PRICE TRANSMISSION AND INFORMATION ASYMMETRY IN BUND FUTURES MARKETS: LIFFE VS. DTB

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INTRODUCTION

The London International Financial Futures Exchange (LIFFE) introduced the Bund futures contract in September, 1988. Since then, the Bund has become one of the most active contracts traded on LIFFE. In the meantime, The Deutsche Terminborse (DTB) was founded in July, 1988 and started trading Bund futures in November, 1990. The introduction of the Bund contract on the DTB creates an interesting opportunity to study the lead–lag relationship between LIFFE and DTB. LIFFE is the established futures exchange with a higher volume of Bund futures trading.[1] DTB is the "home country" exchange of cash Bunds. In addition, DTB employs an automated trading system while LIFFE

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[1]The trading volume on LIFFE is about two or three times that of DTB. The average daily trading volume during the sample period of this study 39,300 contracts on DTB and 91,674 contracts on LIFFE.

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uses the traditional open outcry system during normal trading hours and electronic trading after hours.

Similar situations are found with Nikkei futures traded on both SIMEX and OSE, JGB futures traded on both SIMEX and TSE, and Euro-yen futures traded on both SIMEX and TIFFE.[2] Shyy and Butcher (1993) find that futures exchanges in Japan lead the intermarket price transmission process in JGB and Nikkei futures. On Eurodollar interest rate, Fung and Isberg (1992) find significant reverse causality from the Eurodollar rate (external market) to the U.S. interest rate (domestic market). Other studies on intermarket relationships focus on cash versus the futures market. For example, the interrelationships between derivatives and the underlying assets markets have also been documented by a number of studies. Manaster and Rendleman (1982), Bhattacharya (1987), and Anthony (1988) report consistent evidence that the option market tends to lead the stock market. They attribute this evidence to lower transaction costs and capital requirements, fewer trading restrictions, and greater trading opportunities. However, using transaction data, Stephan and Whaley (1990) show that the stock market leads the option market by 20 minutes, and suggest that the consensus view that options lead stocks may be wrong. Pan, Rim, and Hocking (1991) also document that the currency spot market leads the currency options market by 90 minutes. Freund and Webb (1991) argue that the lead–lag relationship may depend on the type of information. They conjecture that option prices lead stock prices when firm-specific information becomes available to the market, but market-wide information is reflected first in stock prices, and then option prices.

Finnerty and Park (1987), Ng (1987), Kawaller, Koch, and Koch (1987), Harris (1989), Stoll and Whaley (1990), and Chan (1992) report that price movements in the futures markets consistently lead the stock index movements, while there is weak evidence that stock index movements lead futures price changes. This lead–lag relationship between the futures and cash index markets can be attributed to lower transaction costs and less restrictive short selling in the futures market. Chan (1992) suggests that the lead–lag pattern is not well explained by nonsynchronous trading, and that future prices tend to be better at reflecting market–wide information than cash index prices. Martikainen

[2]It is important to note that although the Bund contracts in LIFFE and DTB are very similar to each other, the contract values of Nikkei and JGB futures contracts traded on SIMEX are smaller than those traded on OSE (Nikkei) and TSE (JGB).

and Puttonen (1992) suggest that interrelationships between futures market returns across countries can be stronger than those between stock markets.

The objective of this article is to investigate the intermarket relationship of Bund futures between LIFFE and DTB. Price transmission and information asymmetry between LIFFE and DTB are investigated.

CONTRACT SPECIFICATIONS AND TRADING MECHANISM

The Bund futures contract is based on a notional 6% German Government Bundes–Anliehen with a residual life of 8.5–10 years. The contract specifications for Bund futures traded on LIFFE and DTB are almost identical. The only difference between the DTB Bund futures and the LIFFE Bund futures is the time of delivery. In Frankfurt it is the last trading day plus two days; whereas, in London it is the last trading day plus three days. Table I compares the trading mechanism and contract specifications for Bund futures traded on LIFFE and DTB. LIFFE employs both open outcry (7:30–16:15 GMT) and automated pit trading, APT (16:20–17:55 GMT). DTB uses an automated trading system exclusively (7:00–16:30 GMT). As a result, the Bund futures

