minute trading interval. *MinTick* represents the minimum tick for 10-year U.S. Treasury Note Futures, which is $15.625 (one-half of one thirty-second of a point). This means that execution costs will be expressed in terms of price ticks, which is the convention in futures markets (Frino and Oetomo, 2005). This paper analyses trades that take place in the open auction, consistent with previous research examining trades in futures markets,[7] with the 15-minute reporting intervals being used as the benchmark period.[8]

Previous studies are able to construct entire trade packages by using data that identifies individual traders or brokers.[9] It is not possible to construct trade packages in this paper since account or broker codes are not specified, however, institutional investors can be directly identified from the CTI field (CTI 4) and can be used as a proxy for institutional trades, similar to Chakravarty (2001).

Holder and Sinha (2004) note that bid-ask spreads in Treasury Note Futures markets are generally stable during the course of the day, but are considerably tighter during the opening and closing hours, contrary to stock and options markets. In this paper, trades are partitioned according to the time they are executed to determine if price impacts in Treasury Note Futures exhibit similar patterns as bid-ask spreads. The open auction is divided into three periods; early morning (7:20am to 10am), mid morning (10am to 12pm) and afternoon (12pm to 2pm).[10]

The value of Treasury Note Futures is determined by expectations of future interest rates. Thus, it is likely that movements in interest rates will influence the price impact associated with each trade. Chiyachantana, Jain, Jiang and Wood (2004)

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[7] See Frino and Oetomo (2005) and Frino, Kruk and Lepone (2006).

[8] Additional pre-trade and post-trade benchmarks are used to test the robustness of slippage estimates in this paper. The additional pre-trade benchmark is the price at the start of the previous 15-minute interval to that in which the trade is executed, and the additional post-trade benchmark is the price at the end of the subsequent 15-minute interval.

[9] See Chan and Lakonishok (1995) and Frino and Oetomo (2005).

[10] Trades are also partitioned further into hourly periods, apart from the first period, which covers only 40 minutes. Results from this are quantitatively similar.

examine institutional trading in a variety of international stock markets and find that the major determinants of price impact are the underlying market conditions (whether the market is categorised as a bull or bear market). Therefore, the market is divided according to movements in the U.S. Federal Funds target rate. There are two distinct periods; periods where there are movements in the target rate, which includes the month of the interest rate movement as well as the month on either side of this event; and periods where there are no movements in interest rates, which includes all other months in the sample. Two interest rate movements occur during the sample period and one immediately after (July 2004), meaning there are seven months included in periods surrounding interest rate movements and seventeen months included in periods where there are no movements in interest rates.

Chan and Lakonishok (1995) estimate the impact that commission costs, market capitalisation, package complexity and managerial strategy has on different measures of price impact and execution costs. They find that the identity of the money manager behind the trade is the most important variable in explaining variation in market impact costs in equity markets. Frino and Oetomo (2005) build on this model by omitting brokerage commissions as a variable, as they are found to have no significant impact, and also by using actual rather than relative trade size. In this paper a regression model similar to Frino and Oetomo (2005) is estimated. However, the Trader ID dummy variable is replaced by a CTI dummy variable, allowing the relative price impact associated with each customer type to be compared. The following regression is estimated:

$$s_i = \alpha_0 + \sum_{j=2}^{4} \beta_j Size_j + \sum_{k=2}^{4} \delta_k CTI_k \qquad (4)$$

where s_i represents total, temporary or permanent price impact for trade *i*. To control for the influence of trade size, trades are ranked from smallest to largest and divided into mutually exclusive quartiles. $Size_j$ is a set of dummy variables that takes the value of 1 if the trade is drawn from that quartile and 0 otherwise, with quartile 1 being used as the base. CTI_k is also a set of dummy variables that takes the value of 1 if the trader is from that CTI category and 0 otherwise, with CTI 1 being used as the base. Separate regressions are estimated for buy and sell transactions.

3. RESULTS

3.1. Descriptive Statistics

Table 1 and Table 2 provide a description of all purchases and sales in near term contracts, divided according to their CTI category. There are a total of 1,043,359 trades in the sample, made up predominantly of CTI 1 trades which account for 90 percent of all trades and 79 percent of the dollar value of contracts traded during the sample period. This reflects the market-making role held by locals in open-outcry futures markets, with trades divided evenly between all four size groups. CTI 4 trades, which are made by institutional investors, account for 7 percent of all trades and 14 percent of the dollar value of contracts traded during the sample period. CTI 2 and CTI 3 trades, which are trades made by brokers on their own behalf or on the behalf of another exchange member, represent a combined 3 percent of the number of trades and 7 percent of the dollar value of contracts traded.

