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An Analysis of the Long-Run Market for Shipping Services for Dry-Bulk Commodities

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ABSTRACT

Over the period 1964-83 the dry-bulk-carrier fleet grew by approximately eight times. This study attempts to identify the factors behind this rapid increase in fleet size by analyzing the price, orders, delivery, and scrappage of dry-bulk carriers. Using two-stage least squares regression, statistical relationships were estimated for these activities. Statistically, the price and delivery equations had good explanatory power, while the orders and scrappage equation were weaker. Calculated elasticities indicate that orders for new ships are trade elastic. The calculated flexibilities for the price equation indicate that there has been a parallel rise in the price of steel and the price of new carriers. The deliveries equation indicates that most carriers are delivered within two years of being ordered. The scrappage equation indicates increased scrappage activity with weak conditions in the market. In general the model indicates a rather flexible market in the long-run, with elastic response to many factors, despite the large capital investment requirements.

I. INTRODUCTION

Over the past 25 years the dry-bulk-transport business has changed from the use of freighters to the use of specialized dry-bulk carriers. In addition to the changes in shipping technology, the period has also seen a major increase in trade. Trade in the major dry-bulk products of coal, iron ore, phosphate, bauxite, and grain has grown substantially. Each of these commodities are important to the United States, either in raw or processed form; especially grain and coal in this period of large trade deficits. The revenue generated by the exports of these commodities partially offsets the expenditures on imported oil. However, the quantity of these products exported is affected by the cost of shipping them. For example, Dunn and Gianoulades found that the elasticity of U.S. grain exports with respect to freight rates was −0.1. Since export demand is elastic, export revenues would also grow. This means that there is a direct link between the dry-bulk-shipping market and the U.S. economy; a link which affects both the commodities directly involved and the economy in general.

There have been short-run studies of ocean-freight rates for dry-bulk commodities (Binkley and Harrer, Dunn and Gianoulades). However, the long-run market has not been studied. Only the paper by Hawdon on the tanker market has dealt with the long-run behavior of the bulk-shipping industry.

The objective of this paper is to study the long-run behavior of the dry-bulk-carrier market. This will be done by estimation of an econometric model of this market. This model will have as endogenous variables orders for new dry-bulk carriers, deliveries of dry-bulk carriers, scrappage of dry-bulk carriers, and the price of dry-bulk carriers. Total fleet size and ships under construction will be determined by identities.

II. THEORY AND MODEL SPECIFICATIONS

The number of dry-bulk carriers in the fleet is determined by supply and demand. In this respect, the market for new ships is no different than any other market. The differences in the market are mainly associated with time. Like many capital goods, ships required a substantial time to build. Furthermore, once built a ship can remain in service for many years. These two factors make the market much less responsive to changes in economic factors than markets with fewer time constraints.

Most of the economic decisions in the dry-bulk-carrier market involve expectations. These expectations may or may not be closely related to current levels of economic variables. The most obvious role of expectations is in the orders for new ships. A buyer will order a new ship when his expectations suggest that it will be profitable to do so. This means that the buyer expects the revenues from operating this ship to exceed the costs by an adequate amount to compensate the outlay of funds in the present to gain this income stream in the future.

The demand for ships is derived from the demand for shipping space. The observed demand is a reflection both of the cost of the ships and the expected revenues which may be generated using this ship. In the short-run, these revenues, or freight rates, are determined by the balance between the supply of shipping and the volume of trade. In the short-run the fleet size is fixed. However, in the long-run the fleet can grow in response to higher rates.

It is hypothesized that some observable vriables provide clues to the outlook for the industry. These variables include the size of the fleet, the number of ships currently under construction, and the level of trade. The cost of the ship is balanced against this outlook.

A new ship, once ordered, is not available immediately. It takes from 1.5 to 3 years to build a ship. This means that the demand for ships has two components: new demand as reflected by orders; and old demand still unsatisfied, which is seen in ships on order or under construction, and will eventually be reflected in deliveries. Therefore, deliveries are hypothesized to depend on past orders.

In general the price of a carrier should respond to market conditions. Shipyards would charge a rate that reflects their cost of building the ship. This cost should increase as the number of ships under construction increases. Furthermore it should increase as the cost of raw materials increase. In the case of shipbuilding the major raw material used in steel. In addition, considerable labor is required and, because the process is so lengthy, considerable capital.

Scrappage is the negative demand for ships. This is the removal of a ship from the fleet because it is expected to be unprofitable to operate in the future, either because newer ships are cheaper to operate, or because the outlook for shipping rates is unfavorable. Since the alternative to an existing ship is a new ship, higher ship prices should discourage scrappage. In general, older ships are less efficient to operate, either because of technological advances or increasing repair costs. Therefore as the number of old ships increases, so also does the number of potential scrappages.