TABLE I

Comparison of Bund Futures Contracts between DTB and LIFFE

LIFFE	*DTB*
Trading hours (GMT): 7:30 AM–16.15 PM (open outcry trading 16.20 PM–17.55 PM (APT trading)	Trading hours (GMT): 7:00 AM–16.30 PM
Initial Margin: Risk based margins	Initial Margin Risk based margins
Trading unit: DM250,000 nominal value notional German Government Bond with a 6% coupon	Trading unit: Same as LIFFE
Open outcry system and APT trading	Automated trading system
Delivery day: Tenth calendar day Delivery Month	Same as LIFFE
Last trading day: *Three* Frankfurt business days prior to delivery day	Last trading day: *Two* business days before delivery day

Sources: LIFFE, Mclean (1991).

can be traded on both DTB and LIFFE between 7:30 and 16:15 GMT. Minute-by-minute market quotes and transaction prices are collected from both exchanges. The price transmission and information asymmetry between DTB and LIFFE are compared. Since synchronous Bund trading on both DTB and LIFFE during LIFFE APT trading only lasts for ten minutes per day (16:20–16:30 GMT), there is not enough data for separate testing of this trading span.

REAL TIME QUOTES AND DATA COLLECTION

Minute-by-minute transaction prices and bid/ask quotes for December 1993 Bund futures are collected from the Reuter Terminal from November 8–19, 1993. The raw data set is modified as follows:

1. Occasionally there are communication breakdowns due to telephone line problems. Whenever there is a transmission breakdown in the Reuter Terminal, the terminal shows an "IDN COMM FAULT" signal. To maintain continuous intraday transaction prices, trading days that experience data transmission problems are deleted.
2. In some (very rare) cases, there are some prices that are completely aberrant, due to human and technical errors. For all data series, the validity of the data is checked by filtering out impossible market conditions, e.g., filtering out minute-by-minute price movements higher than 50%, ask prices higher than bid prices, etc.

There are 3158 observations collected for each Bund futures contract from November 8 through November 19, 1993.[3] All prices reflect the last trade of the trading minute at both LIFFE and DTB. This study collects the real time quotations from the Reuter Terminal through Excel Access, a software developed jointly by Reuters and Microsoft.

The symbols used in this article for real time quotes provided by Reuters Money 2000 Services are as follows:

exchange	contract	symbol
DTB	BUND	BD
LIFFE	BUND	FDB

[3] In addition to the weekend, November 13 and 14, four trading days, November 9, 10, 11, 17, are deleted due to the lack of continuity in the data collection process because of transmission errors on the Reuter Terminal. All transaction prices during the six trading days in the sample are continuous from open to close without any technical errors.

INTERMARKET BID/ASK ARBITRAGE CONDITIONS

Bid/Ask Quotes

Figure 1 shows the intraday patterns of bid/ask spreads for Bund December 1993 futures contracts traded on both LIFFE and DTB. The spreads shown in Figure 1 are the average spreads in the relevant trading hours in the sample period. The spreads on DTB are wider than in LIFFE. The average spreads in DTB and LIFFE are 0.013 and 0.010, respectively. The means of these two markets are significantly different at the 0.01 level. Since the goal of the article is to discuss the intermarket relationship between LIFFE and DTB, the arbitrage conditions between these two markets are examined.

Arbitrage Conditions

If a trader can make a profit by buying (selling) a futures contract on the DTB and selling (buying) it on LIFFE simultaneously, the current bid/ask prices violate the arbitrage conditions. Therefore, the following conditions can generate arbitrage profit.

$$BD_a < FDB_b \tag{1}$$

$$BD_b > FDB_a \tag{2}$$

Based on these arbitrage conditions, the empirical results show that there are 92 minutes violating condition (1) and 12 minutes violating condition (2). However, 97 minutes out of those 104 minutes generate a profit of 0.01 points per contract. Five minutes generate a profit of 0.02 points per contract. Two minutes generate a profit of 0.03 points per contract. If transaction cost, e.g., commission and margin cost, is considered, there is hardly any arbitrage profit left for traders.

