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Market liquidity and depth on two different electronic trading systems: A comparison of Bund futures trading on the APT and DTB

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Abstract

This paper investigates the liquidity of two different electronic trading systems – the APT system at LIFFE and the DTB system. First we describe the different characteristics of the trading systems and give potential reasons as to why they might differ in liquidity. Second we investigate empirically the liquidity provided by the two trading system. The comparison is especially interesting because the Bund Futures instruments traded are identical and the markets are open simultaneously. The intra-day data used in the study is from August 1997 to February 1998. The results show that the APT has smaller spread but the DTB is slightly deeper. © 2000 Elsevier Science B.V. All rights reserved.

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1. Introduction

The Bund futures contract, which is based on the German government's 10-year bond, is the most actively traded bond future contract in Europe. The London International Financial Futures Exchange (LIFFE), with its open

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outcry trading and Automated Pit Trading (APT) has historically dominated the volume in this instrument since its inception in September 1988. Lately, however, the Deutsche Terminbörse (DTB[1]), with its computerized trading system, has significantly closed the gap in volume between the two exchanges, and now claims to be the leading exchange in Bund futures trading with a market share of approximately 83%.

Studies of liquidity in Bund futures markets have concentrated so far on the comparison of open outcry trading at LIFFE and the DTB trading system. Shyy and Lee (1995) compare quoted spreads and information asymmetry, and test for arbitrage opportunities in the two trading systems. Kofman and Moser (1995) compare spreads and information flows on the DTB and LIFFE Bund markets. Franke and Hess (1995) measure liquidity by the market share each trading system is able to capture and compare market shares in situations differing of information intensity. Pirrong (1996) compares spreads and market depth across the two trading systems. Breedon and Holland (1997) compare spreads and the composition of the spreads across the two trading systems. Automated Pit Trading, the system used as an after-market after pit trading closes, has not been a subject of study as it has been open simultaneously with the DTB system only 10 minutes per day. However, as of August 1, 1997, the DTB extended Bund Futures Trading by 90 minutes, and now the two electronic systems are simultaneously open for 1 hour 35 minutes per day. This provides the opportunity to study the two electronic systems in an empirically meaningful context.

A comparison of the APT and DTB trading systems is especially interesting because the instruments traded are effectively identical, presenting the opportunity for a potentially controlled experiment of two trading system characteristics: the openness of the limit order book and trader anonymity. Additionally, the APT share of Bund future's trading has collapsed even more severely than the full exchange market share figures, from 60.3% on the first full trading week in August 1997 to 26.4% on the last trading week of February 1998. Whether this result was caused by inferior market liquidity on the APT market is an interesting question.

This paper sets out to describe the different characteristics of the trading systems and to give potential reasons as to why they might have created a liquidity differential between the two systems. We examine empirically the liquidity provided by the two different electronic trading systems as measured by (1) the effective bid–ask spread and by (2) market depth. The intra-day data used in the study is from LIFFE and DTB and covers the period from August 1997 to February 1998.

[1] On September 17, 1998 the DTB and the Swiss Options and Financial Futures Exchange (SOFFEX), and the MATIF of Paris announced their merger to create a common market planned to be fully integrated by 2001. For simplicity, we will refer to the DTB with its own name.

The rest of the paper is organized as follows. Section 2 compares the APT and the DTB trading systems, and discusses the factors that affect the effective spread and market depth in the two markets. Section 3 describes the data and the methodology. Section 4 presents the results and Section 5 summarizes the paper.

2. The factors affecting the liquidity of the APT and DTB trading systems

Although the APT and DTB are similar in that both are computerized trading systems with consolidated limit order books, they differ markedly because the LIFFE created the APT system by applying the principles of pit trading, and it is these pit trading-like qualities that account for some of the differences between the APT and DTB. As in any open outcry market, trading on the APT is not anonymous, with trader identities published via three-letter mnemonics, while trading on the DTB is totally anonymous. Similarly, locals are the primary source of liquidity on the APT and the lower capitalization of locals and the correspondingly more limited ability to absorb order shocks as compared to the large financial institutions operating on the DTB may cause a liquidity differential between the two markets.

While both markets have, they differ in the ex ante transparency engendered by their broadcasts of the state of market liquidity. The APT publishes only the best bid and offer while the DTB publishes the ten best bids and offers, thus providing better ex ante transparency to the market. Moreover, the DTB provides more information on depth by publishing also the volumes of the ten best bids and offers whereas the APT publishes only the total volume being bid and offered for each contract month.

