Dynamic Interrelationships between Sea Freight and Shipbuilding Markets

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Abstract

This paper examines the dynamic interrelationships between the sea freight and shipbuilding markets. Many practitioners argue that the freight rates rely on the shipbuilding activities, because the shipbuilding is the primary source of ship supply. Other specialists argue that demand for shipbuilding is activated by the demand of freight market, where the shipbuilding decisions are made on the outlook of future freight rates. We examine these competing views by analysing the time series in dry bulk shipping. The results indicate the shipbuilding market unlikely leads the freight market, implying that the shipbuilding activity depends on the freight market.

Keywords: Shipbuilding; Sea freight; Time series analysis; Cointegration; VECM

1. Introduction

This paper studies the dynamic interrelationship of shipbuilding and sea freight markets, both are in the shipping industry. The shipping industry is quite different from other industries. The shipping industry is capital intensive and truly global competition, that contributes to competition prevailing in shipping industry. Ships are central in the shipping industry. The sale of a ship is one of the major capital transactions in the world and involves in a capital expenditure generally running into millions of US dollars. Ships are physical assets with limited economic life (about 20 years) but a significant residual (scrapping) value (i.e. value of steel). A ship functions on two levels in shipping industry: firstly as part of the supply of carrying capacity in the sea freight market and secondly, as a physical asset in the capital market.

Freight rates in the sea freight market are determined as the interaction of the supply and demand for cargo carrying services. Shipbuilding prices depend on the supply and demand for shipbuilding capacities. While both are in the shipping industry, the shipbuilding market is very different from the freight market. As the shipbuilding contracts are not traded in any exchange, they are not standardized and they are negotiated individually between the shipowner and the shipbuilder, and as a consequence, they can be tailor-made to their needs. At the same time, there is no secondary market to trade shipbuilding contracts. In other words, the capital involved in the shipbuilding process is a huge amount of sunk cost, meaning that it is non-redeemable during the shipbuilding.

As the ship investment exercise is highly risky, a shipowner always faces a difficult decision to make about the right timing of shipbuilding. For instance, shipbuilding needs to be designed, constructed and commissioned long before coming into services, a new ship is usually be delivered into the freight market after one and a half to two years with a totally different market situation. Therefore, the timing of the ship investment decisions is extremely important. Wrong timing of shipbuilding can turn the possibility of profits into heavy losses and to the closure of the business. However, the up-to-date understanding in shipbuilding markets may not be useful in timing the shipbuilding investment, which is increasingly a key dimension for competitive success.

Many argue that the freight rates depend on the shipbuilding activities (*e.g. Stopford 1997*). Others argue that demand for shipbuilding depends mainly on the operating environment of the shipping market. We examine these competing views by testing whether freight rates and shipbuilding prices are related in the long-run and, if related, whether it is mono-directional or bi-directional relationship between them. Therefore, we analyze the dynamic relationship between shipbuilding market and freight market. We further investigate whether the decisions are made on the basis of short-term market trend (small time lags) or long-term prospects (long time lags). Furthermore, to quantify the dynamic relationship among shipping markets, we determine the number of time lags between two shipping markets and whether it is mono-directional or bi-directional relationship between the time series.

This paper is organized as follows. Section 2 reviews the related literature in the shipping markets and theoretical considerations. Section 3 discusses the data, the empirical results and the implications. Section 4 summarises the findings.

2. Literature Review and Theoretical Framework

Two areas of the previous literature are related to this research: first, the existing research on shipping freight rate and shipbuilding price, and second, the dynamic relationship of two markets.

The sea freight market trades sea transport service, and the shipbuilding market trades new ships. Freight rates have been considered the most critical indicators among the shipping markets because freight rates represent the principal source of earnings for shipping companies. Many existing studies have focused on the characteristics of shipping freight rate and have looked at the factors influencing the rates, the relative forecasting ability of market rates, their stationarity, cointegration, term structures, optimal split for a risk-averse shipowner (*Evans and Marlow, 1990; Hsu and Goodwin, 1995; Kavussanos, 1996; Koekebakker, Adland and Sodal, 2006*). Previous studies showed that the freight rate is not stationary as most economic and financial time series, the freight rates are less volatile for smaller size vessels than for larger ones, and the volatilities of freight rates in the spot rates is higher than those in the time-charter (long time contracts) rates.

The lead-lag relationship between two markets indicates how fast one market reflects information relative to the other and how well the two markets are linked (*e.g., Bollerslev and Melvin, 1994; Tse and Booth, 1995; Kavussanos and Nomikos, 2003; Kavussanos and Visvikis, 2004; Batchelor, Alizadeh and Visvikis, 2005*). An abundance of empirical work analyzed the lead-lag relationship in the financial economics literature, for example, spot and futures markets, foreign exchange rates, and stock returns. The spot and futures markets are linked by the cost-of-carry model. The foreign exchange markets across countries are linked on the basis of law of one price or purchasing power parity (PPP). Although the price relationships across financial markets have been incorporated into some applied investment models, the studies into the price interdependence across shipping markets are still very limited.

Existing shipping studies in the literature are based upon the use of freight market models by determining the demand and supply of ships but do not know what circumstances affect the decision-making of shipbuilding. This left the more fundamental question about mutual economic effects between shipbuilding price and freight rate. While this study may compliment the traditional economic perspective that the freight market depends on the supply and demand of ships, this paper on the dynamic relationship between freight market and shipbuilding market may suggest new insights on the commercial judgments.

