Cointegration Analysis of Unbiased Expectations in the BIFFEX Freight Futures Market

By

Michael S. Haigh*

*Department of Agricultural and Resource Economics, North Carolina State University, Box 8110, Raleigh, NC 27695-8109, USA Tel: (919) 515-3006; Fax: (919) 515-7873; E-mail: mshaigh@unity.ncsu.edu. Paper prepared for presentation at the 1998 AAEA Annual Meeting.

Abstract

The continued survival of the Baltic International Freight Futures Exchange (BIFFEX), based at the London International Financial Futures Exchange (LIFFE), has come as a surprise to many critics of this unique futures market (the only futures contract on a service). The level of trading activity remains low and the number of players limited, and as a result, this has disappointed advocates of the use of derivatives in the shipping market. Therefore, in an effort to explain, at least partially, the reasons for its continued success, this paper tests long-term and short-term unbiasedness in the freight futures market with respect to its ability to unbiasedly predict future spot prices, using cointegration and error-correction techniques. Findings show that results from cointegrating regressions may falsely lead to the acceptance of unbiasedness by ignoring short-term dynamics. Results confirm that the freight futures market is "long-term" efficient but does experience "short-term" deviations. In light of these results, recent market developments are discussed.

1. Introduction

When the Baltic Freight Futures Contract was launched in May 1985 it was unique in several respects. It was the first futures contract encompassing nearly every part of the globe, and the first contract designed to respond to erratic freight rate fluctuations in the maritime industry. The futures contract was also unique in the sense that it was the first futures contract designed for a service rather than representing an index or a product. Since the futures contract is based on an index of various shipping routes known as the Baltic Freight Index (BFI), it seems that the freight futures contract has failed to accurately reflect the market conditions on lightly weighted routes. This, industry experts suggest, is the reason why tailor-made over the counter (OTC) derivatives like Freight Forward Agreements (FFAs) were introduced in 1991, and have realized relatively high growth rates in trading activity. Despite this, the freight futures market is well established after thirteen years of trading.

Ignoring its apparent shortcomings, the freight futures contract; accounting for some 35% of the global shipping business in tonnage terms, remains unique and still continues to be an important tool for many participants. Consequently, this article has two major objectives: first to briefly present the institutional details of BIFFEX and FFAs, and second, for the first time, to utilize cointegration and error-correction techniques to test the unbiasedness hypothesis in this futures market.

This article extends long-term cointegration tests for unbiasedness by utilizing Johansen's (1988, 1990) methodology, and by utilizing Error-Correction Models (ECMs) (see Engle and Granger (1987)) in order to test for short-term unbiasedness. This two step procedure enables one to show that while on the surface, a market may appear to be long-term efficient, that very same market may indeed be inefficient in the short-term, thus permitting the possibility of arbitrage opportunities. Several empirical studies have used this methodology with the aim of testing for efficiency and unbiasedness in futures markets. A partial list includes Lai and Lai (1991), Krehbiel and Adkins (1993), Beck (1994) and Fortenbery and Zapata (1997). However, most studies using cointegrating models to discuss efficiency and unbiasedness ignore the short-term dynamics. But tests of unbiasedness require the use of long-term cointegration techniques to capture the long-term relationship, and the use of ECMs to pick up on short-term dynamics.

2. Institutional Aspects of BIFFEX

Creating a futures market whose underlying commodity is a service contract in the freight industry created a fundamental problem. Freight services lacked fungibility – the ability to interchange or substitute one item for another freely. Freight services differ in terms of size, gear, fuel efficiency, cargo, destination, dates, and so forth, and in a service market like the freight market where there exists no standard uniform unit, the only possible option was to trade an index. Indeed, it was the conceptual difficulty in developing an index that delayed the establishment of the futures contract by the London Commodity Exchange, the Baltic Exchange and the Grain and Feed Association until 1984. It was in January 1985, that the BFI was published and the rules in constructing the BFI were set forth. The Baltic Exchange began publishing on a daily basis the BFI which represented a bundle of shipping services and was (and still is) widely accepted as an indicator of the world wide dry cargo freight market.

The BFI is constructed from fixture (recently negotiated rates) reports given daily to the Baltic Exchange in strict confidence by a panel of broking companies. After compiling estimates from the panel of experts, the Baltic Exchange establishes the average freight rate on each route after ignoring the highest and lowest rates reported by the panelists. The average rate for each route is then multiplied by the weighting factor for each route. However, because the spot freight market is continuously changing, previously important voyages have become irrelevant or become subject to long-term contracts. Therefore, as the index is designed to correctly reflect the freight market, its composition has been regularly updated.