The most intriguing features of this sample are the extreme differences between the number of purchases and sales for the CTI 2, CTI 3 and CTI 4 trade categories. These differences are particularly evident for CTI 4 trades; there are 27,180 purchases compared with 49,521 sales, with the average volume of purchases being 16 contracts compared with 92 contracts for sales. These differences are also evident when comparing the number of trades in the largest size category, where there are over ten times as many sales as purchases. Similar patterns exist in both the CTI 2 and CTI 3 categories, where there are around twenty times as many sales as purchases in the largest size category. This is consistent with earlier studies which document far fewer buyer-initiated than seller-initiated block trades.[11]

[11] See Kraus and Stoll (1972), Holthausen, Leftwich and Mayers (1987, 1990), Keim and Madhavan (1996) and Bozcuk and Lasfer (2005).

Table 1 Descriptive Statistics – Purchases

This table reports descriptive statistics for all purchases of 10-year U.S. Treasury Notes Futures near contracts executed on the CBOT during the period July 2002 to June 2004. Trades are partitioned according to CTI category and then divided into quartiles according to trade volume. Trades with the same volume are always assigned to the same quartile.

Size Group	1 (Small)	2	3	4 (Large)	All
# Contracts	1-3	4-10	11-39	40+	
Panel A: CTI 1					
# Trades	104 761	155 755	100 744	106 127	467 387
Volume					
Mean	2.00	7.14	20.39	102.42	30.48
Median	2	6	20	70	10
Dollar Value (US$)					
Mean	226 956	808 343	2 306 325	11 596 140	3 450 442
Median	227 156	706 875	2 264 063	7 749 219	1 138 594
Panel B: CTI 2					
# Trades	71	125	147	176	519
Volume					
Mean	2.04	6.34	21.20	144.78	56.91
Median	2	6	20	90	20
Dollar Value (US$)					
Mean	232 452	720 744	2 405 191	16 357 550	6 433 697
Median	228 719	672 000	2 273 750	9 988 336	2 216 875
Panel C: CTI 3					
# Trades	194	348	341	588	1 471
Volume					
Mean	1.84	6.87	21.51	167.44	73.79
Median	2	6	20	100	20
Dollar Value (US$)					
Mean	208 400	779 069	2 431 990	18 967 706	8 357 488
Median	223 391	685 266	2 270 000	11 350 781	2 298 750
Panel D: CTI 4					
# Trades	16 917	5 100	3 070	2 093	27 180
Volume					
Mean	1.51	6.12	20.77	151.57	16.10
Median	1	5	20	85	2
Dollar Value (US$)					
Mean	170 981	694 315	2 354 275	17 164 815	1 824 396
Median	115 313	578 555	2 199 547	9 490 688	228 750

Table 2 Descriptive Statistics – Sales

This table reports descriptive statistics for all sales of 10-year U.S. Treasury Notes Futures near contracts executed on the CBOT during the period July 2002 to June 2004. Trades are partitioned according to CTI category and then divided into quartiles according to trade volume. Trades with the same volume are always assigned to the same quartile.

Size Group	1 (Small)	2	3	4 (Large)	All
# Contracts	1-3	4-10	11-39	40+	
Panel A: CTI 1					
# Trades	102 104	156 464	102 775	106 481	467 824
Volume					
Mean	2.01	7.17	20.36	102.86	30.72
Median	2	7	20	70	10
Dollar Value (US$)					
Mean	228 162	811 950	2 302 634	11 649 389	3 478 720
Median	227 188	776 563	2 262 188	7 982 188	1 140 313
Panel B: CTI 2					
# Trades	1 515	1 918	1 763	3 898	9 094
Volume					
Mean	2.02	7.39	21.56	131.20	62.31
Median	2	8	20	100	20
Dollar Value (US$)					
Mean	230 626	837 079	2 439 751	14 834 514	7 046 529
Median	227 969	900 063	2 271 875	11 118 750	2 305 000
Panel C: CTI 3					
# Trades	1 622	3 910	4 685	10 146	20 363
Volume					
Mean	2.01	7.29	21.53	167.91	90.17
Median	2	8	20	100	38
Dollar Value (US$)					
Mean	228 710	827 257	2 440 936	19 026 719	10 218 849
Median	227 844	893 438	2 280 313	11 406 250	4 288 750
Panel D: CTI 4					
# Trades	5 175	5 874	10 238	28 234	49 521
Volume					
Mean	1.77	7.30	22.68	152.12	92.47
Median	2	8	20	100	48
Dollar Value (US$)					
Mean	201 274	827 128	2 573 391	17 221 108	10 469 645
Median	225 500	896 938	2 293 750	11 243 750	5 400 000