3. Empirical Results and Discussions

The three stages approach to assessing a causal relationship has been widely adopted. Firstly, the unit root test is performed for checking the non-stationarity of time series. Secondly, the test for cointegration is conducted to check the existence of long-run relationships between two or more time series. Finally, Granger causality test is used to find the direction of the cause-effects among the variables.

3.1. Data Description and Properties

The time series data used covers two shipping markets over the period of 1998 to 2007 (data source: *Clarkson 2007*). All the time series data are transformed into *natural logarithm*, since the logarithm transformation tends to squeeze together the larger values in data set and stretches out the smaller values. In order to have robust results, data are divided into the three ship sizes (capesize, panamax and handymax), because three ship sizes are used for three types of sea trades and represent three markets. Time series are into monthly, quarterly and yearly data of Shipbuilding Price (*SBP*) in US dollars per compensated gross ton and Freight Rate (*FRT*). Without the bias on which way of using ships, three freight rates *FRT* are quoted and they are:

- Baltic Dry Index (*BDI*) for short-term contract,
- one-year time charter rate (*TC1*) for one-year term contract, and
- three-year time charter rate (*TC3*) for three-year term contract.

The subscripts *C*, *P* and *H* denote capesize, panamax and handymax ship sizes, respectively. And the *SBP* and *FRT* (= *BDI*, *TC1*, or *TC3*) are interpreted as the percentage changes of the values. This squeezing and stretching can correct one or more of the following problems with data: skewed data, outliers, unequal variation. Figure 1 illustrates the freight rates in logarithm of Baltic Dry Index, one year time-charter rates, three year time-charter rates and shipbuilding prices for capesize ships. The time series do not exhibit any particular linear trending pattern. Summary descriptive statistics in logarithms of monthly freight rates and shipbuilding prices for three sizes of dry bulk ships are shown in Table 1.

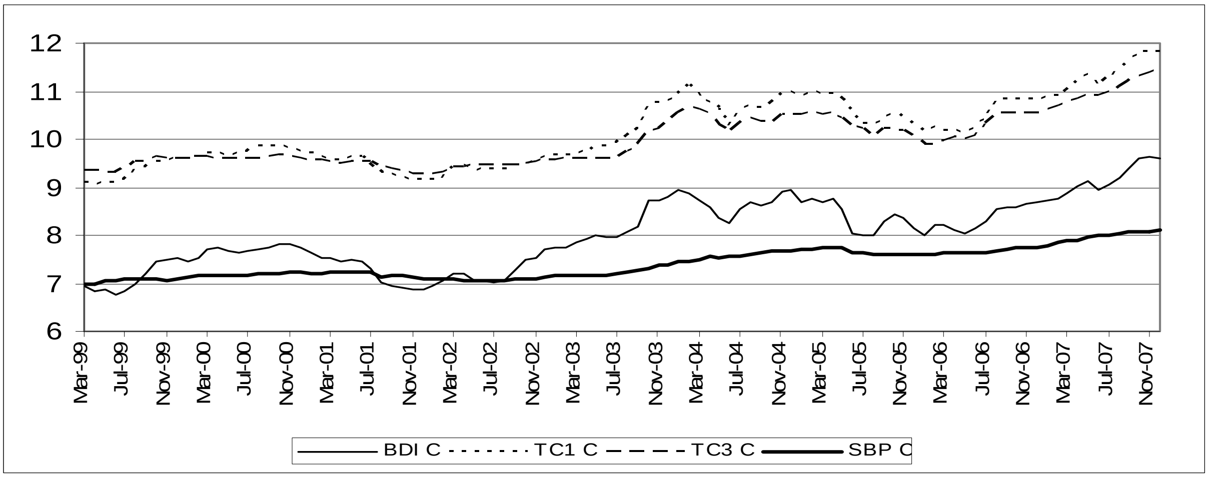

Figure 1: Freight rates (BDI_C, $TC1_C$ & $TC3_C$) and shipbuilding prices (SBP_C) in logarithm; Capesize bulker; monthly data (1999:03 to 2007:12)

Table 1: Descriptive statistics in logarithm; Capesize, Panamax and Handymax ships

	N	Mean	Std.Dev.	Skewness	Kurtosis	J-B	Probability
Capesize Bulker series (1999:03-2007:12)							
BDI_C	106	8.013	0.732	0.133	2.103	3.863	0.145
$TC1_C$	106	10.151	0.726	0.378	2.097	6.128	0.047
$TC3_C$	106	9.984	0.560	0.669	2.432	9.331	0.009
SBP_C	106	7.409	0.314	0.537	2.050	9.080	0.011
Panamax Bulker series (1998:05-2007:12)							
BDI_P	116	7.644	0.679	0.451	2.187	7.129	0.028
$TC1_P$	116	9.401	0.617	0.883	3.179	15.238	0.000
$TC3_P$	116	9.209	0.441	1.597	5.447	78.237	0.000
SBP_P	116	7.285	0.296	0.599	1.959	12.179	0.002
Handymax Bulker series (2000:09-2007:12)							
BDI_H	88	9.722	0.596	0.129	1.935	4.399	0.111
$TC1_H$	88	7.510	0.293	0.361	1.865	6.639	0.036
$TC3_H$	88	9.645	0.592	0.290	2.046	4.573	0.102
SBP_H	88	9.442	0.434	0.799	2.820	9.477	0.009

Note:
All series are measured in logarithmic.
BDI, TC1 and TC3 denote the freight rate for short-term, 1-year term and 3-year term contracts
SBP denotes the shipbuilding price.
N is the number of observations.
J-B is the Jarque-Bera statistic for testing whether the series is normally distributed.
Probability is the probability that a Jarque-Bera statistic exceeds (in absolute value) the observed value under the null hypothesis: A small probability value leads to the rejection of the null hypothesis of a normal distribution.