CAUSALITY TEST: AN ERROR CORRECTION MODEL

To investigate the intermarket relationship between DTB and LIFFE, a Granger Causality Test is conducted. Under this test, a time series $\{X_t\}$ is said to cause another time series $\{Y_t\}$ if the present Y can be predicted better by using past values of X than by not doing so. Other relevant information, including the past values of Y, are used in either case.

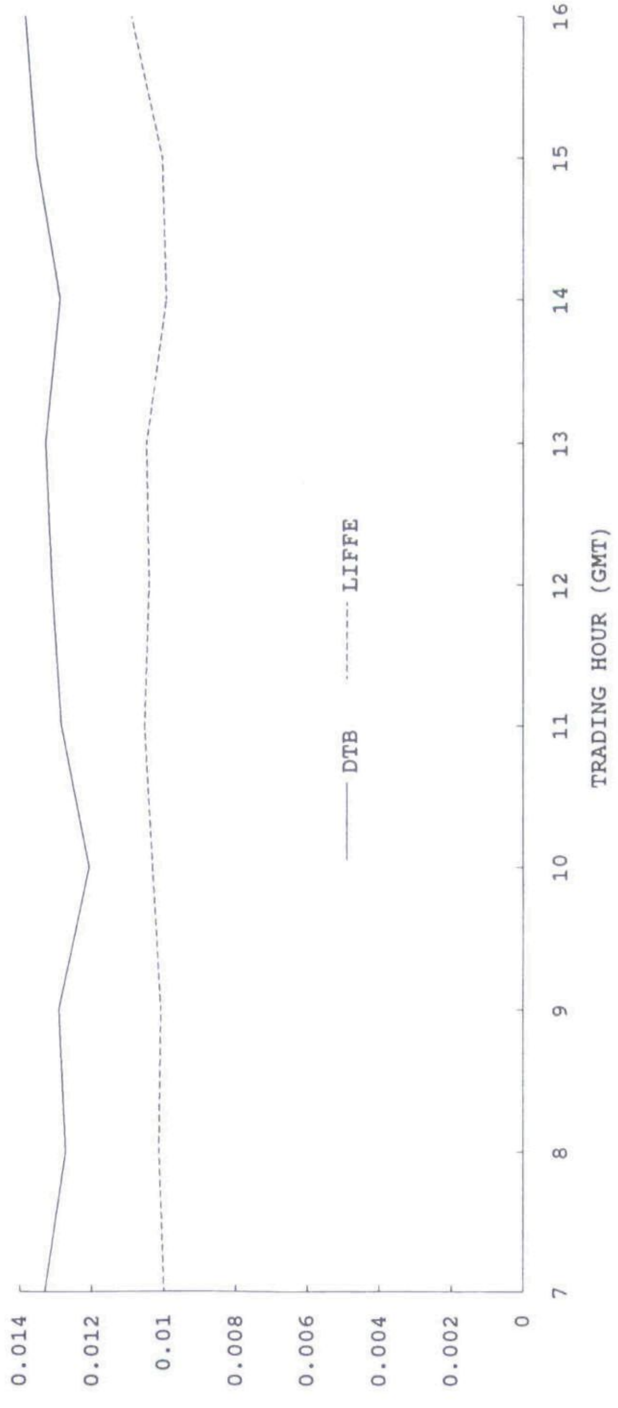

FIGURE 1.
Hourly patterns of bid/ask spread for Bund futures on DTB and LIFFE.