These results are consistent with institutional investors and brokers selling large blocks of futures contracts in order to realise gains. During the sample period, Treasury Note Futures reached record price levels as a result of interest rates being reduced to an all-time low of 1 percent. It is possible that many institutional investors believe that since future rate falls are unlikely, Treasury Note Futures may have reached a peak and thus could only fall, resulting in institutional investors selling Treasury Note Futures contracts to maximise profits. This is consistent with the behaviour in the smallest size category for CTI 4 trades, where there were 16,917 purchases compared with 5,175 sales, which is indicative of purchasing for strategic reasons or portfolio rebalancing.

3.2 Price Impact

Table 3 reports slippage, liquidity and information estimated across CTI categories. Slippage costs associated with CTI 1 trades (Panel A) are in the opposite direction than expected; there is a negative price impact associated with purchases and a positive price impact associated with sales. This is possibly due to the market-making role of locals, providing liquidity to institutional investors. It is interesting to note that there is a substantial price reversal following each trade, which leads to a significant positive information effect for almost every trade ranging from 0.1193 ticks to 0.2439 ticks. These results do not indicate that all trades by locals carry positive information; it is more likely that they are indicative of the general rise in prices for Treasury Note Futures during the sample period as a result of falling interest rates.

Results for CTI 2 traders are reported in Panel B of Table 3. The majority of price impacts are small and statistically insignificant, with the exception of the largest size category. Slippage effects associated with the largest trades are 0.8440 ticks for purchases and -0.1557 ticks for sales, while the information effect is 1.7318 ticks for purchases and 0.1183 ticks for sales. These results indicate that large trades made by brokers trading on their own account appear to contain some information. Panel C documents price impacts associated with CTI 3 traders. Results follow a similar pattern as CTI 1 traders, with a negative impact for purchases and a positive impact for sales. However, most returns are insignificantly different from zero.

Panel D of Table 3 documents price impact estimates associated with CTI 4 trades. The impact of purchases is consistent with results from both equity and futures markets. For all size categories there is an initial positive price impact, followed by a slight reversal, leading to a positive overall permanent price impact. These results are consistent with Hypothesis 2 (trades have a permanent price impact) and Hypothesis 3 (institutional investors are informed). The impact of sales, however, is quite different. There is an initial significant negative price impact across all size categories, which is generally less than half the magnitude of the impact recorded for purchases. Following this, there is almost a complete reversal for all trade sizes, unlike the partial reversal documented for purchases. Thus, the information effect associated with sales is significantly less than that associated with purchases. In addition, the permanent effects are insignificantly different from zero at the 5 percent level, apart from trades in the largest size category.

Table 3 Price Impact

This table reports the mean and volume weighted price impacts associated with all trades in 10-year U.S. Treasury Notes Futures near contracts executed on the CBOT during the period July 2002 to June 2004. Trades are partitioned into buy and sell categories, then into CTI categories and finally into quartiles according to trade volume. Trades with the same volume are always assigned to the same quartile. Three measures of price impact are reported; slippage measures the return from the price at the start of the 15-minute trading interval to the execution price, liquidity measures the return from the execution price until the price at the end of the 15-minute trading interval and information measures the return from the price at the start of the 15-minute trading interval to the price at the end of the 15-minute interval in which the trade was executed. Price impacts are reported in terms of the minimum price tick of the contract, which is one-half of one thirty-second (1/32) of a point, or $15.625. The deviation of the mean and volume-weighted price impacts from zero are tested using a t-test.