3.2. Unit Root Test

In order to test for cointegration between *SBP* and *FRT*, testing the order of stationarity of the variables is a prerequisite. The existence or absence of stationarity in the time series of *SBP* and *FRT* are checked by the augmented Dickey-Fuller (*ADF*) test (*Dickey and Fuller, 1979*) and Phillips and Perron (*PP*) test (*Phillips and Perron, 1988*). Two tests are carried out in order to make sure the results are robust. To determine the lag lengths, the Akaike information criterion (AIC) is used (*Akaike, 1973*). Table 2 shows that the results of both ADF and PP tests and reveals that the time series of *SBP* and *FRT* in three sizes of dry bulk ships are all stationary in their log-first difference, all containing a unit root in their log-level representation. The results are in line with the statement that only $I(1)$ variables are considered as candidates for a possible cointegrating relationship (*McAleer and Oxley, 1999*).

Table 2: Unit Root Tests of Capesize, Panamax and Handymax ships

	Levels			First Difference		
	ADF	lags	PP	ADF	lags	PP
Capesize Bulker series (1999:03-2007:12)						
BDI_C	-0.799	-0.669	2	-6.741**	-7.046**	1
$TC1_C$	-0.615	-0.197	1	-7.588**	-7.588**	0
$TC3_C$	-0.016	0.632	1	-6.371**	-6.371**	0
SBP_C	0.158	0.735	4	-3.016*	-8.696**	3
Panamax Bulker series (1998:05-2007:12)						
BDI_P	-0.590	-0.223	1	-8.643**	-8.643**	0
$TC1_P$	-0.586	-0.494	2	-7.306**	-6.910**	1
$TC3_P$	-1.221	-0.164	1	-6.610**	-7.037**	1
SBP_P	0.774	1.527	1	-6.707**	-6.707**	0
Handymax Bulker series (2000:09-2007:12)						
BDI_H	-0.594	-0.062	1	-6.278**	-6.278**	0
$TC1_H$	-0.819	-0.064	1	-5.386**	-5.386**	0
$TC3_H$	-0.125	0.246	2	-5.451**	-5.366**	1
SBP_H	0.674	1.185	1	-6.350**	-6.350**	0
1% critical value	-3.50833	-3.50833		-3.50833	-3.50833	
5% critical value	-2.89551	-2.89551		-2.89551	-2.89551	

Note:
ADF is the Augmented Dickey and Fuller (1981) test.
PP is the Philips and Perron (1988) test.
Levels and First Difference correspond to series in log-levels and log-first differences.
The lag lengths of the ADF test is determined by Akaike Information Criterion (AIC).
*(**) denotes rejection of the null hypothesis of a unit root at 5% (1%) critical value levels.

3.3. Cointegration between Markets

After having established that all the variables possess *I*(1) characteristics for long-run equilibrium relationship, we proceed to test the cointegration between *SBP* and *FRT*. Johansen's (1988) cointegration test is applied based on the vector error correction model (*VECM*) as follows:

$$\Delta y_t = \prod y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \varepsilon_t \,, \qquad (1)$$

where $y_t=(SBP_t, FRT_t)'$ is the column vector of logarithm shipbuilding price and freight rate, each being non-stationary, *I*(1) variables; Δ denotes the first difference operator; coefficient matrix $\prod$ and Γ_i are used to test the long-run and short-run adjustment to changes in y_t, such that

$$\prod = \sum_{i=1}^{p} A_i - I \,, \;\; \Gamma_i = -\sum_{j=i+1}^{p} A_j \,. \qquad (2)$$

Johansen's (1988) method is to estimate $\prod$ matrix in an unrestricted form, and then test whether we can reject the restrictions implied by the reduced rank of $\prod$. If the coefficient matrix $\prod$ has a reduced rank $r < k$, where *k* is the number of endogenous variables of y_t, then there exist $k \times r$ matrices α and β each with rank r such that $\prod = \alpha\beta'$ and $\beta' y_t$ is stationary, *I*(0). The reduced rank r is known as the number of cointegrating relations (the cointegrating rank). The simplest case of cointegration tests appears when *k* = 2, or the maximum number of cointegrating relations is one.

The estimated trace statistic λ_{trace} and maximum eigenvalue statistics λ_{max} are used to determine the number of cointegrating vectors. The variables are tested in pairs of *SBP* and *FRT* for the three ship sizes. The Akaike information criterion (*AIC*) is used to determine the lag length in the *VECM* model.

Besides, *Figure 1* illustrates that the freight market becomes volatile after the year of 2003. Therefore, in order to investigate whether the cointegration relationship between *FRT* and *SBP* has altered along the sample period, we divide the whole sample into two sub-periods: up to December 2002, and from January 2003 to December 2007. The Johansen's (1988) cointegration test results on monthly data are shown in *Table 3* to *Table 5*.