The first step in the empirical analysis is to examine the stationarity of the price series. Non-stationarity is tested using the Augmented Dickey–Fuller (ADF) test (5-minute lag is used arbitrarily to reflect the quick response in the financial market).[4] As shown in Table II, the ADF test for all last price series cannot reject the non-stationary hypothesis at the 0.01 level based on Fuller (1976). On the other hand, all first differenced series reject the non-stationary hypothesis at the 0.01 level. A test is conducted to determine if long-term comovements of Bund futures prices exist between LIFFE and DTB. As suggested by Engle and Granger (1987), if Y_t and X_t are cointegrated, then there exists a constant A, such that $\varepsilon_t = Y_t - AX_t$ is stationary. As a result,

$$Y_t = \alpha + \beta X_t + \epsilon_t \tag{3}$$

where Y_t is price series in LIFFE and X_t is price series in DTB. The augmented Dickey–Fuller (ADF) test is used to test the significance of

TABLE II

Parameter Estimates and t-Statistics (in Parentheses) for Bund Futures Price Traded on LIFFE and DTB

$$\Delta Y_t = \alpha + \beta_1 Y_{t-1} + \beta_2 \Delta Y_{t-1} + \beta_3 \Delta Y_{t-2} + \beta_4 \Delta Y_{t-3} + \beta_5 \Delta Y_{t-4} + \beta_6 \Delta Y_{t-4} + e_t$$

Y^a	β_1	β_2	β_3	β_4	β_5	β_6
DTB	−0.095	−2.84	4.52	−2.99	−1.48	1.06
	(−1.28)	(−1.59)	(2.54)	(−1.68)	(−0.83)	(0.59)
LIFFE	−0.113	−6.12	2.43	−1.08	−5.99	−0.60
	(−2.20)	(−3.42)	(1.36)	(−0.60)	(−3.39)	(−0.34)

$$\Delta^2 Y_t = \alpha + \beta_1 \Delta Y_{t-1} + \beta_2 \Delta^2 Y_{t-1} + \beta_3 \Delta^2 Y_{t-2} + \beta_4 \Delta^2 Y_{t-3} + \beta_5 \Delta^2 Y_{t-4} + \beta_6 \Delta^2 Y_{t-4} + e_t$$

Y	β_1	β_2	β_3	β_4	β_5	β_6
DTB	−1.038	0.009	0.054	0.023	0.009	0.019
	(−23.5)	(0.24)	(1.53)	(0.77)	(0.37)	(1.09)
LIFFE	−1.150	0.089	0.113	0.102	0.045	0.038
	(−24.8)	(2.13)	(3.09)	(3.25)	(1.78)	(2.16)

[a]Numbers reported in the table are actual estimates × 100.

[4]Different lag periods are used and results are not sensitive to lag length used.

β in the following regression.[5]

$$\Delta\epsilon_t = \alpha + \beta\epsilon_{t-1} + \sum_{i=1}^{n} \phi_i \Delta\epsilon_{t-i} + \nu_t \tag{4}$$

where ϵ_t is the error-term from the co-integration equation, v_t is a stationary random error term. Regressing DTB Bund futures price series against LIFFE Bund futures price series[6] produce the following estimates:

$$DB_t = \underset{(1.166)}{0.0024} + \underset{(2227.85)}{0.999}FDB_t .$$

$$R^2 = 0.999 . \quad N = 3156 .$$

Using the error terms from the regression, the t-statistic for the β estimates for eq. (4) is -18.50. The results reject the non-cointegration hypothesis at the 0.01 level.[7]

An error correction term is added to the causality tests [see Engle and Granger (1987)]. Table III shows the testing results. The results indicate that the price movement on the DTB Granger causes the price movement in LIFFE. The F-value for the DTB leading LIFFE is significant at the 0.01 level. The F-value for LIFFE leading the DTB is not significant at the 0.40 level.[8] Looking at the t-values for lagging variables, the price transmission process is found to be very fast and only the one-minute lag variable for DTB has significant impact on the LIFFE price movement. As mentioned in footnote 2, the trading volume in Bund futures at LIFFE is much more active than Bund futures trading at the DTB. The unidirectional lead from the DTB to LIFFE is surprising.

INFORMATION ASYMMETRY

The degrees of information asymmetry at LIFFE and DTB are compared in this section. An empirical model similar to Huang and Stoll (1992) is presented to estimate the adverse selection cost component of the

[5]The results of a Phillips–Perron test are similar.

[6]All price series are measured in natural logarithms.

[7]When a trend component is included in eq. (4), the results are similar and significant.