	1 (Small)		2		3		4 (Large)	
	Buy	Sell	Buy	Sell	Buy	Sell	Buy	Sell
				Panel A: CTI 1 Trades				
# Trades	34 423	33 393	54 200	53 983	46 991	46 941	69 619	70 266
Slippage								
Volume Weighted	-0.1705**	0.3549**	-0.1026**	0.2438**	-0.0761**	0.2212**	-0.3200**	0.4358**
Mean	-0.1680**	0.3448**	-0.1272**	0.2920**	-0.0791**	0.2129**	-0.2062**	0.3014**
Liquidity								
Volume Weighted	0.2897**	-0.1527**	0.2496**	-0.0958**	0.2221**	-0.0865**	0.3047**	-0.1920**
Mean	0.2882**	-0.1487**	0.2479**	-0.1086**	0.2315**	-0.0850**	0.2527**	-0.1451**
Information								
Volume Weighted	0.1193**	0.2022**	0.1470**	0.1480**	0.1460**	0.1347**	-0.0152	0.2439**
Mean	0.1201**	0.1961**	0.1207**	0.1834**	0.1524**	0.1279**	0.0465**	0.1563**

Table 3 (Continued)

				Panel B: CTI 2 Trades				
# Trades	52	897	88	1 359	104	1 252	127	2 876
Slippage								
Volume Weighted	1.0388*	-0.0145	0.3879	0.0232	-0.2152	0.2731**	0.8440**	-0.1557*
Mean	1.0192*	-0.0346	0.3919	-0.0008	-0.0659	0.2493**	0.2432	0.0435
Liquidity								
Volume Weighted	-0.1165	-0.0750	-0.3556	-0.2721**	0.4090	-0.0659	0.8878**	0.2740**
Mean	-0.0577	-0.0652	-0.1622	-0.2354*	0.4176	-0.1110	0.1171	0.1793**
Information								
Volume Weighted	0.9223	-0.0895	0.0323	-0.2489*	0.1938	0.2073	1.7318*	0.1183
Mean	0.9615*	-0.0999	0.2297	-0.2363	0.3516	0.1383	0.3604	0.2227**
				Panel C: CTI 3 Trades				
# Trades	142	976	259	2 074	252	2 682	444	6 985
Slippage								
Volume Weighted	-0.1452	0.5587**	-0.1935	0.5650**	-0.1945	0.3107**	-0.7587**	0.5586**
Mean	-0.2721	0.5663**	-0.2939	0.6011**	-0.2963	0.3205**	-0.5264**	0.4771**
Liquidity								
Volume Weighted	0.2339	-0.0366	-0.0255	-0.0467	0.0786	0.0070	0.3161*	-0.0357
Mean	0.1838	-0.0367	0	-0.0298	0.1646	0.0131	0.2000	-0.0016
Information								
Volume Weighted	0.0887	0.5221**	-0.2190	0.5183**	-0.1159	0.3177**	-0.4426	0.5228**
Mean	-0.0882	0.5297**	-0.2939	0.5714**	-0.1317	0.3336**	-0.3264	0.4755**

Table 3 (Continued)

	Panel D: CTI 4 Trades							
# Trades	11 838	2 748	3 520	2 576	1 988	3 441	1 003	8 448
Slippage								
Volume Weighted	1.3303**	-0.7305**	1.1952**	-0.3836**	1.2651**	-0.3658**	1.0913**	-0.4060**
Mean	1.3331**	-0.7832**	1.1847**	-0.4425**	1.2217**	-0.3789**	1.3868**	-0.3704**
Liquidity								
Volume Weighted	-0.2873**	0.5732**	-0.3705**	0.2880**	-0.3569**	0.2678**	-0.3924**	0.2992**
Mean	-0.2701**	0.6469**	-0.3656**	0.2751**	-0.3811**	0.2407**	-0.2137**	0.2426**
Information								
Volume Weighted	1.0431**	-0.1573	0.8247**	-0.0956	0.9082**	-0.0981	0.6990**	-0.1068*
Mean	1.0630**	-0.1363	0.8192**	-0.1674	0.8406**	-0.1382	1.1731**	-0.1277**

* Significantly greater than zero at the 5% level of significance.
** Significantly greater than zero at the 1% level of significance.

These results are puzzling as they are not consistent with Berkman, Brailsford and Frino (2005) or Frino and Oetomo (2005). These studies examine slippage costs associated with both trade packages and individual trades in futures markets and find no evidence of a permanent price impact asymmetry between purchases and sales, although this asymmetry is consistently documented in equity markets.[12] This asymmetry in information effects between purchases and sales appears to be driven by falling interest rates, causing an upward bias in returns and possibly leading institutions to sell off Treasury Note Futures and realise gains. This is supported by the fact that, in the largest size category, there are over ten times as many sales as there are purchases.