The fleet in a particular year is the fleet last year plus deliveries less scrappage. The ships on order or under construction in a particular year is the ships on order or under construction from last year plus orders less deliveries. Because ships are not uniform in size all measures of ships are in dead weight tons.

This discussion is operationalized in the following model specification:

Orders:

$$O_t = f(F_{t-1}, P_t, T_t, U_{t-1}) + e_{t1} \quad (1)$$

Deliveries:

$$D_t = f(O_{t-1}, O_{t-2}, O_{t-3}) + e_{t2} \quad (2)$$

Price of Ships:

$$P_t = f(I_t, U_t) + e_{t3} \quad (3)$$

Scrappage:

$$S_t = f(P_t, T_t, R_{t-1}, F_{t-1}) + e_{t4} \quad (4)$$

Fleet:

$$F_t = F_{t-1} + D_t - S_t \quad (5)$$

Under Construction:

$$U_t = U_{t-1} + O_t - D_t \quad (6)$$

where:

O_t are the orders for new dry-bulk carriers (dwt.);
D_t are the deliveries of new dry-bulk carriers (dwt.);
P_5 is the price of a new carrier ($ 1000);
S_t is the scrappage of dry-bulk carriers (dwt.);
F_t is the dry-bulk-fleet size (dwt.);
U_t are the ships on order or under construction (dwt.);
T_t is the dry cargo trade (mil. met. tons);
I_t is the price of steel in Japan (1975 = 100);
R_t is the dry-bulk-cargo rate (1970 = 100); and
e_{ti} are error terms.

The time period for the study is 1965-83, although the lagged values for certain variables required data from 1962-64. The primary source of the fleet data is the Maritime Administration. Data for D_t, O_t, and U_t are from "New Ship Construction." Data for F_t and S_t are from "Merchant Fleets of the World." *Fairplay International Shipping Weekly* is the source of P_t, which is the price of a hypothetical ship. The United Nations is the source of T_t and the *Japanese Statistical Yearbook* is the source for I_t. Lastly, R_t is from the Bureau of Mines.

III. EMPIRICAL RESULTS

The system of equations was estimated using two-stage least squares. The equation for P_t exhibited autocorrelated errors and was reestimated using the Cochrane-Orcutt method. The estimated system is found in Table 1. The elasticities reflecting these

Table 1. Results of the Estimation*

Equation 1: Orders for new dry bulk carriers

$$O_t = \underset{(-1.33)}{-18280} \underset{(-2.63)}{- 0.436\, F_{t-1}} + \underset{(1.67)}{1.296\, P_t} + \underset{(2.49)}{54.75\, T_t} - \underset{(-0.36)}{0.0485\, U_{t-1}}$$

$R^2 = 0.35$ DW = 1.96

Equation 2: Deliveries of new dry bulk carriers

$$D_t = \underset{(0.61)}{881.} + \underset{(2.86)}{0.243\, O_{t-1}} + \underset{(4.42)}{0.377\, O_{t-2}} + \underset{(3.12)}{0.256\, O_{t-3}}$$

$R^2 = 0.79$ DW = 1.37

Equation 3: Price of new dry bulk carriers

$$P_t = \underset{(-2.62)}{-9520} + \underset{(5.09)}{163.1\, I_t} + \underset{(0.49)}{0.0359\, U_t}$$

$R^2 = 0.76$ $\hat{p} = -0.504$

Equation 4: Scrappage of dry bulk carriers

$$S_t = \underset{(1.76)}{5730} - \underset{(-1.21)}{15.28\, R_{t-1}} - \underset{(-1.75)}{0.327\, P_t} - \underset{(-1.84)}{9.47\, T_t} + \underset{(2.51)}{0.0971\, F_{t-1}}$$

$R^2 = 0.48$ DW = 2.60

*Figures in parentheses are t statistics

Table 2. Estimated Elasticities for the Structural Model

Dependent Variable	Explanatory Variables			
	F_{t-1}	P_t	T_t	U_{t-1}
Orders	−4.46	0.68	6.46	−0.11
	O_{t-1}	O_{t-2}	O_{t-3}	
Deliveries	0.26	0.40	0.25	
	I_t	U_t		
Price of Ship	2.47	−0.16		
	R_{t-1}	P_r	T_t	F_{t-1}
Scrappage	−2.91	−3.41	−22.21	19.74

estimates, when evaluated at the mean for each variable, are found in Table 2.

