Temporal Links between the Freight and Ship Markets in both Dry Bulk and Tanker Sectors

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Abstract

This paper examines the temporal relations between the freight and ship (newbuilding and second-hand) markets in two related sectors - the dry bulk and tanker sectors. Evidences show that the relations among these markets are differed for these two shipping sectors. These results imply that the ways of information transmitting across these three markets are different. Thus, ship owners should pay special attention to their decision making in different shipping sectors. Moreover, we suggest that this difference is more likely caused by the role played by the newbuilding price or even the newbuilding market.

Keywords: temporal links, freight market, ship markets

1. Introduction

It is well known that there are four closely related markets in the international shipping industry based on the linkage of cash flows, namely the freight, the second-hand, the newbuilding and the demolition markets. Indeed the freight market is a service market in which cargo-owners can rent vessels for sea transport services while the newbuilding, second-hand and demolition markets are all dealing with ships and can be viewed ship markets.

A very important point is that these markets are not independent but related to each other. In this paper, we examine these relations from a new point of view – the direction of ship flow. It is well known that world shipping is an economic activity directly dependent on global seaborne trade. Seaborne transport activities can then cause the demand for ships by the cargo-owners. In this circumstance, the cargo-owners will enter into a special contract with the ship-owners for the hire of their ships. For the ship-owners, they have two ways to get ships: purchase an old ship immediately in the secondhand market or order a new one in the newbuilding market. Ship-owners can hire out their ships in the freight market for just operating the ships for a period of time or they can also sell them to take the advantage of the value increase for speculation purpose in the secondhand market. Any decision made by the ship-owners on how to get the ships will influence the ship markets (newbuilding and secondhand markets) immediately. On the other hand, ship-owners have three ways to deal with the ships when the freight market is in recession - to sell them in the second-hand market, scrap them in the scrapping market or lay-up them for a period of time. The choice they made can also affect the market.

In this paper, the demolition market is not considered. We just focus on the timing of obtaining the ships. So the ship markets here specially mean the newbuilding and second-hand markets.

Furthermore, the shipping industry comprises the dry bulk and tanker sectors, each with its own distinct market structure. Comparing these two sectors, despite the different shipping routes, the shipped cargoes and the sizes of vessels, etc., the links between the freight and ship markets for these sectors may also be different.

Veenstra (1999) indicated the different economic structures with these two sectors. Specially, he pointed out that the role of second-hand prices differed in the dry bulk and tanker shipping sectors. *Kou and Liu (2010)* have also found opposite relations between the newbuilding and second-hand ship prices in these two shipping sectors.

Indeed, past studies usually were carried out within either the dry bulk or the tanker sector separately. Although in some studies, these two sectors are examined simultaneously (for example, *Glen 1997, Hale and Vanags 1992, Haralambides et al. 2004, Tsolakis et al. 2003*), their original intentions are not to compare and explain the difference between these two sectors.

Therefore, our aim is to investigate the temporal linkage between the freight and ship markets in two shipping sectors and to compare if these two sectors have the same or different structures. In order to study this issue, we choose a typical variable to represent each market. For the freight market, it has been established in previous work that the time charter rate is the variable that channels information on freight market developments to the ship markets (*Haralambides et al. 2004, Tsolakis et al. 2003, Veenstra 1999*). Thus, we choose time charter rates as represented variables in the freight market. For the ship markets, *Veenstra (1999)* has used order book as the typical variable to represent the newbuilding market in VAR model. Thus, linear relationship between the variables is the underlying assumption of his model. However, linear or non-linear relationships between order book and freight rate (or second-hand price) are unknown to us. Then, using newbuilding price as the key variable to represent newbuilding market seems more reasonable than order book. First, the second-hand ship price can be viewed as a discount newbuilding price under some normal circumstance. Second, researchers in the past suggested that the expected future time charter rates could be viewed as current secondhand ship price. Although we do not know the exact function between the three variables, at least the existence of some linear relationship between them is plausible. Furthermore, in shipping industry, since the movable capital assets are traded, ship prices over time are of great importance to investors taking decisions. Thus, we choose newbuilding and secondhand ship prices in these two markets.

Research on the temporal relationships can provide insight on the directions of information flow between the freight and ship markets and on how well these markets are linked. This information is important to agents in shipping and may be of interest to ship owners, charterers and investors in their decision making activities. Research on the difference between the dry bulk and tanker sectors is important because if the market linkages are different, the investment timing on ships will be different in these two sectors. Knowing the difference, ship owners and investors can pay special attentions to their decision making in different sectors.

The remainder of this paper is organized as follows. The next section is the literature review. The third section discusses methodology used in this paper. The fourth section presents the results of the tests within all ship segments in two shipping sectors and discusses the implications of these results. The last section concludes the paper.

2. Literature Review

Regarding the research on the links between the freight and ship markets, past studies usually paid their attention to only two of them in just one shipping sector (dry bulk or tanker). For example, past studies have worked on the relationship between the secondhand ship price and time charter rate (*Alizadeh and Nomikos 2007, Strandenes 1984*), or the relationship between the freight rate and newbuilding price (*Hawdon 1978, Xu et al. 2008*), or the relationship between the newbuilding and second-hand ship price (*Kou and Liu 2010*).