It is interesting to note that slippage costs for CTI4 trades actually decrease as trade size increases, from 1.3303 to 1.0913 for purchases and from -0.7305 to -0.4060 for sales between the smallest and largest size categories. The information effect also decreases as trade size increases for purchases, from 1.0431 to 0.6990, while for sales the impact is generally small and insignificant. Similar results are documented for all other CTI categories. This trend is consistent with the results found in Berkman, Brailsford and Frino (2005), but contradicts the results of Frino and Oetomo (2005), who find that "slippage costs associated with futures trade packages increase monotonically with size" (p. 1136).

Frino, Kruk and Lepone (2006) argue that when a single trade is part of a larger institutional package, the post-trade benchmark is biased upwards (downwards) for

[12] See Kraus and Stoll (1972), Holthausen, Leftwich and Mayers (1987, 1990), Chan and Lakonishok (1993, 1995), Gemmill (1996) and Bozcuk and Lasfer (2005).

purchases (sales), with subsequent results biased into finding a permanent price effect. Thus, it is possible that the price impact associated with small trades is greater than that of large trades. They find that slippage is largest for medium-sized trades and that trades in the largest size group are the only trades that do not contain information. This evidence is consistent with ‘stealth-trading’ documented in Barclay and Warner (1993) and Chakravarty (2001), where informed traders disguise large orders by breaking them up into a number of smaller transactions. Thus, it is possible that, in this paper, trades in the small and medium-sized categories incur the largest price impact because they are part of large, informed trade packages.

Table 4 reports the intra-day price effects associated with CTI 4 near trades. The trading day is broken up into three periods; Early Morning from 7:20am to 10:00am, Mid Morning from 10:00am to Midday and Afternoon from Midday to 2:00pm. The early morning period accounts for half of all trades executed throughout the entire trading day, which is not surprising as it is the first opportunity for traders to trade overnight information. The information effect associated with CTI 4 trades in the largest size category during the early morning period is 0.7349 for purchases and -0.2997 for sales, compared with 0.6990 and -0.1068 for purchases and sales during the entire day. Similar results are obtained during the late morning and afternoon periods. The information effects associated with sales across all size categories and in each time period are generally quite small and mostly insignificant, possibly indicating that sales are primarily liquidity-motivated and contain very little information. The information effect associated with purchases remains significant (and close to one tick) across all time periods and for each size category. These results indicate that price impact remain constant throughout the entire trading day, confirming the results reported in Table 3. These results are inconsistent with Hypothesis 4, which predicts that slippage costs are lower at the beginning of the trading day.

3.3 Regression Analysis

The results from the regression analysis are reported in Table 5. Coefficients estimates for trade-size dummy variables are generally small and insignificant, and do not increase and decrease monotonically for purchases and sales, respectively, as in Frino and Oetomo (2005). These coefficients are consistent with the slippage estimates reported in this paper, which indicate that trades in the smallest size category have the largest price impact.

Coefficient estimates for the CTI dummy variables indicate that there is a significant price impact associated with CTI 4 trades, as well as evidence of an asymmetry between purchases and sales. The coefficient associated with slippage for CTI 4 purchases is 1.07308, compared with -0.13095 for sales. The information effect coefficient is 0.54650 for purchases, while for sales it is -0.01402 (which is insignificantly different from zero). There is no evidence of any significant slippage or information effects associated with any other CTI category. These results confirm earlier evidence that there is significant information associated with CTI 4 purchases.

Table 4 Intra Day Price Impact of CTI 4 Trades

This table reports the mean and volume weighted price impacts associated with all CTI 4 trades in 10-year U.S. Treasury Notes Futures near contracts executed on the CBOT during the period July 2002 to June 2004. Trades are partitioned into three categories according to the time of day they were executed; Early Morning from 7:20am to 10:00am, Mid Morning from 10:00am to Midday and Afternoon from Midday to 2:00pm. Trades are then divided into buy and sell categories and finally into quartiles according to trade volume. Trades with the same volume are always assigned to the same quartile. Three measures of price impact are reported; slippage measures the return from the price at the start of the 15-minute trading interval to the execution price, liquidity measures the return from the execution price until the price at the end of the 15-minute trading interval and information measures the return from the price at the start of the 15-minute trading interval to the price at the end of the 15-minute interval in which the trade was executed. Price impacts are reported in terms of the minimum price tick of the contract, which is one-half of one thirty-second (1/32) of a point, or $15.625. The deviation of the mean and volume-weighted price impacts from zero are tested using a t-test.