For practical purposes, freight rates on each individual route are converted into indices by the Baltic Exchange, along with the overall average index known as the BFI. The index is then normally published by the Baltic Exchange on each working day, and is then transmitted to the LIFFE and forms the basis of trading on the BIFFEX market. The futures market at LIFFE trades an idea of the forward value of the Baltic Freight Index (BFI), and the market traders buy or sell units of cash known as freight futures contracts. The BFI contracts were originally traded on a quarterly basis, but in July 1988 'spot' and 'prompt' months were introduced. BFI contracts are now available for the current month, the following two consecutive months and January, April, July, and October for up to eighteen months forward. Trading on BIFFEX involves no supply of cargo or ships. It is a cash settlement market, and can be thought of as a financial tool to be used alongside the physical freight market.

The most fundamental concept is that the freight futures follow the movement of prices on the spot market: if the freight market is falling, the BFI falls. Simply stated, hedging in this market involves setting up an opposite position on the futures market as to that held on the physical market so that what a trader loses on one transaction, will be gained back, at least partially so, on the other.

Since the various segments of the dry bulk cargo market may move somewhat independently, the BFI seems to have failed to accurately reflect the market condition on lightly weighted routes. Indeed, as certain routes in the index seem to be more highly correlated than others with the BFI, hedging may only be desirable for certain routes within the index (although conceivably, BIFFEX could be used to a hedge a route not represented in the index). It is for this reason that the concept of FFAs evolved in 1991. The FFAs are tailor-made hedges between two principles who have different views of the market with a need to hedge a forward commitment. The FFA is a principal-to-principal agreement, and counterparties are free to introduce their own variations into the contract, provided they are mutually agreed upon.

When a trade is transacted across the BIFFEX, the London ClearingHouse (LCH) guarantees all contracts so that default risk is minimized. Since FFAs on the other hand, are over the counter (OTC) contracts (i.e. principal to principal) and are not guaranteed by the clearinghouse, or the exchange. Credit risk is therefore a limiting factor with the FFAs.

3. Cointegration and Unbiasedness

Unbiasedness suggests that the current futures price, F_{t-1}, of a contract expiring at time t, should equal the spot price expected to prevail at time t. If market participants had access to additional information to predict the spot price expected to prevail at time t, they would profit by selling or buying a futures contract if the current futures price was not equal to the expected spot price at time t. Such buying and selling should ensure that equality is reestablished. In order to test unbiasedness there have been several attempts to estimate the following:

$$S_t = \alpha + \beta F_{t-1} + \mu_{t.} \quad (1)$$

That is, the expected spot price is replaced by the actual spot price plus an error term, assuming the existence of rational expectations. Unbiasedness is thus confirmed when the joint restriction $\alpha = 0$ and $\beta = 1$ holds. It has been shown that OLS procedures are inappropriate when non-stationary data are used (see Elam and Dixon (1988)). A solution to this problem is offered by cointegration methodology, which deals specifically with the issue of non-stationary time series data.

The development of cointegration modeling stems largely from the work by Granger and Engle (Granger, 1986; Engle and Granger, 1987). The principle is to test for the presence of a long-term equilibrium relationship between a set of variables. Specifically, a vector Z_t, with the property that each component of Z_t has been differenced d times to achieve stationarity may be written as $z_t \sim I(d)$ (where z_t is a component of Z_t). If all of these subcomponents happen to be integrated of the same order, cointegration exists if a cointegrating vector λ is found such that

$$X_t = Z_t\lambda \sim I(0). \tag{2}$$

In other words, X_t is stationary and simply represents random deviations from an equilibrium position, with the system readjusting to the long-term equilibrium. If two series are cointegrated, short run deviations are possible, but market forces ensure that equilibrium is regained in the long-term. In the case of futures markets, the actions of market participants are such that if the futures price diverges "too far" from the equilibrium level, buying and selling of futures contracts would ensue, causing the futures price to return to its long-term equilibrium. Engle and Granger (1987) offer a simple test for cointegration using a two-stage approach. A limitation of the Engle-Granger procedure is that no strong statistical inference can be drawn with respect to the parameters, α and β, which are the crux of unbiasedness testing (see Hall (1986) and Stock (1987)). The other inherent problem with the Engle-Granger two step procedure is that the cointegrating vector is assumed to be unique.