Alizadeh and Nomikos (2007) investigated relationship between 5-year-old ship price and 1-year time charter rate in the dry bulk shipping. Results suggested that these two variables are cointegrated in every ship segment. Causality between them is from time charter rate to second-hand ship price.

Strandenes (1984) studied the relationship between the time charter rate and the second-hand ship price using annual data. She explained the second-hand price as a function of discounted earnings at current market and the market replacement value of the ship which was assumed to be equal to the corresponding newbuilding price.

Hawdon (1978) developed and estimated an econometric model of the behaviour of annual average tanker spot rates for the period 1950-1973. He found that current level of freight rates have a significant impact on newbuilding ship prices, while lagged freight rates are non-significant. But he didn't test whether the lagged newbuilding ship price has impact on freight rate.

Xu et al. (2008) used panel cointegration to test the dynamic relationship between international sea freight rate and shipbuilding price in dry bulk market. She found that freight rate is sensitive to shipbuilding prices and they have a positive directional relationship in the dry bulk sector.

Kou and Liu (2010) investigated the temporal relationship between the newbuilding and second-hand ship prices in both the dry bulk and tanker sectors. They found the temporal linkage in the dry bulk sector is from the second-hand to the newbuilding ship price but it is opposite in the tanker sector.

Studies related to the linkage among three markets are *Haralambides et al. (2004), Tsolakis et al. (2003)* and *Veenstra (1999)*.

Tsolakis et al. (2003) used the Error Correction Model (ECM) to analyze second-hand ship prices in the tanker and dry bulk markets under the supply-demand equilibrium model. *Haralambides et al. (2004)* extended *Tsolakis et al. (2003)*'s research to include both second-hand ship prices and newbuilding ship prices. Their results showed that the newbuilding prices and time charter rates have the greatest effect of all variables on the second-hand prices. This is also the reason why we use the newbuilding, secondhand ship price and time charter rate as represented variables in our model.

Veenstra (1999) is the only researcher who mentioned and verified the casual links between the main ship markets are different in the dry bulk and tanker sectors. He presented a structural VAR model consisted of five variables: order book, trade flow, second-hand price, time charter rate and spot charter rate. His purpose is to offer insights into the structure of the whole shipping industry. Then he investigated this issue with the average data series rather than separating ship segments. In addition, he used quarterly data sample from 1980 to 1995 in which only 60 observations contains. This sample size seems limited by using structure VAR model. Another question discussed above is that he chose order book rather than newbuilding price as the key variable in the newbuilding market. His results indicated that the role of secondhand prices differed in the dry bulk and tanker shipping sectors.

In summary, most of the existing works either concerned two or three markets, the purposes of them are usually not to compare the results drawn from the dry bulk and the tanker sectors but to find the influence of one variable on another. In other words, their results just suggested the degree of impact between the markets in two sectors. From these results, we are still unclear about how fast one market reflects new information relative to another. Furthermore, *Veenstra (1999)* has already inferred that the tanker and dry bulk sector may differ in the information transmitting because the role played by the second-hand market. However, there is a lack of work on testify this inference.

Thus the aim of our work is to study the temporal links between the freight and ship markets within specific ship segments. Then we will compare the different linkages between the dry bulk and tanker sectors and testify if this difference is caused by the second-hand market.

3. Methodology

We will use the Granger causality test to capture the temporal relationship between freight and ship markets. This test requires stationary data. To test the stationarity of each series, Augmented Dickey Fuller (ADF) (*Dickey and Fuller 1981*) and the Phillips and Perron (PP) (*Perron 1988; Phillips and Perron 1988*) methods will be applied.

From results of the past research, we know that the price series in our study are likely non-stationary. *Engle and Granger (1987)* pointed out that the non-stationary time series are cointegrated if the linear combination of the series is stationary. In this paper, *Johansen (1988, 1991)* cointegration test will be applied to test for possible existence of cointegration.

For the Johansen cointegration test, it usually used with VAR model together. The VAR model contained cointegrated variables can be also called Vector Error Correction (VEC) model. A VEC model is a restricted VAR designed for use with non-stationary series that are known to be cointegrated. The basic *p*-lag VAR model is as follows:

$$Y_t = c + \Pi_1 Y_{t-1} + \Pi_2 Y_{t-2} + \cdots + \Pi_p Y_{t-p} + \varepsilon_t \quad (1)$$

where Y_t is a k vector of macroeconomic variables, Π_i are matrices of coefficients to be estimated, c is the intercept, p is the lag length and ε_t is an unobservable zero mean white noise vector process which can be also viewed as a vector of innovations. Then the general cointegration VAR model is written as:

$$\Delta Y_t = c + \Pi Y_{t-p} + \sum_{i=1}^{p} \Gamma_i \Delta Y_{t-i} + \varepsilon_t \quad (2)$$

The matrix Π contains the components of the long-run cointegration relations between the variables, if they exist. Johansen test focuses the examination of the matrix Π which can be interpreted as a long-run coefficient matrix. The test for cointegration in Y_t is performed by calculating the rank of the Π matrix. There are three possibilities for this rank: first, it can be zero indicating no cointegration relations; second, it can be equal to the total number of components indicating stationary of all time series in the model; third, it can also be r rank between zero and the total number of components. In this case, there are r cointegrating vectors in Y_t. *Johansen (1988, 1991)* proposed trace statistic and maximum eigenvalue statistic to determine the rank of Π.