These factors affect the effective spread and market depth in the two markets. The spread is generally thought of as being comprised of three components: adverse selection costs (Copeland and Galai, 1983; Easley and O'Hara, 1987; Glosten and Milgrom, 1985); inventory holding costs (Amihud and Mendelson, 1980; Ho and Stoll, 1981; Stoll, 1978); and order processing costs (Tinic, 1972) and we briefly discuss the likely effect of the two market structures of these components in turn.

In its simplest form, adverse selection costs can be related to information intensity (see Franke and Hess, 1995). At times of low information intensity the limit order book provides more information about the evolution of prices in the near future. A trader can use this information in order to avoid being "picked off" by other traders, i.e. trading against the market. At times of high information intensity knowledge of the identities of market participants executing trades is more useful than the information provided by an open limit order book.

Strictly from the adverse selection point of view, non-anonymity will increase market liquidity. An increase in market liquidity is the result of a non-pooling equilibrium being achieved with respect to adverse selection costs (see Röell (1990) and Benveniste et al. (1992) for detailed discussions of this issue). Based on Röell (1990) and Benveniste et al. (1992) it can be argued that the non-anonymity of the APT should imply lower adverse selection costs and better market depth.

Order books and especially their structures are considered as the distinguishing factor between the open outcry and computerized trading systems (see Domowitz and Wang, 1994; Bolerslev and Domowitz, 1991). The most important point with order books is that is the open limit order book, the system employed at the DTB, the optimal structure (see Glosten, 1994; Black, 1995). The existence of an open limit order book has a dual effect. On the one hand, it tends to reduce adverse selection costs as parties acting as market-makers will have information on future order flows, and thus are able to protect themselves against adverse price movements. On the other hand, Harris and Hasbrouck (1996) argue that the information on future order flow may actually reduce competition among potential liquidity suppliers and therefore reduce liquidity in a market. However, given the extreme competitive dynamics of the Bund futures market, it is hard to imagine a situation where competition would be reduced so much as to effect the bid–ask spread of the market.

In conclusion, the APT should have smaller adverse selection costs if the non-anonymity of the market is only considered, but if the structure of the order books is only considered, the DTB should have smaller adverse selection costs. However, it is not possible to say which one of these factors overrides the other one.

Both market anonymity and the openness of the limit order book have an effect on the inventory holding costs in the two trading systems (see Franke and Hess (1995) for a detailed discussion of this issue[2]). The DTB seems to have the advantage at periods of low information intensity, when the ex ante transparency provided by an open limit order book provides information on expected future order flow. The capitalization of the parties acting as market makers in the markets can also affect inventory holding costs (see Amihud and Mendelson (1980)). The lower capitalization of locals on the APT might increase inventory holding costs. However, considering the markets in total it is indistinguishable which one is better from the theoretical point of view, numerous thinly capitalized market participants or fewer well-capitalized firms.

Order processing costs can be divided into two separate components, the fixed and variable costs. As both the APT and DTB markets are electronic, their fixed costs structures are probably similar due to the high initial investment in

[2] Although Franke and Hess (1995) apply their analysis to the differences between open outcry trading and the DTB trading of Bund futures, their analysis can still be extended to the APT as nearly the same market microstructure characteristics apply with respect to anonymity and limit order book openness.

hardware in the form of computer equipment and market analytics (see Pagano (1989) and Pirrong (1996) for a general discussion of how fixed costs affect market liquidity). As the variable costs are composed of the clearing and exchange fees, the significance of this component depends very much on the average trading volume of the average market participant on each market.[3] Although, from the theoretical point of view it is not possible to determine the likely effects of the order processing costs on the liquidity, Sarkar and Tozzi (1998) argue that DTB seems to have a lower variable order processing cost component. Furthermore, order processing costs should not affect market depth in the two markets.

In summary it can be said that no superiority in liquidity between the two trading systems can be established on the basis of theoretical arguments alone. However, the APT seems to advantage at times of high information intensity, whereas the DTB at times of low information intensity.

3. APT and DTB market liquidity – data and methodology

To compare the liquidity of the two trading systems, intra-day time and sales data were obtained from the DTB and LIFFE. The data records are accurate to the 1/100th of a second on the DTB and to the second on the LIFFE. The data obtained from LIFFE contain: bid, ask and transaction prices with associated volumes whereas the DTB data contain only realized trades and associated volumes.