Solutions to the problems of the Engle-Granger approach have been offered by Johansen's multivariate approach (Johansen (1988), Johansen and Juselius (1990)). This method presents a methodology for testing parameter restrictions in cointegrated systems.

Explained briefly, the method of Johansen utilizes the concept of canonical correlations from the theory of multivariate statistical analysis. The technique of canonical correlations is then applied to search for linear combinations of the data in levels (non-differenced) which are as highly correlated as possible to the data that has been differenced. It therefore follows that these linear combinations are stationary, or cointegrated. The assumption is that Y_t is generated by an autoregressive form:

$$Y_t = c + \sum_{i=1}^{k} \Pi_i Y_{t-i} + \varepsilon_t \ , \tag{3}$$

where Y_t is an N x 1 vector of the I(1) variables (Spot and Futures prices respectively in this instance), Π_i is an N x N matrix of parameters, c is a vector of constants, and ε_t is a random error term. Johansen and Juselius (1990) suggest that (3) can be re-written as:

$$\Delta Y_t = \sum_{i=1}^{k-1} \Gamma_i \Delta Y_{t-i} + \Pi Y_{t-k} + \varepsilon_t \ , \tag{4}$$

with

$$\Gamma_i = -(I - \Pi_1 - \Pi_2 - ....\Pi_i) \quad (i = 1, ...k-1) . \tag{5}$$

Since ε_t is stationary, the rank of the “long-run” matrix Π determines how many linear combinations of Y_t are stationary. When Π is full rank, or when its rank is zero, cointegration will not be present. In the case of studying the relationship between the spot and futures prices: if the rank of Π = 2, then S_t and F_{t-1} are jointly stationary; if the rank of Π = 1 then S_t and F_{t-1} are not stationary, but are cointegrated; and if the rank of Π = 0, then S_t and F_{t-1} are not cointegrated and their relationship can simply be studied by using first differenced data.

The Johansen procedure permits testing of the restrictions on the parameters in the cointegrating vectors. Establishing the definition of stationary linear combinations of nonstationary variables $C`Y_t$, one may define:

$$C`Y_t = 0, \tag{6}$$

where $Y_t = (S_t, F_{t-1}, 1)$, and $C` = (1, -\beta, -\alpha)$. Solving equation (7) gives the cointegrating relation described in equation (1). The long-term test for unbiasedness is then undertaken by imposing $C` = (1, -1, 0)$, which normalizes S_t to unity and gives the restrictions that $\alpha = 0$ and $\beta = 1$. The test statistics involve comparing the number of cointegrating vectors under the null and alternative hypotheses. Asymptotically, this test statistic is distributed as a χ^2 with the number of restrictions imposed on β equaling the number of degrees of freedom.

5.Short Term Dynamics and Error Correction Models

A principle feature of cointegrated variables is that their time paths are influenced by the extent of any deviation from the long-term equilibrium. Consequently, the short-term dynamics must be influenced by the deviation from the long-term relationship. An ECM for I(1) variables implies cointegration, and similarly, cointegration implies error correction. This result is known as the Granger representation theorem [Granger (1983), Engle and Granger (1987)]. The transformed series represented in error correction terms are now stationary, so parameter estimates are asymptotically normally distributed and hypothesis testing is valid. It is within the ECM framework that the cointegration methodology can incorporate a long-run equilibrium with short-term dynamics. Therefore

$$\Delta S_t = \alpha + \rho\left[S_{t-1} - \delta F_{t-2,t}\right] + \varphi \Delta F_{t-1} + \sum_{i=1}^{k} \lambda_i \Delta S_{t-i} + \sum_{i=1}^{l} \Delta \varphi_i F_{t-i} + \varepsilon_t, \quad (7)$$

where ε_t is a stationary (although possibly auto-correlated) series with zero mean, and $\left[S_{t-1} - \delta F_{t-2,t}\right]$ is the error correction term. Cointegration in this form implies that $\rho < 0$ because the spot price responds to movements from the long-term equilibrium position illustrated in Equation 1. Unbiasedness implies that $\varphi = 1$ because any new information affecting movements in the future spot rate will be incorporated immediately in the current futures price. The coefficients on the lagged values, λ_i and φ_i should be equal to zero because all past information has already been incorporated into the current futures price. If these restrictions do not hold, the futures market would be deemed inefficient.