After determining the existence of cointegration, we can carry out Granger causality test to capture the casual linkages. If there is no cointegration, tests of Granger causality based on VAR involving the first differences of the data will be used. The bivariate VAR model of the first difference data are estimated with:

$$\begin{aligned} \Delta x_t &= c_1 + \sum_{j=1}^{q} \alpha_{1j} \Delta x_{t-j} + \sum_{i=1}^{q} \beta_{1i} \Delta y_{t-i} + \varepsilon_{1t} \\ \Delta y_t &= c_2 + \sum_{j=1}^{q} \alpha_{2j} \Delta y_{t-j} + \sum_{i=1}^{q} \beta_{2i} \Delta x_{t-i} + \varepsilon_{2t} \end{aligned} \quad (3)$$

where Δx_t and Δy_t denote the variables for the first difference. $\varepsilon_t = (\varepsilon_{1t}, \varepsilon_{2t})'$ is the vector of the corresponding error terms which contain all the other information that may affect *x* and *y*, and *q* is the optimal lag length. All the criteria of selecting a lag length are discussed in *Lütkepohl (1991)*. In this paper, *Schwarz (1978)* (SC) and Akaike's Information Criterion (AIC) will be employed. If SC and AIC choose different orders, we will try both of the lags. Which criterion will be used depends on the size of data sample and whether the test results are robust.

If cointegration does exist, Granger causality test based on the VEC model will be adopted instead of using the first difference data based on VAR model. The Granger causality test based on the VEC model can be expressed as:

$$\begin{aligned} \Delta x_t &= c_1 + \sum_{j=1}^{q} \alpha_{1j} \Delta x_{t-j} + \sum_{i=1}^{q} \beta_{1i} \Delta y_{t-i} + \delta_1 ECT_{t-1} + \varepsilon_{1t} \\ \Delta y_t &= c_2 + \sum_{j=1}^{q} \alpha_{2j} \Delta x_{t-j} + \sum_{i=1}^{q} \beta_{2i} \Delta y_{t-i} + \delta_2 ECT_{t-1} + \varepsilon_{2t} \end{aligned} \quad (4)$$

Compared with equation Eq. 3, Eq. 4 has an additional term ECT_{t-1}, which is known as the error correction term containing long-run relationship between cointegrated variables since the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments, δ is the coefficient of this term.

Thereafter, the Granger causality test examines the null hypothesis that $\beta_{1i} = 0$ or $\alpha_{2j} = 0$ for all *i* and *j* (*i*, *j*=1, 2… *q*) in both Eq. 3 and Eq. 4. When $\beta_{1i}=0$, the null hypothesis is that *y* does not Granger cause *x* in the first regression in Eq. 3 and Eq. 4. When $\alpha_{2j}=0$, the null hypothesis is that *x* does not Granger cause *y* in the second regression in Eq. 3 and Eq. 4. Thus, evaluation of the significance of variables in VAR should be conducted.

4. Estimate Results

4.1 Data Analysis

The data used in this paper consists the time series of monthly newbuilding and 5-year-old ship prices, 6-month, 1-year and 3-year time charter rates for three different-size carriers in both dry bulk (Capesize, Panamax and Handysize) and tanker (VLCC, Suezmax and Aframax) sectors from Clarkson Research Studies, Lloyd's Shipping Economist and Fearnleys. The categories of the ship segments in each sector are divided as most studies in the past (*Alizadeh and Nomikos 2007, Haralambides et al. 2004, Kavussanos 1996, Kavussanos 1997, Tsolakis et al. 2003*). All ship prices are quoted in million dollars in each category and time charter rates are measured in dollars per day. *NP* and *FP* will use to represent the newbuilding and 5-year-old second-hand ship prices. For the time charter rate, *TC* broadly means the time charter rate and *TC*6, *TC*1 and *TC*3 are used for the 6-month, 1-year and 3-year time charter rates, respectively. The logarithmic transformation of series is applied with all data series.

In this paper, we use *TC*6, *TC*1 and *TC*3 to test the temporal relations in the dry bulk sector. In the tanker sector, ships are usually hired in a longer time period than in the dry bulk sector. Therefore, *TC*6 are not available. Then we just consider *TC*1 and *TC*3. One problem is that the data for *TC*3 is not so widely available in the tanker sector. The starting point of *TC*3 is Dec. 2001 for all the tanker types. Since the data series of *TC*1 are all from Jan. 2000, the data samples of *TC*3 are enlarged from Jan. 2000 to the original data series. Then the adjusted sample period of 3-year time charter rate is from 2000 to Oct. 2008. The notations used for the new sample is *TC*3'. Since the data sample of *TC*3 is relatively limited, the test results from *TC*3' are more trustable.