Table 3: Johansen's Tests for the number of cointegrating vectors between freight rates and shipbuilding price; Capesize ships

	Order of VAR	Hypothesis H0	Hypothesis H1	Eigenvalue	Test Statistics $\lambda_{\max}$	Test Statistics λ_{trace}	5% (1%) critical values $\lambda_{\max}$	5% (1%) critical values λ_{trace}
Period A.	The whole period from 1999:03 to 2007:12							
BDI_C , SBP_C	2	r = 0	r = 1	0.183	20.772**	20.773**	14.07 (18.63)	15.41 (20.04)
		r ≤ 1	r = 2	0.000	0.002	0.002	3.76 (6.65)	3.76 (6.65)
$TC1_C$, SBP_C	2	r = 0	r = 1	0.151	16.853*	16.925*	14.07 (18.63)	15.41 (20.04)
		r ≤ 1	r = 2	0.001	0.072	0.072	3.76 (6.65)	3.76 (6.65)
$TC3_C$, SBP_C	2	r = 0	r = 1	0.148	16.483*	16.791*	14.07 (18.63)	15.41 (20.04)
		r ≤ 1	r = 2	0.003	0.308	0.308	3.76 (6.65)	3.76 (6.65)
Period B.	The sub- period from 1999:03 to 2002:12							
BDI_C , SBP_C	4	r = 0	r = 1	0.305	14.936*	15.055*	11.44 (15.69)	12.53 (16.31)
		r ≤ 1	r = 2	0.003	0.118	0.118	3.84 (6.51)	3.84 (6.51)
$TC1_C$, SBP_C	4	r = 0	r = 1	0.360	18.318**	18.510**	11.44 (15.69)	12.53 (16.31)
		r ≤ 1	r = 2	0.005	0.192	0.192	3.84 (6.51)	3.84 (6.51)
$TC3_C$, SBP_C	6	r = 0	r = 1	0.312	14.586*	14.646*	11.44 (15.69)	12.53 (16.31)
		r ≤ 1	r = 2	0.002	0.060	0.060	3.84 (6.51)	3.84 (6.51)
Period C.	The sub- period from 2003:01 to 2007:12							
BDI_C , SBP_C	2	r = 0	r = 1	0.165	10.274	13.479*	11.44 (15.69)	12.53 (16.31)
		r ≤ 1	r = 2	0.055	3.205	3.205	3.84 (6.51)	3.84 (6.51)
$TC1_C$, SBP_C	2	r = 0	r = 1	0.134	8.169	8.935	11.44 (15.69)	12.53 (16.31)
		r ≤ 1	r = 2	0.013	0.767	0.767	3.84 (6.51)	3.84 (6.51)
$TC3_C$, SBP_C	2	r = 0	r = 1	0.112	6.779	7.473	14.07 (18.63)	15.41 (20.04)
		r ≤ 1	r = 2	0.012	0.695	0.695	3.76 (6.65)	3.76 (6.65)

Note:
r represents the number of cointegrating vectors.
Order of VAR is the lag length of a VAR model; the lag length is determined by Akaike Information Criterion (AIC).
$\lambda_{\max}$ and λ_{trace} are the Maximum Eigenvalue Statistic and Trace Statistic used to determine the number of cointegrating vectors.
*(**) denotes rejection of the null hypotheses at 5% (1%) critical value levels.

Table 4: Johansen's Tests for the number of cointegrating vectors between freight rates and shipbuilding prices; Panamax ships

	Order of VAR	Hypothesis H0	H1	Eigenvalue	Test Statistics λ_{max}	Test Statistics λ_{trace}	5% (1%) critical values λ_{max}	λ_{trace}
Period A. The whole period from 1998:05 to 2007:12								
BDI_P, SBP_P	2	$r = 0$	$r = 1$	0.134	16.318*	16.322*	14.07 (18.63)	15.41 (20.04)
		$r \leq 1$	$r = 2$	0.000	0.005	0.005	3.76 (6.65)	3.76 (6.65)
$TC1_P$, SBP_P	2	$r = 0$	$r = 1$	0.128	15.441*	15.676*	14.07 (18.63)	15.41 (20.04)
		$r \leq 1$	$r = 2$	0.002	0.235	0.235	3.76 (6.65)	3.76 (6.65)
$TC3_P$, SBP_P	2	$r = 0$	$r = 1$	0.052	6.087	6.156	14.07 (18.63)	15.41 (20.04)
		$r \leq 1$	$r = 2$	0.001	0.069	0.069	3.76 (6.65)	3.76 (6.65)
Period B. The sub- period from 1998:05 to 2002:12								
BDI_P, SBP_P	1	$r = 0$	$r = 1$	0.386	26.321**	28.776**	14.07 (18.63)	15.41 (20.04)
		$r \leq 1$	$r = 2$	0.044	2.456	2.456	3.76 (6.65)	3.76 (6.65)
$TC1_P$, SBP_P	2	$r = 0$	$r = 1$	0.336	21.670**	25.126**	14.07 (18.63)	15.41 (20.04)
		$r \leq 1$	$r = 2$	0.063	3.456	3.456	3.76 (6.65)	3.76 (6.65)
$TC3_P$, SBP_P	2	$r = 0$	$r = 1$	0.357	23.399**	26.714**	14.07 (18.63)	15.41 (20.04)
		$r \leq 1$	$r = 2$	0.061	3.316	3.316	3.76 (6.65)	3.76 (6.65)
Period C. The sub- period from 2003:01 to 2007:12								
BDI_P, SBP_P	2	$r = 0$	$r = 1$	0.198	12.609*	14.947*	11.44 (15.69)	12.53 (16.31)
		$r \leq 1$	$r = 2$	0.040	2.338	2.338	3.84 (6.51)	3.84 (6.51)
$TC1_P$, SBP_P	2	$r = 0$	$r = 1$	0.200	12.752*	15.518*	11.44 (15.69)	12.53 (16.31)
		$r \leq 1$	$r = 2$	0.047	2.766	2.766	3.84 (6.51)	3.84 (6.51)
$TC3_P$, SBP_P	2	$r = 0$	$r = 1$	0.088	5.264	7.400	14.07 (18.63)	15.41 (20.04)
		$r \leq 1$	$r = 2$	0.037	2.136	2.136	3.76 (6.65)	3.76 (6.65)

Note:
r represents the number of cointegrating vectors.
Order of VAR is the lag length of a VAR model; the lag length is determined by Akaike Information Criterion (AIC).
λ_{max} and λ_{trace} are the Maximum Eigenvalue Statistic and Trace Statistic used to determine the number of cointegrating vectors.
*(**) denotes rejection of the null hypotheses at 5% (1%) critical value levels.