6. Data

The data set used in this study are futures prices for the period between July, 1988, and September, 1997. Because trading volumes on distant contracts have historically been fairly thin, this study tests only the nearest contract (one-month). Trading began for freight futures in May, 1985, for quarterly contracts, but it was not until July, 1988, that trading began for the one-month contract. Data used in this study were made available by the Statistics Department at the LIFFE. Data are evaluated both in levels and using logarithmic transformations. Only results from the logarithmic form are presented as data evaluated in levels produced qualitatively similar results.

7. Empirical Results

Firstly, it is necessary to test for the presence of unit roots in order to avoid the problem of spurious regression. Therefore, in this study, both the augmented Dickey-Fuller (ADF) and Phillips Perron (PP) unit root tests are undertaken. Both tests are undertaken allowing for the presence of a time trend. Excluding the time trend yielded qualitatively similar results so these results are omitted. The order of the estimated autoregression for the ADF and PP tests in this analysis was determined using the AIC2 criteria described in Pantula et al. (1994). Results (see Table I) indicate that the time series are nonstationary, a necessary condition for cointegration analysis. When the tests are applied to the differenced series however, both test statistics clearly reject the null hypothesis of the presence of a unit root.

Table I: Unit Root Testing: July 1988 – Sept 1997

	S_t	F_{t-1}		S_t	F_{t-1}	τ_τ (5%)	τ_τ (10%)
ADF	-2.848	-2.922	PP	-2.774	-2.891	-3.45	-3.15

Critical values are taken from Fuller (1976).

The "optimal lag" used in the Johansen procedure is selected using Akaike's (1973) Information Criterion, and one lag is chosen. The unbiased pricing condition, $\alpha = 0$ and $\beta = 1$ is then tested in the cointegrating vector: i.e., $\alpha = (1, -1, 0)$. Also, individual tests are carried out on $\alpha = 0$: (1, -b, 0) and $\beta = 1$: (1,-1,a). Results in Table II clearly illustrate that the null hypothesis of no cointegration, r = 0, is rejected at the 1% level using both the L-max and Trace statistics.

Table II: Johansen Cointegration Tests of Spot and Futures Markets July 1988 – Sept 1997

Lag Length	Ho:	Ha:	L-max	Trace	Parameter estimates for $\alpha = (1, b, a)$	Ho: $\alpha = 0$	Ho: $\beta = 1$	Ho: $\alpha = 0, \beta = 1$
1	r = 0	r = 1	119.65[a]	127.17[a]	(1,-1.029,0.203)	1.04	1.13	4.42
	r = 1	r = 2	7.52	7.52				

Critical values for the L-max and Trace statistics are from Osterwald-Lenum (1992). The critical values for the Lmax and Trace statistics are: r=0, 14.90 and 17.95 (5%), and 19.19 and 23.52 (1%). For r=1, the critical values are for both the Lmax and Trace statistics: 8.18 (5%) and 11.65 (1%). Critical values for the χ^2 distribution for the individual tests (number of degrees of freedom are equal to the number of restrictions) are: 3.84(5%), and 6.63(1%). For the joint test the critical values are 5.99(5%) and 9.21(1%). K refers to the lag length.
[a] Significant at the 1% level.

The hypothesis that r = 1 is not rejected however, so the results clearly indicate that S_t and F_{t-1} are cointegrated. Individual test statistics indicate that indeed $\alpha = 0$, and $\beta = 1$. Moreover, the joint test, distributed as a χ^2 with two degrees of freedom, illustrates that the null hypothesis cannot be rejected at the 1% significance level or better. Therefore, results indicate that for the one-month contract the futures contract is an unbiased predictor of the spot market in the long-term.

Next, the short-term dynamics are estimated using an error correction model. The model was estimated with zero to five lags, with significant coefficients retained (see, e.g., Engle and Granger, (1987)). Results confirm that only the third lagged futures price is statistically significant in the model. Tests were then undertaken for serial correlation, autoregressive conditional heteroscedasticty (ARCH), normality, and heteroscedasticty. Only heteroscedasticity was found in the model using White's test, so the t and Wald statistics were recomputed with heteroscedastic-consistent standard errors (White, 1980).

$$\Delta S_t = \alpha + \rho(S_{t-1} - F_{t-2,t}) + \varphi \Delta F_{t-1,t} + \varphi_4 \Delta F_{t-3} + \mu_t$$

Table III
Estimated Error Correction Model after deleting insignificant lagged coefficients