We applied ADF and PP tests to examine the stationarity of each series. Results are the same as most studies in the past, namely all the prices and time charter rates are satisfied I(1) process.

We then applied *Johansen (1988)* test to examine the existence of cointegration between the newbuilding price, second-hand price and time charter rates. The estimation results are summarized in Table 1. Here we just give trace statistic results.

As the findings in Table 1 show, the time charter rate and ship prices are cointegrated for most of the ship segments in the dry bulk sector. One exception is the existence of cointegration among *TC*6, *NP* and *FP* in the Panamax segment. For the Panamax vessels, cointegration does not exist with using trace statistics. In the tanker sector, *TC*, *NP* and *FP* are only cointegrated in the VLCC ship segment. For the Suezmax and Aframax tankers, no cointegration could be found. Comparing these results with the dry bulk sector, it seems that these three variables tie more closely in the dry bulk sector than in the tanker sector. This finding reveals the distinct structures of two shipping sectors. In addition, asset play is significant then speculation is more likely to be happened in the tanker sector. Meanwhile, these three variables are more likely to have a long-run relationship for large ship types (Capesize and VLCC).

Table 1: Cointegration test results in two shipping sectors

Hypothesized No. of CE(s)	Ship type	Lags	λ_{trace}	0.05 Critical Value	Ship type	Lags	λ_{trace}	0.05 Critical Value
		Capesize			VLCC			
None	*TC*6,	*q*=2	56.41309**	29.79707	*TC*1,	*q*=2	53.86795**	29.7971

At most 1	*NP* and *FP*		18.05794*	15.49471	*NP* and *FP*		11.09526	15.4947
At most 2			2.724816	3.841466			0.002788	3.84147
None	*TC*1, *NP* and *FP*	*q*=2	52.52243**	29.79707	*TC*3', *NP* and *FP*	*q*=2	38.09448**	29.7971
At most 1			19.15854*	15.49471			11.64747	15.4947
At most 2			3.248650	3.841466			0.016645	3.84147
None	*TC*3, *NP* and *FP*	*q*=2	43.12533**	29.79707	*TC*3, *NP* and *FP*	*q*=2	42.61477**	29.7971
At most 1			13.34411	15.49471			17.37051*	15.4947
At most 2			0.449850	3.841466			0.464803	3.84147
	Panamax				Suezmax			
None	*TC*6, *NP* and *FP*	*q*=2	21.43779	29.79707	*TC*1, *NP* and *FP*	*q*=2	23.43648	29.7971
At most 1			6.045812	15.49471			7.079093	15.4947
At most 2			2.514359	3.841466			0.001166	3.84147
None	*TC*1, *NP* and *FP*	*q*=2	31.72669*	29.79707	*TC*3', *NP* and *FP*	*q*=2	21.10283	29.7971
At most 1			11.72797	15.49471			7.622421	15.4947
At most 2			1.969166	3.841466			0.058478	3.84147
None	*TC*3, *NP* and *FP*	*q*=2	35.43023*	29.7971	*TC*3, *NP* and *FP*	*q*=3	25.27856	29.7971
At most 1			14.60661	15.4947			9.942263	15.4947
At most 2			0.474882	3.84147			0.607510	3.84147
	Handysize				Aframax			
None	*TC*6, *NP* and *FP*	*q*=2	43.73723**	29.79707	*TC*1, *NP* and *FP*	*q*=2	24.93157	29.7971
At most 1			11.33900	15.49471			7.005578	15.4947
At most 2			3.002197	3.841466			0.058514	3.84147
None	*TC*1, *NP* and *FP*	*q*=2	56.05595**	29.79707	*TC*3', *NP* and *FP*	*q*=2	24.14568	29.7971
At most 1			16.16873*	15.49471			7.114220	15.4947
At most 2			3.219941	3.841466			0.067019	3.84147
None	*TC*3, *NP* and *FP*	*q*=2	36.05628**	29.79707	*TC*3, *NP* and *FP*	*q*=3	30.05167*	29.7971
At most 1			14.07369	15.49471			4.383573	15.4947
At most 2			2.313907	3.841466			0.185861	3.84147

Notes: * indicates statistical significance at 5% level; ** indicates statistical significance at 1% level.

4.2 Temporal relations in two shipping sectors

Granger causality is employed to investigate the temporal linkages between the time charter rates and ship prices. Table 2 summarizes the temporal linkages for all ship types we concerned. For the dry bulk sector, we can observe that although the relationships may be different with using different durations of the time charter rate (*TC*6, *TC*1 and *TC*3), the temporal links between *TC*1, *NP* and *FP* are exactly the same for all the ship types in the dry bulk sector. Results from *TC*1 show that 1-year time charter rate plays as an indicator in the dry bulk ship sector. It leads both *NP* and *FP*. Results drawn from *TC*6 and *TC*3 are slightly different with *TC*1 for the Capesize vessels. In the Handysize segment, the relations with these three variables are more uncertain, the direction runs between *NP* and *FP* can be changed with using *TC*6 and *TC*3. However, one conclusion is obvious and notable that time charter rate plays as an indicator in the dry bulk sector. In other words, the freight market reacts to the new information more quickly than the ship markets, and information transmits from freight market to ship markets in this shipping sector.