Table 5: Johansen's Tests for the number of cointegrating vectors between freight rates and shipbuilding prices; Handymax bulker series

	Order of VAR	Hypothesis H0	H1	Eigenvalue	Test Statistics λ_{max}	Test Statistics λ_{trace}	5% (1%) critical values λ_{max}	λ_{trace}
Period A. The whole period from 2000:09 to 2007:12								
BDI_H, SBP_H	1	r = 0	r = 1	0.139	12.687*	14.625*	11.44 (15.69)	12.53 (16.31)
		r ≤ 1	r = 2	0.023	1.938	1.938	3.84 (6.51)	3.84 (6.51)
$TC1_H$, SBP_H	2	r = 0	r = 1	0.130	11.815*	14.277*	11.44 (15.69)	12.53 (16.31)
		r ≤ 1	r = 2	0.029	2.461	2.461	3.84 (6.51)	3.84 (6.51)
$TC3_H$, SBP_H	2	r = 0	r = 1	0.079	6.972	7.111	14.07 (18.63)	15.41 (20.04)
		r ≤ 1	r = 2	0.002	0.139	0.139	3.76 (6.65)	3.76 (6.65)
Period B. The sub-period from 2000:09 to 2002:12								
BDI_H, SBP_H	6	r = 0	r = 1	0.397	10.618	13.949*	11.44 (15.69)	12.53 (16.31)
		r ≤ 1	r = 2	0.147	3.331	3.331	3.84 (6.51)	3.84 (6.51)
$TC1_H$, SBP_H	6	r = 0	r = 1	0.567	17.587*	17.600*	14.07 (18.63)	15.41 (20.04)
		r ≤ 1	r = 2	0.001	0.013	0.013	3.76 (6.65)	3.76 (6.65)
$TC3_H$, SBP_H	2	r = 0	r = 1	0.415	13.390	15.617*	14.07 (18.63)	15.41 (20.04)
		r ≤ 1	r = 2	0.085	2.227	2.227	3.76 (6.65)	3.76 (6.65)
Period C. The sub-period from 2003:01 to 2007:12								
BDI_H, SBP_H	1	r = 0	r = 1	0.122	7.448	8.040	14.07 (18.63)	15.41 (20.04)
		r ≤ 1	r = 2	0.010	0.593	0.593	3.76 (6.65)	3.76 (6.65)
$TC1_H$, SBP_H	2	r = 0	r = 1	0.099	5.964	6.479	14.07 (18.63)	15.41 (20.04)
		r ≤ 1	r = 2	0.009	0.514	0.514	3.76 (6.65)	3.76 (6.65)
$TC3_H$, SBP_H	2	r = 0	r = 1	0.096	5.744	6.460	14.07 (18.63)	15.41 (20.04)
		r ≤ 1	r = 2	0.012	0.716	0.716	3.76 (6.65)	3.76 (6.65)

Note:
r represents the number of cointegrating vectors.
Order of VAR is the lag length of a VAR model; the lag length is determined by Akaike Information Criterion (AIC).
λ_{max} and λ_{trace} are the Maximum Eigenvalue Statistic and Trace Statistic used to determine the number of cointegrating vectors.
*(**) denotes rejection of the null hypotheses at 5% (1%) critical value levels

In the first sub-period, the estimated λ_{trace} and λ_{max} statistics show that *SBP* and *FRT* of three ship sizes are all cointegrated. The second subperiod shows a relatively weaker cointegration relationship between *SBP* and *FRT*, especially in handymax size case. However, the results of the whole sample period show that *SBP* and *FRT* of three ship sizes are cointegrated essentially, which indicates a long-run relationship between the two shipping markets.

It is worth to mention that quarterly and annual data have also been tested for possible cointegration, but no cointegration relationship is shown. This may suggest that the long-run equilibrium relationship between freight and shipbuilding markets is mainly based on a monthly adjustment.

3.4. Granger Causality Test

When two variables are cointegrated, one time series is useful in forecasting the other or there exists causality along at least one direction (*Granger, 1986*). Granger causality test is conducted to find the direction(s) of the causal effect between the two time series. As Engle and Granger (1987) pointed out, if the variables are cointegrated, a pure Vector Autoregressions (*VAR*) in difference to test the existence of Granger causality will be miss-specified. The *VECM* is suggested to estimate cointegrated data. In this study, the causal relationship between *SBP* and *FRT* is investigated using the *VECM* and *VAR*. In order to make the results robust, both *VECM* and *VAR* models have been tried to test the existence of Granger causality. The results of *VAR* are in line with the reported results using *VECM* and thus are not reported here.