Liquidity is measured over a time interval ranging from August 2, 1997 to February 27, 1998. The period from December 22 to January 2 is omitted from the analysis as trading volumes during that period were relatively low and the markets were simultaneously open only five days.

Fig. 1 shows the aggregate trading volume and the APT market share of Bund futures trading on the APT during the examination period. As can be seen from the figure, aggregate volumes have risen, and the APT has lost the market share to the DTB. This fact has to be taken into consideration when interpreting the results; liquidity has been measured during a time-period when the APT has lost its market share to the DTB, and this shift started immediately after the trading time extension on the DTB.

Although errors in trading are more frequent in open outcry trading than in electronic trading, mistrades still happen on electronic trading systems. As the spread measure used is sensitive to large price changes due to mistrades, the data

[3] A factor speaking in favor of the significance is that both exchanges gave a complete fee holiday in the end of 1997 to increase both competition and market share (the fee holidays lasted from September 1, 1997 to December 31, 1997 and from September 18, 1997 to December 31, 1997 for the DTB and LIFFE, respectively).

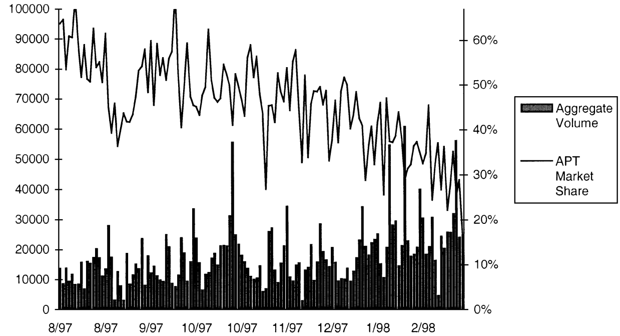

Fig. 1. Trading volume of Bund futures during the APT trading hours on the DTB and LIFFE, and the APT market share of volume between August 4, 1997 and February 27, 1998. Dates during which both exchanges were not open have been omitted from the time-series. Volume figures are in contracts traded.

sets are purged of identifiable mistrades. A trade is identified as a mistrade if it results in immediately reversing price change larger than five ticks in absolute value. When a mistrade is identified, it is removed from the database. In the analyzed data sets, 31 mistrades are identified on the DTB data and 0 mistrades on the APT data.

In this study we use the Roll (1984) estimator to measure the effective bid–ask spread. Roll (1984) estimates the effective spread from the autocovariance of price changes, and the effective spread estimate S is defined as follows:

$$S = 2\sqrt{-Cov(\Delta P_t,\ \Delta P_{t+1})}, \tag{1}$$

where ΔP_t is the price change over an interval.

The measure of market depth employed is a modified approach of the measure used by Pirrong (1996).[4] To examine market depth, price changes during a time interval are regressed against volume measures of the same interval. The method used is a two-step regression approach originally pioneered by Barro (1977).

In the first step, expected and unexpected[5] volume during a time interval are estimated using the following regression equation

$$E(V_t) = a + \sum_{i=1}^{5} \beta_i V_{t-i} + \sum_{j=1}^{5} \theta_j |\Delta P_{t-j}| + \sum_{k=1}^{5} \lambda_k \sigma_{t-k} + \varepsilon_t, \tag{2}$$

[4] Ragunathan and Perker (1997) used a similar methodology in their study of market depth on the Australian futures market.

[5] The difference in the effects of expected and unexpected volume on price changes has been found to be especially strong in futures markets. In their study of eight financial and commodity futures markets, Bessimbinder and Seguin (1993) found that the effect of unanticipated volume is two to thirteen times as large as the effect of expected volume on price changes.

where
V_t = the actual trading volume at time interval t,
ΔP_t = the price change from the beginning to the end of time interval t,
σ_t = a measure of volatility during time interval t,
ε_t = an error term.

In this study we measure the trading volume by the number of contracts traded whereas Pirrong (1996) used the number of trades during a time interval as a measure of trading volume. Although he found that his proxy yields similar results as the actual volumes, we believe that the actual volume should provide a better estimate of market depth, as the trading systems are characterized by significantly different mean trade sizes (approximately 10 on the APT and 30 on the DTB during the study period). Furthermore, our data is accurate enough to use the actual trading volume whereas Pirrong (1996) had data problems, which was one of the reasons to use the proxy as the volume. The measure of volatility used is the difference between the maximum and minimum prices during a time interval. Lagged absolute price changes are included in the regression equation to better capture the effect of expected price volatility on volume.