For the tanker sector, it appears that the temporal linkages among *TC*, *NP* and *FP* are more similar for the Suezmax and Aframax vessels, i.e. *NP* and *TC* significantly lead *FP*. Unlike these two ship segments, it is found that causality can also run from *NP* to time charter rates (*TC*1 or *TC*3) for VLCC vessels. The difference may be because the relatively longer period time of hiring for this kind of vessel. Then, the time charter rate in this ship segment respond to the information outside slower than the newbuilding ship price. Meanwhile, the relationships between *TC* and *FP* also appear distinct direction for the VLCC tankers. Because, most of the cases, one-way causality runs from *TC* to *FP* in the Suezmax and Aframax segments whereas causality from *FP* to *TC* is more significant than it is from *TC* to *FP* in the VLCC ship segment.

Indeed, a mutual relationship exists between *TC* and *FP* at 5% significant level. Overall, results for specific ship types indicate the distinct characteristic for the VLCC vessels. So it is worth to investigate this ship segment separately in the future.

Table 2: Granger causality test results in two shipping sectors

Capesize								
Dependent variable: ΔNP_t			Dependent variable: ΔFP_t			Dependent variable: ΔTC_t		
ΔFP_{t-1}	$\Delta TC6_{t-1}$	All	ΔNP_{t-1}	$\Delta TC6_{t-1}$	All	ΔNP_{t-1}	ΔFP_{t-1}	All
0.022521	8.138687	11.05831	0.004070	18.32106	18.40763	4.663044	0.243713	4.666004
(0.8807)	(0.0043**)	(0.0040**)	(0.9491)	(0.0000**)	(0.0001**)	(0.0308*)	(0.6215)	(0.0970)
ΔFP_{t-1}	$\Delta TC1_{t-1}$	All	ΔNP_{t-1}	$\Delta TC1_{t-1}$	All	ΔNP_{t-1}	ΔFP_{t-1}	All
0.463348	15.52406	18.33930	0.187358	32.09429	32.65503	3.335979	0.975270	5.248843
(0.4961)	(0.0001**)	(0.0001**)	(0.6651)	(0.0000**)	(0.0000**)	(0.0678)	(0.3234)	(0.0725)
ΔFP_{t-1}	$\Delta TC3_{t-1}$	All	ΔNP_{t-1}	$\Delta TC3_{t-1}$	All	ΔNP_{t-1}	ΔFP_{t-1}	All
0.086143	8.176288	10.42677	0.174206	46.78157	48.26500	0.689392	0.160656	1.000323
(0.7691)	(0.0042**)	(0.0054**)	(0.6764)	(0.0000**)	(0.0000**)	(0.4064)	(0.6886)	(0.6064)
Panamax								
Dependent variable: ΔNP_t			Dependent variable: ΔFP_t			Dependent variable: ΔTC_t		
ΔFP_{t-1}	$\Delta TC6_{t-1}$	All	ΔNP_{t-1}	$\Delta TC6_{t-1}$	All	ΔNP_{t-1}	ΔFP_{t-1}	All
0.017058	17.15193	35.54651	3.308737	18.10370	19.92208	0.015397	1.354078	1.650273
(0.8961)	(0.0000**)	(0.0000**)	(0.0689)	(0.0000**)	(0.0001**)	(0.9012)	(0.2446)	(0.4382)
ΔFP_{t-1}	$\Delta TC1_{t-1}$	All	ΔNP_{t-1}	$\Delta TC1_{t-1}$	All	ΔNP_{t-1}	ΔFP_{t-1}	All
0.038042	29.58790	42.32346	1.557739	31.78742	39.24770	0.547773	1.327670	1.904513
(0.8454)	(0.0000**)	(0.0000**)	(0.2120)	(0.0000**)	(0.0000**)	(0.4592)	(0.2492)	(0.3859)
ΔFP_{t-1}	$\Delta TC3_{t-1}$	All	ΔNP_{t-1}	$\Delta TC3_{t-1}$	All	ΔNP_{t-1}	ΔFP_{t-1}	All
0.029617	37.11237	48.47750	2.490379	28.14116	37.74548	0.033490	0.002669	0.034477
(0.8634)	(0.0000**)	(0.0000**)	(0.1145)	(0.0000**)	(0.0000**)	(0.8548)	(0.9588)	(0.9829)
Handysize								
Dependent variable: ΔNP_t			Dependent variable: ΔFP_t			Dependent variable: ΔTC_t		
ΔFP_{t-1}	$\Delta TC6_{t-1}$	All	ΔNP_{t-1}	$\Delta TC6_{t-1}$	All	ΔNP_{t-1}	ΔFP_{t-1}	All
6.561820	4.934070	14.41462	0.100036	9.577832	9.577832	1.891969	2.971787	3.967186
(0.0104*)	(0.0263*)	(0.0007**)	(0.7518)	(0.0020**)	(0.0083**)	(0.1690)	(0.0847)	(0.1376)
ΔFP_{t-1}	$\Delta TC1_{t-1}$	All	ΔNP_{t-1}	$\Delta TC1_{t-1}$	All	ΔNP_{t-1}	ΔFP_{t-1}	All
1.944122	8.654803	14.38118	1.242318	19.93999	22.85875	0.739754	2.861619	4.333012
(0.1632)	(0.0033**)	(0.0008**)	(0.2650)	(0.0000**)	(0.0000**)	(0.3897)	(0.0907)	(0.1146)
ΔFP_{t-1}	$\Delta TC3_{t-1}$	All	ΔNP_{t-1}	$\Delta TC3_{t-1}$	All	ΔNP_{t-1}	ΔFP_{t-1}	All
4.388947	9.796195	19.40553	8.685586	4.697005	14.99461	3.775556	5.011155	10.81764
(0.1114)	(0.0075**)	(0.0007**)	(0.0130*)	(0.0955)	(0.0047**)	(0.1514)	(0.0816)	(0.0287*)
VLCC								
Dependent variable: ΔNP_t			Dependent variable: ΔFP_t			Dependent variable: ΔTC_t		
ΔFP_{t-1}	$\Delta TC1_{t-1}$	All	ΔNP_{t-1}	$\Delta TC1_{t-1}$	All	ΔNP_{t-1}	ΔFP_{t-1}	All
0.435240	0.165141	0.497031	5.432197	4.148579	8.866533	19.66168	9.938883	20.63669
(0.5094)	(0.6845)	(0.7800)	(0.0198*)	(0.0417*)	(0.0119**)	(0.0000**)	(0.0016**)	(0.0000**)
ΔFP_{t-1}	$\Delta TC3'_{t-1}$	All	ΔNP_{t-1}	$\Delta TC3'_{t-1}$	All	ΔNP_{t-1}	ΔFP_{t-1}	All
0.003293	1.403426	1.716187	9.261323	3.914238	11.79035	17.70410	7.556378	18.03006
(0.9542)	(0.2362)	(0.4240)	(0.0023**)	(0.0479*)	(0.0028**)	(0.0000**)	(0.0060**)	(0.0001**)
ΔFP_{t-1}	$\Delta TC3_{t-1}$	All	ΔNP_{t-1}	$\Delta TC3_{t-1}$	All	ΔNP_{t-1}	ΔFP_{t-1}	All
0.970870	0.488552	1.069014	14.16410	2.841322	15.36741	13.08544	2.878414	13.09760
(0.3245)	(0.4846)	(0.5860)	(0.0002**)	(0.0919)	(0.0005**)	(0.0003**)	(0.0898)	(0.0014**)
Suezmax								
Dependent variable: ΔNP_t			Dependent variable: ΔFP_t			Dependent variable: ΔTC_t		
ΔFP_{t-1}	$\Delta TC1_{t-1}$	All	ΔNP_{t-1}	$\Delta TC1_{t-1}$	All	ΔNP_{t-1}	ΔFP_{t-1}	All
0.933185	1.221578	3.092692	7.777389	28.79299	44.46884	0.255498	0.080470	0.513781