The expanded *VECM* of equation (1) can be estimated by the ordinary least squares (OLS) method:

$$\Delta SBP_t = \sum_{i=1}^{p-1} a_{SBP,i}\Delta SBP_{t-i} + \sum_{i=1}^{p-1} b_{SBP,i}\Delta FRT_{t-i} + \alpha_{SBP}ECT_{t-1} + \varepsilon_{SBP,t} \quad (3)$$

$$\Delta FRT_t = \sum_{i=1}^{p-1} a_{FRT,i}\Delta SBP_{t-i} + \sum_{i=1}^{p-1} b_{FRT,i}\Delta FRT_{t-i} + \alpha_{FRT}ECT_{t-1} + \varepsilon_{FRT,t} \quad (4)$$

The null hypothesis that *FRT (= BDI, TC1, TC3)* does not Granger-cause *SBP* in the first regression Eq. (3) is formed as H_0: $b_{SBP,i} = 0$. Similarly, in the second regression Eq. (4), the null hypothesis that *SBP* does not Granger-cause *FRT* is H_0: $a_{FRT,i} = 0$. The test statistic is the usual *F*-statistics. $a_{SBP,i}$, $b_{SBP,i}$, $a_{FRT,i}$ and $b_{FRT,i}$ are short-run coefficients, ECT_{t-1} is the error correction term. The coefficients (α_{SBP} and α_{FRT}) of the error correction term provide insights into the adjustment process of *SBP* and *FRT* towards equilibrium, and their signs show the direction of convergence to the long-run relationship.

Table 6 to *Table 8* show *VECM* estimates and Granger causality tests for *FRT* and *SBP* in three ship sizes. The results show a positive correlation between *SBP* and *FRT*, and confirm a causal relationship that *FRT* leads *SBP*. The results in *Panel A* show the *VECM* estimates. The coefficients (α_{SBP} and α_{FRT}) of the ECT_{t-1} provide insights into the adjustment process of *SBP* and *FRT* towards equilibrium. The results are consistent among the three ship size cases. The coefficient α_{SBP} of the ECT_{t-1} in *Eq. (3)* is statistically significant and negative, while the coefficient α_{FRT} of the ECT_{t-1} in *Eq. (4)* is statistically significant and positive. Therefore, both *SBP* and *FRT* adjust to eliminate any disequilibrium of their long-run relationship. If there is a positive deviation from their equilibrium relationship at period *t*, *SBP* in the next period will decrease in value, while *FRT* in the next period will increase in value, thus converging to the long-run relationship. To sum up, the long-term relationship between *SBP* and *FRT* are stable.

Table 6: VECM estimates and Granger causality test for freight rates and shipbuilding prices; Capesize ships

$$\Delta SBP_t = \sum_{i=1}^{g-1} a_{SBP,i}\Delta SBP_{t-i} + \sum_{i=1}^{g-1} b_{SBP,i}\Delta FRT_{t-i} + \alpha_{SBP} ECT_{t-1} + \varepsilon_{SBP,t}$$

$$\Delta FRT_t = \sum_{i=1}^{g-1} a_{FRT,i}\Delta SBP_{t-i} + \sum_{i=1}^{g-1} b_{FRT,i}\Delta FRT_{t-i} + \alpha_{FRT} ECT_{t-1} + \varepsilon_{FRT,t}$$

where $\Delta FRT_t = \Delta BDI_t$, $\Delta TC1_t$, or $\Delta TC3_t$

	ΔSBP_{C_t}	ΔBDI_{C_t}		ΔSBP_{C_t}	$\Delta TC1_{C_t}$		ΔSBP_{C_t}	$\Delta TC3_{C_t}$
Panel A: VECM model Estimates								
ECT_{t-1}	-0.049	0.158	ECT_{t-1}	-0.054	0.218	ECT_{t-1}	-0.075	0.169
	(0.015)	(0.074)		(0.019)	(0.091)		(0.027)	(0.082)
	[-3.356]	[2.138]		[-2.750]	[2.384]		[-2.783]	[2.075]
$\Delta SBP_{C_{t-1}}$	0.000	0.330	$\Delta SBP_{C_{t-1}}$	0.005	0.809	$\Delta SBP_{C_{t-1}}$	0.012	0.276
	(0.098)	(0.498)		(0.098)	(0.458)		(0.099)	(0.297)
	[0.000]	[0.663]		[0.049]	[1.767]		[0.125]	[0.931]
$\Delta SBP_{C_{t-2}}$	0.091	1.016	$\Delta SBP_{C_{t-2}}$	0.043	0.682	$\Delta SBP_{C_{t-2}}$	0.070	0.505
	(0.099)	(0.498)		(0.097)	(0.453)		(0.098)	(0.296)
	[0.921]	[2.039]		[0.449]	[1.506]		[0.715]	[1.702]
$\Delta BDI_{C_{t-1}}$	0.046	0.457	$\Delta TC1_{C_{t-1}}$	0.059	0.301	$\Delta TC3_{C_{t-1}}$	0.072	0.479
	(0.020)	(0.100)		(0.022)	(0.102)		(0.034)	(0.103)
	[2.303]	[4.563]		[2.693]	[2.947]		[2.109]	[4.642]
$\Delta BDI_{C_{t-2}}$	-0.034	-0.165	$\Delta TC1_{C_{t-2}}$	-0.001	-0.002	$\Delta TC3_{C_{t-2}}$	-0.024	-0.040
	(0.021)	(0.105)		(0.023)	(0.108)		(0.037)	(0.111)
	[-1.624]	[-1.574]		[-0.034]	[-0.015]		[-0.656]	[-0.362]
Panel B: Walt tests for Granger causality								
	ΔSBP_{C_t}	ΔBDI_{C_t}		ΔSBP_{C_t}	$\Delta TC1_{C_t}$		ΔSBP_{C_t}	$\Delta TC3_{C_t}$
Walt tests	H0:	H0:	Walt tests	H0:	H0:	Walt tests	H0:	H0:
	$b_{SBP,i}=0$	$a_{FRT,i}=0$		$b_{SBP,i}=0$	$a_{FRT,i}=0$		$b_{SBP,i}=0$	$a_{FRT,i}=0$
	6.461	4.642		7.326	5.467		4.483	3.832
	[0.040]*	[0.098]		[0.026]*	[0.065]		[0.106]	[0.147]

Note:
Sample (adjusted): 1999:03 to 2007:12
In Panel A, Figures in ( ) and [ ] indicate Standard errors and *t*-statistics, respectively.
In Panel B, Figures in [ ] stands for P-values.
The lag length of the VECM model is determined by Akaike Information Criterion (AIC).
*(**) denotes rejection of the null hypotheses at 5% (1%) critical value levels.