In the second step, a slightly different approach than in Pirrong (1996) is used. To control the tendency of market prices to quickly revert to their equilibrium level after a volume shock, i.e. a resilient market, two regression equations are estimated. In the first equation expected and unexpected volume are used to explain the change between the first and last prices of the interval, and in the second equation the dependent variable is set as the difference between the minimum and maximum prices of the interval.

$$|\Delta P_t| = \phi + \delta EVOL_t + \gamma UVOL_t + \mu UVOLPOS_t + \sum_{k=1}^{r} \rho_k \sigma_{t-k} + \eta_t. \quad (3)$$

$$\sigma_t = \vartheta + \varsigma EVOL_t + \tau UVOL_t + \omega UVOLPOS_t + \sum_{k=1}^{s} \psi_k \sigma_{t-k} + \xi_t. \quad (4)$$

Expected volume during a time interval, $EVOL_t$, is estimated as the fitted value from Eq. (2). Unexpected volume, $UVOL_t$, is the residual from the regression Eq. (2), ε_t. Unanticipated trading volume is further divided into the negative and positive unexpected volumes. A new variable, $UVOLPOS_t$, is created to control for asymmetrical effects of positive and negative volume shocks. If $UVOL_t < 0$, $UVOLPOS_t = 0$ and if $UVOL_t > 0$, $UVOLPOS_t = UVOL_t$. As the magnitude of price changes is affected by the volatility of the underlying price series, lagged volatilities, σ_{t-k}, are included in the depth regressions to allow for time varying components in price variances.

The coefficients on the volume terms *EVOL*, *UVOL* and *UVOLPOS* in Eqs. (3) and (4) are measures of the depth of the market.

To correct the error in variables – problem caused by the fact that the *EVOL* and *UVOL* terms in Eqs. (3) and (4) are generated regressors, an instrumental variables approach is used to estimate the market depth regressions.[6]

4. Results

To ensure the statistical validity of the spread measures and market depth regressions, the stationarity of all variables is tested by the Augmented Dickey-Fuller test. Non-stationarity is rejected for all variables at 1% level.

4.1. Bid–ask spreads

Spreads are estimated for trade to trade data and for one-minute intervals in order to check whether the differencing interval has any effects on the consistency of the spread estimates.

Table 1 presents the estimated spreads for the whole sample period. Panel A shows the estimates for the trade to trade data and panel B shows the estimates for one-minute intervals. In both cases the spreads are smaller on the APT than on the DTB and the differences are statistically significant at the 1% level. However, the differencing interval affects the size of the spreads in different ways. When the time interval increases, the spreads decrease on the DTB but on the APT they increase. One explanation for this can be the different number of trades and the different trade sizes on the two systems. The mean trade size is 10 on the APT and the total number of trades is 98994 whereas on the DTB the

Table 1
The Estimated Bund futures bid–ask spreads for the whole sample period

The estimated Bund futures bid–ask spreads for the whole sample period. The column labeled $\chi^2(3)$ reports the Box Statistic testing the hypothesis that the true spreads are equal on the DTB and APT. The statistic is distributed as a chi-square with 3-degrees of freedom and in both panels the APT spread is significantly smaller at the 1% level.

DTB	APT	$\chi^2(3)$
Panel A: Trade to trade data		
0.841	0.309	62464
Panel B: Minute to minute data		
0.679	0.621	100

[6] We are grateful to Antti Kanto for suggesting this approach.

Table 2
The estimated Bund futures bid–ask spreads at two-week periods

The estimated Bund futures bid–ask spreads split into two-week periods. The column labeled $\chi^2(3)$ reports the Box Statistic testing the hypothesis that the true spreads are equal on the DTB and APT. The statistic is distributed as a chi-square with 3-degrees of freedom.