	1 (Small)		2		3		4 (Large)	
	Buy	Sell	Buy	Sell	Buy	Sell	Buy	Sell
Panel A: Early Morning (7:20am to 10:00am)								
# Trades	6 095	1 846	1 684	1 337	1 013	1 538	466	3 559
Slippage								
Volume Weighted	1.0771**	-0.8964**	1.0445**	-0.4680**	1.0344**	-0.4213**	0.9672**	-0.5282**
Mean	1.0370**	-0.9108**	1.0340**	-0.5647**	1.0064**	-0.4852**	1.2673**	-0.4764**
Liquidity								
Volume Weighted	-0.1897**	0.6528**	-0.2459**	0.3561**	-0.2128	0.3083**	-0.2323	0.2285**
Mean	-0.1379**	0.7465**	-0.2215**	0.3463**	-0.1983	0.2598**	-0.3018	0.1424*
Information								
Volume Weighted	0.8874**	-0.2435*	0.7986**	-0.1119	0.8216**	-0.1130	0.7349**	-0.2997**
Mean	0.8991**	-0.1643	0.8125**	-0.2184	0.8081**	-0.2254*	0.9654**	-0.3340**

Table 4 (Continued)

	Panel B: Mid Morning (10:00am to Midday)							
# Trades	1 794	493	627	626	319	945	212	2 404
Slippage								
Volume Weighted	2.1787**	-0.6960**	1.3419**	-0.5120**	1.2924**	-0.3560**	1.3200**	-0.4206**
Mean	2.2698**	-0.7560**	1.3169**	-0.5477**	1.3609**	-0.3031**	1.5052**	-0.3179**
Liquidity								
Volume Weighted	-0.5170**	0.5042**	-0.6954**	0.2405	-0.5135**	0.1906	-0.5276*	0.2253**
Mean	-0.6041**	0.5121**	-0.7615**	0.2462	-0.6589**	0.1685	-0.1856	0.2170**
Information								
Volume Weighted	1.6617**	-0.1918	0.6465**	-0.2715	0.7789**	-0.1654	0.7924**	-0.1953*
Mean	1.6657**	-0.2440	0.5554**	-0.3015	0.7020**	-0.1346	1.3196**	-0.1009
	Panel C: Afternoon (Midday to 2:00pm)							
# Trades	3 934	420	1 201	620	652	959	324	2 487
Slippage								
Volume Weighted	1.2962**	-0.1385	1.3270**	-0.0565	1.6298**	-0.2928**	1.0524**	-0.2202**
Mean	1.3509**	-0.2436	1.3251**	-0.0625	1.4911**	-0.2886**	1.4984**	-0.2712**
Liquidity								
Volume Weighted	-0.3220**	0.3296*	-0.3831**	0.2109	-0.5083**	0.2834**	-0.4801**	0.4728**
Mean	-0.3192**	0.3641*	-0.3638**	0.1774	-0.5252**	0.2833**	-0.1205	0.4085**
Information								
Volume Weighted	0.9741**	0.1911	0.9439**	0.1544	1.1216**	-0.0095	0.5722*	0.2526**
Mean	1.0317**	0.1205	0.9613**	0.1149	0.9659**	-0.0054	1.3779**	0.1373

* Significantly greater than zero at the 5% level of significance.
** Significantly greater than zero at the 1% level of significance.

The models estimated have very little explanatory power, as evidenced by the extremely low adjusted R^2 values. Chan and Lakonishok (1993) find that “most of the explanatory power comes from the identity of the money manager behind the trade” (p. 193) and Frino and Oetomo (2005) state that “most of the explanatory power comes from the trader-identification dummy variables” (p. 1141). The data set used in this paper does not allow identification of the traders involved in each transaction, which may explain why the explanatory power of this model is so low. This is confirmed by examining the adjusted R^2 of the models from the above two studies when the effects of the trader identification variables are excluded. In both cases, the resulting adjusted R^2 values are quantitatively similar to those found for the models in this paper.