[8]Based on the generalized method of moments (GMM) by Hansen (1982) and Newey and West (1987), a Wald test with χ^2 distribution is also considered to deal with the probable problem of heteroskedasticity. The testing results support the unidirectional causality from DTB to LIFFE at the 0.02 level. The reverse causality from LIFFE to DTB is not significant at the 0.30 level.

TABLE III
OLS Regression for Granger Causality Test on Bund Futures.

LIFFE GC DTB			*DTB GC LIFFE*		
β_{y_1}	0.017	(0.33)	β_{y_1}	−0.038	(−1.06)
β_{y_2}	0.010	(0.21)	β_{y_2}	0.011	(0.34)
β_{y_3}	−0.026	(−0.58)	β_{y_3}	−0.005	(−0.16)
β_{y_4}	−0.028	(−0.72)	β_{y_4}	−0.030	(−1.02)
β_{y_5}	0.012	(0.37)	β_{y_5}	0.022	(0.90)
β_{x_1}	0.040	(0.79)	β_{x_1}	0.089	(2.44)[b]
β_{x_2}	0.043	(0.90)	β_{x_2}	0.019	(0.58)
β_{x_3}	−0.009	(−0.20)	β_{x_3}	−0.016	(−0.50)
β_{x_4}	−0.018	(−0.43)	β_{x_4}	−0.032	(−1.15)
β_{x_5}	0.001	(0.04)	β_{x_5}	−0.033	(−1.43)
γ	−0.456	(−9.24)[b]	γ	−0.176	(−5.03)[b]
F(5,3099) = 0.53611			F(5,3093) = 3.11271[b]		

Parameter estimates for lagged independent variables (ΔX), lagged dependent variables (ΔY), and an error term from cointegration regression (ϵ).

$$\Delta Y_t = \alpha + \sum_{i=1}^{5} \beta_{y_i} \Delta Y_{t-i} + \sum_{i=1}^{5} \beta_{x_i} \Delta X_{t-i} + \gamma \epsilon_{t-1} + e_t$$

T-statistics are in parentheses. *F* value is used to test Null Hypothesis: Coefficients for ΔX_{i-1}, ΔX_{i-2}, ΔX_{i-3}, ΔX_{i-4}, ΔX_{i-5} are zero.
[a]Significant at the 0.05 level.
[b]Significant at the 0.01 level.

bid/ask spread which can be used to measure the degree of information asymmetry.

The Empirical Model

A market makers' estimated value of a security at time t conditional on the information available to market makers at time $t - 1$ is unobservable. It is assumed that the prevailing quote midpoint at time t, denoted as Q_t, is the market makers' estimated value of the security, prior to the trade at time t.[9] Denote P_t as the trade price at time t. Following Huang and Stoll (1992), the trade price is related to the quote midpoint as

$$P_t = Q_t + z_t \tag{5}$$

[9]One objection to this assumption is that an inventory control mechanism may temporarily perturb the quotes away from the market makers' estimated value of the security [see Stoll (1989)]. However, Hasbrouck (1988), Madhavan and Smidt (1991), and George, Kaul, and Nimalendran (1991) find that inventory control has an insignificant impact on intradaily prices.

Huang and Stoll (1992) suggest that z_t can be regarded as half of the (signed) effective bid/ask spread.[10] The adverse information theory suggests that market makers will adjust the quote midpoint upward following a buy order, and downward following a sale order [see Stoll (1989)]. Similar to Huang and Stoll (1992), the quote revision process due to trades is written as

$$\Delta Q_{t+1} = \lambda z_t + e_{t+1} \tag{6}$$

where ΔQ_{t+1} is the change in the quote midpoint from time t to $t + 1$; λ is the proportion of the effective spread due to adverse selection. The error term e_{t+1} reflects arrivals of public information and market frictions such as price discreteness and the lag in price adjustment due to limit orders.[11]

The intuition underlying eq. (6) is that λz_t is the amount of quote revision attributable to private information revealed from the trade at time t. Normally, one expects $0 < \lambda < 1$ because market makers have to earn a portion of the effective spread to cover market making costs.