Weeks	DTB	APT	$\chi^2(3)$
Panel A: Trade to trade data			
32-33	0.74	0.28*	3325
34–35	0.79	0.25*	4927
36–37	0.94	0.28*	5894
38–39	0.75	0.31*	4035
40–41	0.81	0.29*	5266
42–43	0.86	0.28*	6525
44–45	0.79	0.38*	2611
46–47	0.89	0.33*	4078
48–49	0.80	0.28*	4404
50–51	0.69	0.31*	3139
2–3	0.80	0.34*	4072
4–5	0.85	0.33*	4893
6–7	0.73	0.29*	4444
8–9	0.83	0.30*	5078
Panel B: Minute to minute data			
32–33	0.51	0.50	1
34–35	0.76	0.75	0
36–37	0.53	0.43*	28
38–39	0.65	0.66	1
40–41	0.46*	0.63	83
42–43	0.75	0.66*	13
44–45	0.52	0.40*	60
46–47	0.92	0.72*	55
48–49	0.50*	0.58	14
50–51	0.39*	0.63	212
2–3	0.76	0.78	0
4–5	0.81	0.65*	32
6–7	0.84	0.68*	30
8–9	0.86	0.46*	339

*Statistically significant at the 1% level.

mean trade size is 30 and the total number of trades is 43316. This fundamental difference can cause the observed feature. Another explanation can be the shifting volume from the APT to the DTB.

In order to detect how the spreads evolve over the time period we estimated the spreads on two-weeks intervals. The results are shown on the Table 2. Panel A presents the spread estimates for the trade to trade data. The obtained spread estimates are relatively stable, especially when compared to the results of Pirrong (1996) where the spread estimates ranged from 0.2 to 1.8 ticks on the DTB data and from 0.6 to 2.7 ticks on the LIFFE open outcry data. Our spread estimates range from 0.69 to 0.94 on the DTB data and from 0.28 to 0.38 on the APT data, and they are statistically smaller on the APT than on the DTB at the 1% level. Panel B shows the estimates obtained from data differenced to a one-minute interval. In addition to a significant loss of stability of the estimates, the move to a one-minute differencing interval has significantly different effects on the spread estimates on the two systems. On the DTB, all but three spread estimates decrease, whereas on the APT all spread estimates increase. These results are similar to the results of the whole sample period and they confirm that the shifting volume from the APT to the DTB cannot explain them. Although the APT spreads increase they still are smaller, statistically significant at the 1% level, for seven two-week periods whereas the DTB spread estimates are smaller for three periods and the differences are statistically insignificant for four periods.

The interpretations of the results are very difficult. Although the estimated spreads are most of the time smaller on the APT, which can imply that the non-anonymity lowers the spreads, but as the trading has been shifting from the APT to the DTB, traders do not consider the non-anonymity as the most important characteristic of a trading systems. Another kind of interpretations is that the Roll (1984) estimator is inefficient and does not correctly measure the effective spread.

4.2. Market depth

The regression results for the depth equation are reported in Table 3. The standard errors for the coefficients are reported in parentheses below the respective coefficients.

The coefficients on the expected volume terms are all positive on both markets, and are statistically significant at the 5% level for seven months on the APT but only four months on the DTB. This implies that expected increases in volume have a pronounced effect on prices on both markets, and thus the markets are not very deep in this sense of the definition. The coefficients are smaller for the DTB for four months, and the last two months of the analysis period have a more pronounced difference in the size of the coefficients. This implies that market depth has improved on the DTB, which means that the change in prices caused by the expected volume is more pronounced on the APT than on the DTB, and thus the DTB is, or at least has become, the deeper market with respect to the expected volume.

The coefficients on the unexpected volume are always positive and statistically significant at the 1% level on the both trading systems. Here a similar

Table 3
Estimates of resiliency controlled market depth in the bund contracts.

Results of regression estimates of resiliency corrected market depth on the APT and DTB Bund markets. The coefficients on expected volume (*EVOL*), unexpected volume (*UVOL*) and unexpected positive volume (*UVOLPOS*) serve as estimates of market depth. The optimal lag structure is defined by using the Akaike Information Criteria (AIC) and is found to be two lags for Eq. (4). Standard errors are presented in parenthesis.