Table 7: VECM Estimates and Granger causality test for freight rates and shipbuilding prices; Panamax ships

$$\Delta SBP_t = \sum_{i=1}^{p-1} a_{SBP,i}\Delta SBP_{t-i} + \sum_{i=1}^{p-1} b_{SBP,i}\Delta FRT_{t-i} + \alpha_{SBP}ECT_{t-1} + \varepsilon_{SBP,t}$$

$$\Delta FRT_t = \sum_{i=1}^{q-1} a_{FRT,i}\Delta SBP_{t-i} + \sum_{i=1}^{q-1} b_{FRT,i}\Delta FRT_{t-i} + \alpha_{FRT}ECT_{t-1} + \varepsilon_{FRT,t} \qquad \text{where } \Delta FRT_t = \Delta BDI_t,\ \Delta TC1_t,\ \text{or } \Delta TC3_t$$

Error Correction:	ΔSBP_{P_t}	ΔBDI_{P_t}	*Error Correction:*	ΔSBP_{P_t}	$\Delta TC1_{P_t}$	*Error Correction:*	ΔSBP_{P_t}	$\Delta TC3_{P_t}$
Panel A: VECM model Estimates								
ECT_{t-1}	-0.055	0.044	ECT_{t-1}	-0.035	0.138	ECT_{t-1}	-0.010	0.115
	(0.015)	(0.078)		(0.014)	(0.072)		(0.012)	(0.052)
	[-3.735]	[0.562]		[-2.575]	[1.922]		[-0.865]	[2.204]
$\Delta SBP_{P_{t-1}}$	0.175	0.549	$\Delta SBP_{P_{t-1}}$	0.123	0.395	$\Delta SBP_{P_{t-1}}$	0.218	0.445
	(0.094)	(0.493)		(0.097)	(0.510)		(0.093)	(0.417)
	[1.859]	[1.113]		[1.270]	[0.774]		[2.333]	[1.069]
$\Delta SBP_{P_{t-2}}$	-0.073	-0.571	$\Delta SBP_{P_{t-2}}$	-0.028	0.462	$\Delta SBP_{P_{t-2}}$	0.030	0.237
	(0.090)	(0.469)		(0.091)	(0.482)		(0.078)	(0.349)
	[-0.817]	[-1.218]		[-0.305]	[0.958]		[0.376]	[0.677]
$\Delta BDI_{P_{t-1}}$	0.054	0.199	$\Delta TC1_{P_{t-1}}$	0.079	0.555	$\Delta TC3_{P_{t-1}}$	0.152	0.483
	(0.020)	(0.103)		(0.019)	(0.098)		(0.023)	(0.101)
	[2.772]	[1.936]		[4.235]	[5.664]		[6.738]	[4.793]
$\Delta BDI_{P_{t-2}}$	0.007	-0.020	$\Delta TC1_{P_{t-2}}$	0.006	-0.237	$\Delta TC3_{P_{t-2}}$	0.005	-0.144
	(0.020)	(0.107)		(0.021)	(0.109)		(0.028)	(0.125)
	[0.360]	[-0.185]		[0.297]	[-2.178]		[0.177]	[-1.152]
Panel B: Walt tests for Granger causality								
Walt tests	H0:	H0:	Walt tests	H0:	H0:	Walt tests	H0:	H0:
	$b_{SBP,i}$=0	$a_{FRT,i}$=0		$b_{SBP,i}$=0	$a_{FRT,i}$=0		$b_{SBP,i}$=0	$a_{FRT,i}$=0
Walt tests	7.899	2.228	Walt tests	19.581	1.858	Walt tests	46.467	2.339
	[0.019]*	[0.328]		[0.000]**	[0.395]		[0.000]**	[0.311]

Note:
Sample (adjusted): 1998:05 to 2007:12
In Panel A, Figures in ( ) and [ ] indicate Standard errors and *t*-statistics, respectively.
In Panel B, Figures in [ ] stands for P-values.
The lag length of the VECM model is determined by Akaike Information Criterion (AIC).
*(**) denotes rejection of the null hypotheses at 5% (1%) critical value levels.

