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An equilibrium price model of spot and forward shipping freight markets

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ABSTRACT

We focus on non-storability, a characteristic of shipping freight that leads to an enormous gap between the widely-used no-arbitrage pricing theory and shipping freight derivative markets. Our main contribution is to modify and generalize the Bessembinder and Lemmon (2002) model. Equilibrium spot and forward price formulae are derived in a shipping freight market where shipowners, charterers, and speculators are non-homogeneous. From our formulae, we also obtain the properties of the forward risk premium and an optimal hedge ratio. In addition, we use the model to quantify the risk attitude of market participants.

1. Introduction

Freight rate risks have traditionally been managed by time-charter contracts, in which shipowners and charterers can only employ static hedges. Since the 1980s, active markets for shipping derivatives such as forward/futures have emerged to provide dynamic hedging strategies. As a result, shipping forward/futures markets have seen huge growth in recent years. From 1985 to April 2002, futures contracts were primarily traded on the London International Financial Futures and Options Exchange. This market was known as the Baltic Freight Futures Exchange (BIFFEX) futures, and its underlying asset was the Baltic Freight Index (BFI). Clarkson started to deal with freight derivatives in 1991. Clarkson Securities Limited (CSL) was established for the Forward Freight Agreement (FFA) market.[1] Maritime agents also began to trade over-the-counter hedging instruments. For example, the International Maritime Exchange (IMAREX) also have acted as a market place like the London Clearing House (LCH).[2] FFAs are cash-settled contracts for differences whereas early BFI futures are only cleared.[3]

The introduction of shipping freight forward markets has provided new tools and techniques for all market participants. Traditionally, once a time charter contract is initiated, any offsetting financial transactions are not generally settled during the contract period.[4] However, any standard forward position can be closed before its expiration. Traditional time-charter contracts have been negotiated only between charterers (operators) and shipowners. Aside from these, other investing agencies,

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[1] For details see http://www.clarksonsecurities.com/.

[2] For details see http://www.imarex.com/.

[3] Our model focuses only on a function of instruments. That is, the futures price is pre-determined and the mark to market is not considered. Thus, we equate forward contract and futures, and use only the word "forward".

[4] In the abstract, it is possible to offset one contract with the other using some time-charter contracts.

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such as trading companies, financial institutions and non-financial firms, can also participate in the forward markets. Some speculators may also appear in shipping derivatives markets. In this way, sufficient market liquidity is retained.

In this paper, we focus on shipping forward contracts. From the viewpoint of researchers and practitioners, there are two problems in shipping finance. The first is the manner in which spot and forward prices are determined, sometimes called the price discovery problem. This problem includes the question of whether the forward price can be an unbiased estimator of spot rates. A price formula might reveal implicit features of the market structure. The second problem is explaining how a firm should use shipping derivatives as risk management instruments.

A number of related studies have been published. Broadly speaking, these can be classified into three thematic approaches: (1) equilibria with demand–supply structural models, (2) time-series analyses of spot and forward prices, and (3) deriving shipping derivatives prices.

Representative studies that employ demand–supply mechanisms are Zannetos (1966), Beenstock (1985), Beenstock and Vergottis (1989a,b), Tvedt (2003) and Adland and Strandenes (2007).

The earliest study, Zannetos (1966), establishes a demand–supply equilibrium framework and shows the relationship between spot markets and the charter market. A positive correlation is found between spot and time charter rates, while the correlation between spot rate and the number of ships in the market is negative. Beenstock (1985) constructs an equilibrium model to consider interdependencies among spot, time charter, ship-building, second-hand and scrapping markets. Beenstock and Vergottis (1989a,b) add some assumptions to simplify their models in the analysis of dry cargo and tanker markets. Each of the models gives a good account of the corresponding market. In particular, there is a positive correlation between the time charter rate at time t and the spot rate at time $t + 1$.

These classical equilibrium models capture well some features of shipping market structure and provide many economic implications. However, it is difficult to apply these models directly in practical situations, such as risk management, because there are many parameters needed for estimation. Furthermore, many variables in the estimation are unobservable, and in some cases there are no proxy variables available. Nevertheless, some theoretical studies have attempted to bridge the gap between equilibrium models and risk measurement.

Tvedt (2003) derives an optimal construction level for vessels in a classical demand–supply shipping market model, where the demand curve is stochastic. The equilibrium freight rate process, which is successively obtained, has properties similar to a standard geometric mean reverting process. Adland and Strandenes (2007) develop a shipping equilibrium model in which scrapping, contracting and demand dynamics are stochastic. By measuring risk, generation of useful information, such as spot freight rate sample paths, distributions of future freight rates, and so on, is enabled. Here, we note that neither of these two works takes account of a nexus between spot freight rates and the corresponding forward/futures prices.

There is also a large body of academic research based on time-series analysis. This type of approach is easily applicable to financial decision-making. Kavussanos and Nomikos (1999) examine the unbiasedness between BFI and BIFFEX prices. Some test statistics indicate unbiasedness between spot and futures prices at 1 and 2 months before maturity, but futures prices 3 months prior to maturity seem to be biased. Despite this fact, futures prices are found to provide better forecasts than those based on vector error correction, random walk, auto-regressive integrated moving average, and Holt–Winters models.

Kavussanos and Nomikos (2000) use the vector error correction model (VECM), specifically a VECM-GARCH and a VECM-GARCH-X for spot and futures returns, respectively, and calculate the time-varying hedging strategy for each model. They then compare several different hedge ratios: one futures position, ratios obtained from a simple linear regression model, and the above time-varying ratios. The hedging effectiveness of the time-varying ratios is found to be superior to the alternatives.

Kavussanos and Visvikis (2004) focus on the relationship between spot and FFA prices, and find that FFA prices tend to reflect new information more rapidly than spot prices, and that the effect of FFA price volatility on spot prices depends on the route through VECM-GARCH and Granger causality.

Koekebakker and Adland (2004) show a theoretical relationship between time charter rates and forward freight rates using a factor model. They estimate the forward freight rate curve parameters in a Panamax 65,000 dwt bulk carrier market. They find that the volatility function of the forward rate curve reaches a peak at about 1-year maturity.

Kavussanos et al. (2004) apply a VECM to investigate the relationship between spot and forward prices in FFA, and find that unbiasedness cannot be rejected for FFA prices with 1- and 2-month maturities. In contrast, FFA prices 3 months prior to maturity are found to be biased for some routes.

Adland and Cullinane (2006) investigate time charter-equivalent spot freight rate fluctuations in the VLCC, Suezmax, and Aframax sectors, using a non-parametric statistical method. Their results suggest that both drift and diffusion aspects of each process are non-linear with respect to freight rate levels.

In addition, a number of studies focus on time charter contracts with different maturities, and attempt to describe the shape of term structure with the expectations hypothesis. This category includes Glen et al. (1981), Strandenes (1984), Hale and Vanags (1989), Veenstra (1999), and Alizadeh et al. (2007). Alizadeh and Kavussanos (2002) give a survey of previous studies on the relationship between spot rate and time charter rate, and examine the expectation hypothesis for charter rates with a variety of size categories and different charter lengths. While Alizadeh and Kavussanos (2002) employ a quantitative approach, Adland and Cullinane (2005) use a qualitative approach on the risk premium of time charter rate to describe the sign of net risk premium in relation to market condition, period of charter duration, and some risk factors such as utilization risk, transport shortage, default risk, spot rate volatility, liquidity risk, and technological/legislative risk.