The orders equation did not explain orders very well. Not only is the explanatory power of the equation weak, but the coefficient for P_t is of the opposite sign expected. It was hypothesized that this equation was a demand equation, meaning that the coefficient on P_t should be negative. In fact it is positive. The coefficients on F_{t-1}, T_t, and U_{t-1} are of the correct sign, although the coefficient for U_{t-1} is not significant. The price of ships, trade, and fleet size are correlated, indicating a possible multicollinearity problem. Although the elasticities for T_t and F^{t}_{-1} reflect this (6.46 and −4.46, respectively), dropping one from the equation not only introduces specification error, but also removes most of the explanatory power of the equation. The poor explanatory power of this equation and the sign on P_t undoubtedly reflect the difficulty of measuring expectations with the quality of data available for this market. Apparently P_t is serving a dual role in this equation. Not only is it a reflection of the cost of a ship, but also an indicator of the potential profitability of a ship. In this latter role it has a positive sign. Although capital theory would allow a better specification than that used here, the data are probably inadequate for such a specification.

The estimated delivery equation has better explanatory power and provides answers consistent with a priori expectations. The results suggest that deliveries are related to past orders with varying time lags, although a two-year lag is most important.

The results of the estimation of the price of ships equation are consistent with a priori expectations, although the quantity effects are very weak and insignificant. If the ships-under-construction variable is decomposed into deliveries and orders, a price flexibility for orders of 0.07 is found. This implies a very elastic supply function. Since supply is not this elastic, either the price of this hypothetical ship does not accurately reflect market conditions, or ship builders raise the cost of the ship by delaying delivery rather than by increasing the nominal price. The price of steel, although an inadequate index of input prices, is apparently a fairly good proxy for input price inflation. Weakness in the steel market has decreased its predictive ability for ship prices in recent years.

The scrappage equation is of intermediate quality. The inability of this equation to predict scrappage well is a combination of poor measurement and inadequate model specification. As in the case of orders, expectations play a major role in scrapping decisions. These expectations are probably poorly reflected in the model specification. In addition, the dependent variable in this equation is not strictly scrappage. Instead, it is changes in the fleet not otherwise explained. This includes ships which sink and ships which were not previously for one reason or another. Given this, the equation is probably quite reasonable. The elasticities implied by the estimates are all quite large, which is probably in part a reflection of actual behavior and in part an indication of multicollinearity. In any case, the estimates are consistent with a prior expectations, showing more scraps as the fleet gets larger and fewer as the prospects for profitable operation improve, whether because of higher rates, increased trade, or more expensive new-ship prices.

The estimated equations can be solved for all endogenous variable to get the reduced-form equations. These equations provide an estimate of the effect of an exogenous or previously determined variable on the system. The elasticities implied by these reduced-form equations are shown in Table 3. These variables are best understood when divided into exogenous variables and predetermined variables. The first group reflects an immediate response, while the second group reflects a carry-over response to previous values of exogenous variables. Trade and the price of steel have substantial immediate effects, while rates have more gradual effects. The time lags in deliveries make the long-run effects of these variables much greater. The complicated structure of the lagged dependent variables makes the long-run elasticities uncomputable. However it is apparent that past actions play a substantial role in present behavior in this market.

IV. CONCLUSIONS

The results of the estimation of the dry-bulk-carrier model were of varying quality. Although the explanatory power of the model was not strong and the estimates have some statistical problems, the results do show that the dry-bulk-carrier market exhibits some interesting characteristics. The scrap-

Table 3. Estimated Elasticities for the Reduced-Form Model

Endogenous Variable	Exogenous Variables							
	T_t	I_t	R_{t-1}	U_{t-1}	F_{t-1}	O_{t-1}	O_{t-2}	O_{t-3}
Orders	6.77	1.76	0	0	−4.67	−0.01	−0.02	−0.01
Deliveries	0	0	0	0	0	0.26	0.40	0.25
Price Ships	0.46	2.59	0	0.15	−0.32	−0.02	−0.03	−0.02
Scrappage	−23.80	−8.83	−2.91	−0.51	20.83	0.06	0.09	0.06
Fleet	0.11	0.04	0.01	0	0.83	0.02	0.03	0.02
Under Construction	2.95	0.77	0	0.96	−2.04	−0.11	−0.17	−0.11

page equation and the price of steel equation both reflect an economic response to market conditions. Except for the wrong sign of the price variable, the orders equation is also consistent with economic behavior. The system as a whole indicates the substantial constraints on present actions that past decisions impose. Undoubtedly as more and better data become available, the economic behavior of this important market will be easier to model and evaluate.

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ENDNOTE

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