(0.3340)	(0.2691)	(0.2130)	(0.0053**)	(0.0000**)	(0.0000**)	(0.6132)	(0.7767)	(0.7735)
ΔFP_{t-1} 1.039531 (0.5947)	$\Delta TC3'_{t-1}$ 5.237506 (0.0729)	All 6.158332 (0.1876)	ΔNP_{t-1} 6.440350 (0.0399*)	$\Delta TC3'_{t-1}$ 23.92146 (0.0000**)	All 37.02077 (0.0000**)	ΔNP_{t-1} 2.526668 (0.2827)	ΔFP_{t-1} 1.280323 (0.5272)	All 5.437787 (0.2453)
ΔFP_{t-1} 0.060839 (0.8052)	$\Delta TC3_{t-1}$ 2.727246 (0.0986)	All 3.221554 (0.1997)	ΔNP_{t-1} 2.217323 (0.1365)	$\Delta TC3_{t-1}$ 10.91618 (0.0010**)	All 13.79807 (0.0010**)	ΔNP_{t-1} 0.407997 (0.5230)	ΔFP_{t-1} 0.844302 (0.3582)	All 0.963081 (0.6178)
Aframax								
Dependent variable: ΔNP_t			Dependent variable: ΔFP_t			Dependent variable: ΔTC_t		
ΔFP_{t-1} 0.387322 (0.5337)	$\Delta TC1_{t-1}$ 2.258778 (0.1329)	All 3.584122 (0.1666)	ΔNP_{t-1} 11.24748 (0.0008**)	$\Delta TC1_{t-1}$ 25.43698 (0.0000**)	All 45.65966 (0.0000**)	ΔNP_{t-1} 0.156409 (0.6925)	ΔFP_{t-1} 1.189086 (0.2755)	All 2.053777 (0.3581)
ΔFP_{t-1} 2.509692 (0.2851)	$\Delta TC3'_{t-1}$ 0.544641 (0.7616)	All 3.759587 (0.4395)	ΔNP_{t-1} 11.03172 (0.0040**)	$\Delta TC3'_{t-1}$ 12.52520 (0.0019*)	All 26.70216 (0.0000**)	ΔNP_{t-1} 2.000887 (0.3677)	ΔFP_{t-1} 7.575589 (0.0226*)	All 12.40396 (0.0146*)
ΔFP_{t-1} 1.397147 (0.2372)	$\Delta TC3_{t-1}$ 1.430030 (0.2318)	All 4.034975 (0.1330)	ΔNP_{t-1} 4.230823 (0.0397*)	$\Delta TC3_{t-1}$ 10.02662 (0.0015**)	All 16.81710 (0.0002**)	ΔNP_{t-1} 0.000509 (0.9820)	ΔFP_{t-1} 2.826543 (0.0927)	All 3.119556 (0.2102)