	α	ρ	φ	φ_4	Ho: $\rho = -1$ χ^2 (1)	Ho: $\varphi = 1$ χ^2 (1)	Ho: $\varphi_4 = 0$ χ^2 (1)	Ho: $\rho = -1$, $\varphi = 1$, $\varphi_4 = 0$ χ^2 (3)
Parameter	0.006	-0.7638	0.895 25	-0.2051				
T value	1.066	-4.881	6.614	-2.185	0.773	1.509	2.185	8.291
P value	0.289	0.000	0.000	0.031	0.439	0.131	0.029	0.040

Critical Values for the t distribution at the 5% and 1% levels respectively are: 1.660 and 2.364
Critical Values for the χ^2 (3) distribution at the 5% and 1% levels respectively are: 7.82 and 11.34

On the basis of the Wald Tests (jointly testing the parameter restrictions), one can see that whilst the BIFFEX futures market is efficient in the long-term, there appear to be short-term inefficiencies, and hence possible arbitrage opportunities. The short-term inefficiency is significant, with a reported p value of 0.04. Individual tests on the parameters in the error correction model indicate that both $\rho = -1$, and $\varphi = 1$. However, an individual test on φ_4 suggests that it is possible to reject the null hypothesis that $\varphi_4 = 0$, with a reported p value of 0.029. It is this significant parameter that seems to drive the rejection of the joint hypothesis that $\rho = -1$, $\varphi = 1$ and $\varphi_4 = 0$.

Despite the rejection of short-term unbiasedness in the BIFFEX market found in this paper, two points are worth considering. First, this result is by no means uncommon, as other tests for market unbiasedness have produced similar results. For example, Beck (1994), tested for market efficiency and unbiasedness in five commodity markets, and found that in several cases the unbiasedness hypothesis could be rejected. Secondly, whilst rejecting unbiasedness does imply the opportunity for arbitrage, without comparing associated transactions costs (round trip brokerage commissions), it is not possible to measure how much could be exploited, and consequently, whether or not arbitrage is worthwhile.

9. Conclusion

Unlike most papers, this paper investigates the issue of unbiasedness in both the long and short-term using futures data from the Baltic International Financial Futures Exchange as the subject matter. Therefore, in this paper a theoretical explanation is offered to the methodology for testing unbiasedness, and a practical application is illustrated adopting both the short and long-term procedures. Results from the Johansen procedure indicate that this market is unbiased in the long-term. Incorporating the long-term structure of the market into an ECM format was shown to be essential to study deviations from the long-term relationship. Results indicate that while in this case, the short-term deviation is significant, omitting the ECM procedure (as is usual in most traditional long run cointegrating regressions) may falsely lead to the acceptance of unbiasedness by ignoring important short-term dynamics.

Despite the existence of significant short-term deviations, the freight futures market can be deemed to be unbiased in the long-term. Perhaps this is the reason why a market that has suffered from a chronic lack of growth in volume in 13 years of trading, still exists. The result of unbiasedness in this futures market might indicate that the underlying mechanism behind this futures market is in full working order, but the "volume problem" rests with the representation of routes in the Baltic Freight Index, on which the futures contract is based. The increases in volume of tailor-made Freight Forward Agreements (FFAs), seem to be indicative of a possible resolution to the apparent problems associated with the freight futures contract. The FFAs are very simple, do not involve speculators and do not constitute a "futures" market as such, although they may, in time, become the vehicle for such development. Further research in this area would therefore be very worthwhile, as would an evaluation of how successful the BIFFEX is in mitigating price uncertainty for commodity traders.

Bibliography

Akaike, H. (1973): "Information Theory and an Extension of the Maximum Likelihood Principle," In B.Petrov and F.Csake, eds., *Second International Symposium on Information Theory*. Budapest: Akademiai Kiado.

Antoniou, A., and A.J. Foster (1994): "Short-Term and Long-Term Efficiency in Commodity Spot and Futures Markets," *Financial Markets, Institutions & Instruments,* 3:17-35.

The Baltic Freight Index Rules, The Baltic Exchange, London, Fall 1997.

Beck, S.E., (1994): "Cointegration and Market Efficiency in Commodities Futures Markets," *Applied Economics,* 26: 2249-257.

Chang, Y.W. (1992): Forward Pricing Function of Freight Futures Prices, Ph.D. Dissertation, University of Wales, U.K.

Chowdhury, A.R. (1991): "Futures Market Efficiency: Evidence from Cointegration Tests," *The Journal of Futures Markets*, 11: 577-589.