4. CONCLUSION

This paper examines the price impact associated with trades in 10-year U.S. Treasury Note Futures. The permanent price impacts incurred by trades in each CTI category are estimated and used as a proxy for information content, in order to investigate whether a particular category of traders are informed. While there is substantial evidence indicating that large trades and institutional trades in equity markets contain information, comparative evidence from futures markets is mixed, and is practically non-existent for interest rate futures markets. This paper addresses this gap in the literature, and its significance is highlighted by the increasing global importance and popularity of interest rate futures contracts.

Table 5 Regression Analysis

This table presents regression results of the following model:

$$s_i = \alpha_0 + \sum_{j=2}^{4} \beta_j Size_j + \sum_{k=2}^{4} \delta_k CTI_k$$

where s_i represents slippage, liquidity or information effects for trade ***i***. In order to control for the influence of trade size on price impact, trades are ranked from smallest to largest and divided into mutually exclusive quartiles. $Size_j$ is a set of dummy variables that takes the value of 1 if the trade is drawn from that quartile and 0 otherwise, with quartile 1 being used as the base case. CTI_k is also a set of dummy variables that takes the value of 1 if the trader is from that CTI category and 0 otherwise, with CTI 1 being used as the base case. The sample consists of all trades in near 10-year U.S. Treasury Notes Futures contracts executed on the CBOT during the period July 2002 to June 2004. Separate regressions are estimated for buy and sell transactions.

	Slippage		Liquidity		Information	
	Buy	Sell	Buy	Sell	Buy	Sell
Estimated Coefficients						
Intercept	0.1412*	0.1724*	0.2598*	0.1414*	0.4011*	0.3138*
Size Group 2	-0.0258	-0.0331	-0.0031	0.0017	-0.0289	-0.0314
Size Group 3	0.0196	-0.0293	0.0091	0.0009	0.0287	-0.0284
Size Group 4	-0.1558*	0.0522*	0.0374	-0.0693*	-0.1184*	-0.0172
CTI 2	-0.5848*	0.0527	-0.0470	-0.0794	-0.6317*	-0.0266
CTI 3	-0.2801	0.1917*	-0.0365	-0.0267	-0.3166	0.1651*
CTI 4	1.0731*	-0.1310*	-0.5266	0.1169*	0.5465*	-0.0140
Adjusted R-Square	0.34	0.02	0.09	0.01	0.08	0.01

* Significantly greater than zero at the 5% level of significance.
** Significantly greater than zero at the 1% level of significance.

The results suggest that institutional investors (CTI 4) are the only informed investors. CTI 1 trades incur a positive permanent price impact, but this is indicative of their role as market makers, and information effects associated with the CTI 2 and CTI 3 categories are small and insignificant. The slippage effect for CTI 4 trades is significant across all categories, however the magnitude of slippage effects is much greater for purchases than it is for sales. This asymmetry is even more apparent when examining information effects, which are significant and range from 1.0431 ticks to 0.6990 ticks between the smallest and largest quartiles for purchases, while for sales they are all insignificantly different from zero, except for the largest quartile, which has a small permanent impact of -0.1068 ticks. However, liquidity effects are quantitatively similar for purchases and sales. This asymmetry appears to be caused by an upward bias in returns as a result of falling interest rates.

Estimates of intra-day price effects for CTI 4 trades are consistent with earlier results, indicating that price impact remains constant throughout the trading day. Additionally, price effects estimated during periods where interest rates remain unchanged are considerably larger than in periods surrounding interest rate movements, possibly indicating greater information asymmetries. However, the asymmetry in price effects is still evident and the evidence confirms that institutions are informed investors. These results are shown to be consistent when using alternative pre- and post-trade benchmarks and when examining first deferred contracts. Coefficient estimates from the regression analysis also confirm that institutions are informed and that there is an asymmetry between purchases and sales.

The results from this paper indicate that institutional trades in Treasury Note Futures markets contain information. This is surprising, considering Frino and Oetomo (2005) and Frino, Kruk and Lepone (2006) find no evidence that trades in interest rate futures contain information. There is also evidence of an asymmetry in price impact surrounding purchases and sales, which appears to be driven by falling interest rates. This is similar to the permanent price impact asymmetry that has been widely documented in equity markets. This result is also quite surprising, as previous studies of futures markets find no evidence of a price impact asymmetry, and is in contrast with the findings of Berkman, Brailsford and Frino (2005), who suggest that the asymmetry in equity markets is due to the high cost of short-selling, meaning it should not be apparent in futures markets..

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