Notes: * indicates statistical significance at 5% level; ** indicates statistical significance at 1% level; Numbers in (·) are p-Value.

Results from cointegration and Granger causality tests display different relationships when using different durations of time charter rate. In order to compare the temporal linkage among three markets, first, a typical relation should be chosen to represent the temporal linkages in these two sectors. For the dry bulk sector, relationships among *TC*1, *NP* and *FP* is established to represent the most common relationships between three markets. For the tanker sector, *TC*3' is chosen to represent VLCC vessels whereas *TC*1 is to express Suezmax and Aframax vessels. Results are summarized in Figure 1.

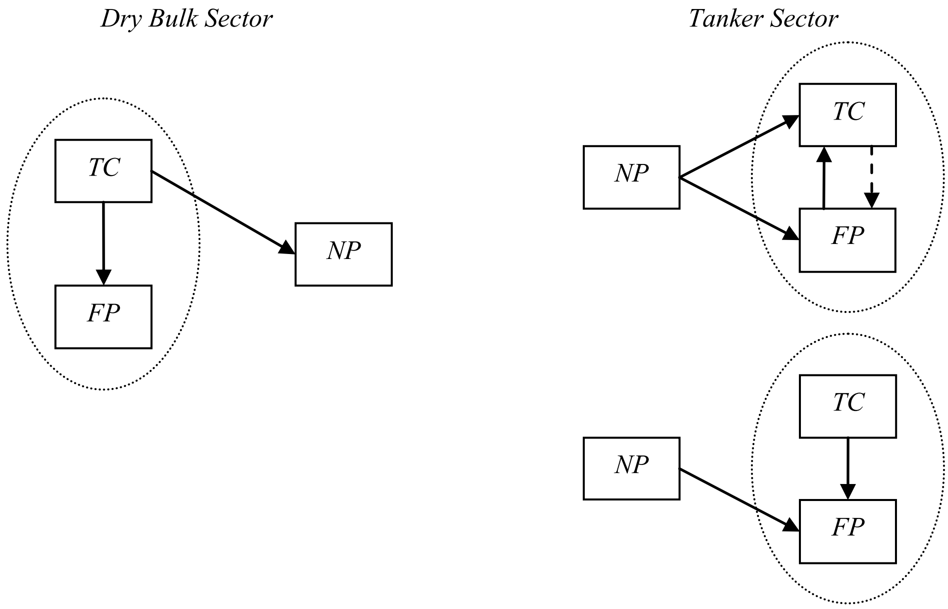
Comparing the results drawn from two shipping sectors, it can be seen that there are some similarities. Results of the cointegration test show that time charter rate and ship prices are more likely to have a long-run relationship for the large ship types (Capesize and VLCC). Moreover, both shipping sectors show an uncertain correlation between second-hand ship price and time charter rate. But causality runs from the time charter rate to the second-hand price most of the time.

Despite the similarity, results also revealed the significant differences for these two sectors. First, from the cointegration test, results show that *TC*, *NP* and *FP* tie more closely in the dry bulk sector. It means that the possibility of cointegration existence among these three variables is higher in the dry bulk sector than in the tanker sector. This difference implies that asset play is more likely to be happened in the tanker sector.

The second difference is that the temporal relationships between freight and ship markets are differ for the dry bulk and tanker sectors. For the dry bulk sector, the time charter rate is an indicator of international shipping. In the counterpart, this indicator is more likely played by the newbuilding prices in the tanker sector. From Figure 1, it can be clearly seen that ship prices can not be found Granger cause time charter rates for all dry bulk vessels, and second-hand prices or time charter rates can not be found Granger cause newbuilding prices in the tanker sector. If extending this conclusion to the whole shipping market, it can be concluded that information transmitted from freight market to ship markets in the dry bulk sector but from newbuilding ship market to the others in the tanker sector.