DTB Bund	Constant	EVOL	UVOL	UVOLPOS	R^2
AUG 97	0.8712	0.0019	0.0034	– 0.0012	0.276
	(0.1687)**	(0.0013)	(0.0012)**	– (0.0015)	
SEP 97	0.6413	0.0011	0.0037	– 0.0021	0.376
	(0.1462)**	(0.0012)	(0.0009)**	– (0.0011)	
OCT 97	0.6604	0.0016	0.0024	– 0.0007	0.398
	(0.1446)**	(0.0009)	(0.0008)**	– (0.0010)	
NOV 97	0.7580	0.0015	0.0026	– 0.0006	0.404
	(0.1581)**	(0.0004)**	(0.0007)**	– (0.0010)	
DEC 97	0.6419	0.0025	0.0029	– 0.0024	0.236
	(0.1260)**	(0.0007)**	(0.0007)**	– (0.0010)**	
JAN 98	0.8721	0.0016	0.0019	– 0.0006	0.571
	(0.1354)**	(0.0003)**	(0.0004)**	– (0.0006)	
FEB 98	0.4606	0.0012	0.0012	– 0.0003	0.463
	(0.1777)**	(0.0004)**	(0.0003)**	– (0.0004)	
APT Bund	**Constant**	**EVOL**	**UVOL**	**UVOLPOS**	R^2
AUG 97	0.9350	0.0016	0.0020	– 0.0004	0.206
	(0.2202)**	(0.0008)*	(0.0007)**	– (0.0010)	
SEP 97	0.7068	0.0021	0.0023	0.0001	0.319
	(0.1306)**	(0.0007)**	(0.0007)**	(0.0011)	
OCT 97	0.8522	0.0011	0.0039	– 0.0027	0.420
	(0.1672)**	(0.0006)**	(0.0007)**	– (0.0010)**	
NOV 97	0.6663	0.0017	0.0024	– 0.0005	0.464
	(0.1410)**	(0.0005)**	(0.0006)**	– (0.0009)	
DEC 97	0.6306	0.0023	0.0026	– 0.0008	0.268
	(0.1364)**	(0.0005)**	(0.0007)**	– (0.0009)	
JAN 98	0.7397	0.0024	0.0029	– 0.0016	0.428
	(0.1686)**	(0.0005)**	(0.0006)**	– (0.0008)	
FEB 98	0.4593	0.0027	0.0026	– 0.0010	0.437
	(0.2124)*	(0.0012)*	(0.0006)**	– (0.0009)	

*Statistically significant at the 5% level.
**Statistically significant at the 1% level.

improvement on the DTB market depth can be seen, as was already seen for the expected volume coefficients, as the coefficient on the unexpected volume terms are markedly smaller for the last two months of the analysis period.

The coefficients on the unexpected positive volume terms are statistically significant at the 1% level for only one month for both trading systems. Furthermore, the sum of the coefficients on the two unexpected volume terms is statistically indistinguishable from zero. This implies an asymmetry of response of prices to volume shocks, i.e. positive volume shocks cause a smaller price reaction than negative volume shocks.

Although we find similar results as Pirrong (1996) that the DTB provides better depth than LIFFE, two differences stand out. First, the results obtained in this study are not as strong as those obtained by Pirrong, and the superior market depth of the DTB when compared to the APT is not indisputably established. Second, whereas Pirrong finds that the DTB is deep with respect to the expected volume, we find that increases in the expected volume do have a pronounced impact on price changes. The differences in the results obtained may be due to the shorter differencing interval used (5 minutes versus 15 minutes in Pirrong (1996)) or to the after-market nature of the time periods examined in this study.

As the market depth seems to be a little bit deeper on the DTB than on the APT, it can imply that traders are more interested in the information that the order books offer than the non-anonymity. On the other hand, the larger capitalization can also help to explain the apparently better market depth on the DTB. With a larger capital base, DTB market-makers are better equipped to absorb temporary order shocks, and thus their price schedules are less affected by temporary order imbalances. Moreover, the market depth can explain why the APT has lost its market share to the DTB.

5. Summary

This article compares the liquidity supply of two electronic trading systems, the APT and the DTB. The two trading systems have two main differences: (1) trading on the DTB is anonymous whereas on the APT is not, and (2) the DTB has an open limit order book publishing the ten best bids and asks, whereas the APT limit order book is relatively closed as it only publishes the best bid and offer. The effect that these differences have on the liquidity supplied by the system is found to depend on the intensity of information prevailing in the market, and thus no conclusions can be made based on theoretical arguments alone.

The empirical section compares the liquidity of Bund futures trading on the two systems on a period ranging from August 2, 1997 to February 27, 1998. The results show that the spread is smaller on the APT than on the DTB. However, the DTB market is found to be slightly deeper than the APT market. This can be interpreted that traders care more about the market depth than the spread and this can partly help to explain why trading volume has gradually moved from the APT to the DTB.

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