To examine the difference in the degree of information asymmetry in LIFFE and DTB, a dummy variable regression model is used. Equation (6) is extended as follows:

$$\Delta Q_{t+1} = a + \lambda_1 z_t + \lambda_2 (D z_t) + \varepsilon_{t+1} \tag{7}$$

where $a = 0$; D is a dummy variable which equal to 1 if the market is DTB and to 0 otherwise; ΔQ_{t+1} and z_t are, respectively, the quote change and the effective spread in DTB if $D = 1$ and in LIFFE; otherwise, ε_{t+1} is the error term; and λ_1 is the proportion of the effective spread due to adverse selection for LIFFE, and $\lambda_1 + \lambda_2$ for DTB.

Evidence of Information Asymmetry

The regression results based on eq. (7) are as follows:

$$\Delta Q_{t+1} = \underset{(2.24)}{0.00000286} + \underset{(12.69)}{0.4034 z_t} - \underset{(-4.81)}{0.2090 (D z_t)}$$

$$N = 6289, \quad R^2 = 0.031$$

[10]Following Hasbrouck and Ho (1987) and Hasbrouck (1991), the trade at time t is classified as a buy order if $z_t > 0$; and is classified as a sell order if $z_t < 0$.

[11]These market frictions may cause serial dependence in the error term. However, the autocorrelations in the error term are small for most of the sample firms and adjusting for these autocorrelations does not have a material effect on the estimate of λ.

The adverse selection cost component for Bund futures on LIFFE is about 40.34% of the effective spread, as indicated by the estimates of λ_1. Since $\lambda_2 = -0.2090$ is significantly different from zero, the hypothesis, H_0: $\lambda_1 = \lambda_1 + \lambda_2$ is rejected. Hence, the degree of information asymmetry for Bund futures on the DTB is significantly lower from that on LIFFE. Based on the evidence, DTB seems to perform better than LIFFE in mitigating the adverse selection problem.

These findings on price transmission seem to suggest that the exchange in the home country of the cash instruments have an advantage on information and price leadership. This implies market segmentation and that a trader should exploit the information in the market which has the lowest transaction cost, assuming other things are equal. Hence, under the assumption of no market fragmentation, even though information is produced in Germany, German traders should still trade on LIFFE which has lower bid/ask spreads and higher trading volume. On the other hand, the findings on information asymmetry could imply that there is more informed trading in LIFFE. This would mean that information is more likely to be exploited at LIFFE than at DTB, an argument that is contrary to the results of previous studies?

One possible explanation is that DTB employs an automated trading system, while LIFFE still conducts trading using an open outcry system during normal trading hours. Becker, Lopez, Berri-Doumar, Cohn, and Adkins (1992) demonstrate that an automated trading system may enhance the market's transparency. Knowing overall market conditions better, market makers at the DTB might be better able to position themselves and reduce adverse selection cost. In addition, it is not unlikely that most informed traders might place orders on both exchanges to smooth the trading volume. If this is correct, DTB might be able to process the information more efficiently in a more transparent environment. Also, the DTB, through its automated trading system, should be able to report its current transaction price faster than LIFFE during normal trading hours. However, it should be cautioned that these conclusions do not suggest that an automated trading system is better than the traditional open outcry system. For example, a wider bid/ask spread and smaller volume is found on the DTB.[12] Evaluating different trading systems beyond the goal of this article.

[12]It is found also that the average bid–ask spread on LIFFE is significantly wider (at the 0.01 level) during APT trading hours that during the open outcry trading hours.

CONCLUSIONS

This article investigates the price transmission process and information asymmetry in Bund futures between LIFFE and DTB. Minute-by-minute data are collected directly from the Reuter Terminal from November 8 through 19, 1993. Very few arbitrage opportunities are observed and there is no meaningful gain on arbitrage profit for intermarket trading between the DTB and LIFFE. The Granger causality test on the intermarket relationship between LIFFE and DTB shows that there exists unidirectional lead from DTB to LIFFE in price transmission. In addition, it is found that the information asymmetry for Bund futures in DTB is lower than that in LIFFE.

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