Furthermore, *Veenstra (1999)* has suggested that the causal links in the dry bulk and tanker sector are different and it is because the roles of second-hand ship price or the even the second-hand market are distinct. It is one possibility that the way of information transaction changed when passing through the second-hand market. However, from Table 2, the temporal linkages between three markets in both two sectors show that second-hand ship price can not lead either time charter rate or newbuilding price. From this point of view, the role of second-hand ship price plays the same situation in these two shipping sectors. Then this difference may be caused by another possible reason - the newbuilding price or newbuilding ship market. As shown in Figure 1, no matter what kind of relationship between *TC* and *FP*, for the dry bulk sector, *NP* is leaded by *TC* or *FP* either with the three-variable or two-variable framework. In the contrary, for the tanker sector, *NP* plays as a leader to *TC* and (or) *FP*. Therefore, there also exists the possibility that the difference drawn from two shipping sectors is caused by the role of the newbuilding price or the newbuilding market. As results shown from this paper, the newbuilding market in the tanker sector responds to the new information much quicker than it in the dry bulk sector. The lead-lag relation is hard to observe between *NP* and *TC* in the tanker sector for Suezmax and Aframax vessels. And for the VLCC tankers, *NP* even leads *TC* most of times. It means that the order activity is more important in this shipping sector especially for the larger tankers. Other markets can be affected by the decision of booking newbuilding ships.

Figure 1: Comparison between Two Sectors



Notes: The solid line indicates that Granger causality is significant at 1% level, while the dashed line indicates that Granger causality is significant at 5% level.

5. Conclusions

This study investigates the temporal links between the freight and ship (newbuilding and second-hand) markets in two shipping sectors - the dry bulk and tanker sectors. The cointegration test results show that asset play more likely happens in the tanker sector than in the dry bulk sector. The evidence from Granger causality test indicates that the temporal linkages among these markets are differed inside these two shipping sectors. And the time charter rate is an indicator in the dry bulk sector, however, this indicator is played by the newbuilding price most of the time in the tanker sector. Meanwhile, it is suggested that this difference is more possible to be caused by the role played by newbuilding price or the newbuilding market. Moreover, results for specific ship types indicate the distinct characteristic for the VLCC vessels. So it is worth to investigate this ship segment separately in the future.

All these findings in this paper suggest that the temporal relationships between these shipping markets are more complex than previously expected. They all imply that the economic structures are obviously distinct for the dry bulk and tanker sectors. Therefore, investigations should be conducted separately for the dry bulk and tanker sectors in the future.

Reference

Alizadeh, A.H. and Nomikos, N.K. (2007), Investment timing and trading strategies in the sale and purchase market for ships, Transportation Research Part B 41 (1): 126-143.

Dickey, D. and Fuller, W. (1981), Likelihood ratio statistics for autoregressive time series with a unit root, Econometrica 49 (4): 1057-1072.

Engle, R.F. and Granger, C.W.J. (1987), Co-integration and error correction: Representation, estimation, and testing, Econometrica 55 (2): 251-276.

Glen, D.R. (1997), The market for secondhand ships: Further results on efficiency using cointegration analysis, Maritime Policy & Management 24 (3): 245-260.

Hale, C. and Vanags, A. (1992), The market for second-hand ships: Some results on efficiency using cointegration, Maritime Policy & Management 19 (1): 31-39.

Haralambides, H.E., Tsolakis, S.D. and Cridland, C. (2004), Econometric modelling of newbuilding and secondhand ship prices, Research in Transportation Economics 12 (1): 65-105.

Hawdon, D. (1978), Tanker freight rates in the short and long run, Applied Economics 10 (3): 203-217.

Johansen, S. (1988), Statistical analysis of cointegration vectors, Journal of Economic Dynamics and Control 12 (2-3): 231-254.

Johansen, S. (1991), Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models, Econometrica 59 (6): 1551-1580.

Kavussanos, M.G. (1996), Price risk modelling of different size vessels in the tanker industry using autoregressive conditional heterskedastic (ARCH) models, Logistics and Transportation Review 32 (2): 161-176.

Kavussanos, M.G. (1997), The dynamics of time-varying volatilities in different size second-hand ship prices of the dry-cargo sector, Applied Economics 29 (4): 433-443.

Kou, Y. and Liu, L. (2010), The relationship between the newbuilding and second-hand ship prices for the dry bulk and tanker vessels, International Association of Maritime Economists (IAME): Portugal.

Lütkepohl, H. (1991), *Introduction to multiple time series analysis,* Berlin.

Perron, P. (1988), Trend and random walks in macroeconomic time series: Further evidence from a new approach, Journal of Economic Dynamics and Control 12 (2-3): 297-332.

Phillips, P.C.B. and Perron, P. (1988), Testing for a unit root in time series regression, Biometrika 75 (2): 335-346.

Schwarz, G. (1978), Estimating the dimension of a model, The Annals of Statistics 6 (2): 461-464.

Strandenes, S.P. (1984), Price determination in the time charter and second hand markets. Working paper MU 06. Center for Applied Research, Norwegian School of Economics and Business Administration.

Tsolakis, S.D., Cridland, C. and Haralambides, H.E. (2003), Econometric modelling of second-hand ship prices, Maritime Economics & Logistics 5 (4): 347-377.

Veenstra, A.W. (1999), Quantitative analysis of shipping markets, TRAIL Thesis Series, Delft University Press.

Xu, J.J., Yip, Y.L. and Liu, L. (2008), Dynamic interrelationships between sea freight and shipbuilding markets, International Forum on Shipping, Ports and Airports (IFSPA): Hong Kong.