Denning, K.C., Riley, W.B., and Delooze, J.P. (1994): "Baltic Freight Futures: Random Walk or Seasonally Predictable?" *International Review of Economics and Finance,* 3(4): 399-428.

Dickey, D. A., Jansen, D. W., and Thornton, D. L. (1991): A Primer on Co-integration with an application to Money and Income. Federal Bank of St. Louis.

Elam, E., and B.L. Dixon. (1988): "Examining the Validity of a Test of Futures Market Efficiency," *The Journal of Futures Markets,* 8:365-372.

Engle, R.F., and Granger, C.W.J. (1987): "Co-Intergration and Error Correction: Representation, Estimation, and Testing," *Econometrica,* 55:251-276.

Fortenbery, T.R., and Zapata, H.O. (1997): "An Evaluation of Price Linkages between Futures and Cash Markets for Chedder Cheese," *The Journal of Futures Markets*, 17: 279-301.

Fuller, W.A. (1976): Introduction to Statistical Time Series, New York: Wiley.

Granger, C. and Newbold, P. (1977): Forecasting Economic Time Series, Academic Press, New York.

Granger, C.W.J (1983): “Co-Integrated Variables and Error Correction Models,” *UCSD Discussion Paper*, 83-13.

Granger, C.W.J (1986): “Developments in the Study of Cointegrated Variables,” *Oxford Bulletin of Economics and Statistics*, 48:213-228.

Hall, S.G. (1986): “An Application of the Granger & Engle Two-Step Estimation Procedure to United Kingdom Aggregate Wage Data,” *Oxford Bulletin of Economics and Statistics*, 48 (3): 229-240.

Hall, S.G. (1991): “The Effect of Varying Length VAR models on the Maximum Likelihood Estimates of Cointegrating Vectors,” *Scottish Journal of Political Economy*, 38:317-323.

Hampton, M. “The industry’s future?” Seatrade Review, pp29-31, Aug 1997.

Hauser, R.J., and Neff, D. (1993): “Export/Import Risks at Alternative Stages of U.S. Grain Export Trade,” *The Journal of Futures Markets*, 13:579-595.

Johansen, S. (1988): “Statistical Analysis of Cointegration Vectors,” *Journal of Economic Dynamics and Control* ,12:231-254.

Johansen, S., and Juselius, K. (1990): “Maximum Likelihood Estimation and Inference on Cointegration with Applications to the Demand for Money,” *Oxford Bulletin of Economics and Statistics*, 52:169-210.

Krehbiel, T., and L.C. Adkins. (1993): “Cointegration Tests of the Unbiased Expectations Hypothesis in Metals Markets,” *The Journal of Futures Markets*, 13: 753-763.

Lai, K.S, and M.Lai. (1991): “A Cointegration Test for Market Efficiency,” *The Journal of Futures Markets*, 11:567-575.

Middleton, I., “Freight Swaps” Seatrade Review p.33, Feb 1997.

Osterwald-Lenum, M. (1992): "A Note with Fractiles of the Asymptotic Distribution of the Maximum Likelihood Cointegration Rank Test Statistics: Four Cases," *Oxford Bulletin of Economics and Statistics,* 54: 461-72.

Pantula, Sastry G., Graciela Gonzalez-Farias, and Wayne A. Fuller, (1994): "A Comparison of Unit-Root Test Criteria," *Journal of Business and Economics Statistics*, October pp.449-459.

Phillips, P and Perron, P. (1988): "Testing for a unit root in time series regression," *Biometrica*: 75, 335-46.

Shipping Futures and Derivatives, From Biffex to Freight Forward Agreements (FFAs) and Beyond, Drewry Shipping Consultants, Sept 1997.

Stock, J.H. (1987): "Asymptotic Properties of Least Squares Estimators of Cointegrating Vectors," *Econometrica*, 55:1035-1056.

Tang, K.H. (1990): Strategic Decision-Making Process in the Baltic Freight Futures Market, SM Thesis, OE Dept, MIT.

Thomas, S., "BFI and Biffex" Seatrade pp.31-33, Dec 1994.

Thuong, L.T. & Ho.C. (1987): "Coping with International Freight Rate Volatility," *Journal of Purchasing and Materials Management,* 29-45, Fall.

Thuong, L.T. & Visscher, S.V (1990): "The Hedging Effectiveness of Dry-Bulk Freight Rate Futures," *Transportation Journal,* 29: 58-65.

White, H. (1980): "A heteroscedasticity-consistent covariance matrix estimator and a direct test for heteroscedasticity," *Econometrica,* 48: 818-838.