Table 8: VECM Estimates and Granger causality test for freight rates and shipbuilding prices; Handymax ships

$$\Delta SBP_t = \sum_{i=1}^{p-1} a_{SBP,i}\Delta SBP_{t-i} + \sum_{i=1}^{p-1} b_{SBP,i}\Delta FRT_{t-i} + \alpha_{SBP} ECT_{t-1} + \varepsilon_{SBP,t}$$

$$\Delta FRT_t = \sum_{i=1}^{q-1} a_{FRT,i}\Delta SBP_{t-i} + \sum_{i=1}^{q-1} b_{FRT,i}\Delta FRT_{t-i} + \alpha_{FRT} ECT_{t-1} + \varepsilon_{FRT,t} \quad \text{where } \Delta FRT_t = \Delta BDI_t,\ \Delta TC1_t\ ,\ \text{or } \Delta TC3_t$$

Error Correction:	ΔSBP_{H_t}	ΔBDI_{H_t}	*Error Correction:*	ΔSBP_{H_t}	$\Delta TC1_{H_t}$	*Error Correction:*	ΔSBP_{H_t}	$\Delta TC3_{H_t}$
Panel A: VECM model Estimates								
ECT_{t-1}	-0.043	0.033	ECT_{t-1}	-0.052	0.022	ECT_{t-1}	-0.053	0.088
	(0.015)	(0.060)		(0.018)	-0.071		(0.030)	(0.078)
	[-2.898]	[0.552]		[-2.827]	[0.310]		[-1.785]	[1.125]
$\Delta SBP_{H_{t-1}}$	0.034	-0.177	$\Delta SBP_{H_{t-1}}$	-0.057	-0.555	$\Delta SBP_{H_{t-1}}$	-0.049	-0.518
	(0.115)	(0.461)		(0.116)	(0.450)		(0.113)	(0.298)
	[0.295]	[-0.383]		[-0.489]	[-1.233]		[-0.436]	[-1.736]
$\Delta SBP_{H_{t-2}}$	–	–	$\Delta SBP_{H_{t-2}}$	-0.001	-0.162	$\Delta SBP_{H_{t-2}}$	0.036	0.343
				(0.111)	(0.431)		(0.106)	(0.282)
				[-0.011]	[-0.375]		[0.341]	[1.218]
$\Delta BDI_{H_{t-1}}$	0.094	0.405	$\Delta TC1_{H_{t-1}}$	0.125	0.598	$\Delta TC3_{H_{t-1}}$	0.176	0.726
	(0.030)	(0.121)		(0.031)	(0.122)		(0.046)	(0.122)
	[3.106]	[3.350]		[3.982]	[4.903]		[3.821]	[5.958]
$\Delta BDI_{H_{t-2}}$	–	–	$\Delta TC1_{H_{t-2}}$	0.012	-0.036	$\Delta TC3_{H_{t-2}}$	0.054	-0.114
				(0.035)	(0.135)		(0.053)	(0.139)
				[0.339]	[-0.267]		[1.023]	[-0.818]
Panel B: Walt tests for Granger causality								
Walt tests	H0:	H0:	Walt tests	H0:	H0:	Walt tests	H0:	H0:
	$b_{SBP,i}$=0	$a_{FRT,i}$=0		$b_{SBP,i}$=0	$a_{FRT,i}$=0		$b_{SBP,i}$=0	$a_{FRT,i}$=0
	9.653	0.147		18.888	1.741		18.935	3.961
	[0.002]**	[0.702]		[0.000]**	[0.419]		[0.000]**	[0.138]

Note:
Sample (adjusted): 2000:09 to 2007:12
In Panel A, Figures in ( ) and [ ] indicate Standard errors and *t*-statistics, respectively.
In Panel B, Figures in [ ] stands for P-values.
The lag length of the VECM model is determined by Akaike Information Criterion (AIC).
*(**) denotes rejection of the null hypotheses at 5% (1%) critical value levels.

The results in *Table 6* to *Table 8* (*Panel B*) show the Granger causality test results through *VECM*.

The null hypothesis that *FRT* (= *BDI, TC1, TC3*) does not Granger-cause *SBP* is rejected in general at 1% critical value (with the exception of SBP_C and $TC3_C$ for capesize ships), while that the null hypothesis that *SBP* does not Granger-cause *FRT* is acceptable at 5% critical value across three ship sizes. Therefore, *FRT* are statistically significantly Granger-cause *SBP*.

The estimates of *Table 6* to *Table 8* further show that the coefficients of *SBP* lags in *Eq. (3)* are generally larger in magnitude than the coefficients of *FRT* lags in *Eq. (4)* for three sizes of bulk ship. Therefore, *FRT* seems to be more sensitive to market changes, and *FRT* plays a price-leading role in incorporating new information.

4. Discussion and Further Research

The interdependence of two shipping markets has been studied, where the sea freight market trades cargo-carrying service and the shipbuilding market trades new ships. Many argue that the freight rates depend on the shipbuilding activities. Others argue that demand for shipbuilding depends mainly on the operating environment of the shipping market. We have examined these competing views by testing whether freight rates and shipbuilding prices are related in the long-run.

This study establishes an econometric model of shipbuilding price and freight rate so as to determine their dynamic relationship. Similar to many financial and economic time series, shipping time series are non-stationary. However, we confirm that there exists a co-integration relationship between freight rate and shipbuilding price, such that the two rates are related to form an equilibrium relationship in the long run. The results have showed a positive correlation between freight market and shipbuilding market, and demonstrate a causal relationship that freight rate leads shipbuilding price.

The time lags of from freight rate to the shipbuilding price are approximately two months. The existence of time lags implies that the information flow between these two markets is not in a timely manner, as rational expectations by the Efficient Markets Hypothesis. This information delay is however expected because the market players are essentially different in these two markets, despite the fact that these markets are related. The market players in the freight market are ship operators and cargo owners who trade the cargo-carrying capacities, while the shipowners and shipbuilders buy and sell the shipbuilding capacities in the shipbuilding market.

The finding concludes that the shipbuilding prices are a function of the past history of freight rate, rather than the expected future values of freight rate. At the same time, the supply of ships alone is not sufficient to forecast the future freight rate. This finding implies that, due to the long delivery time, the future supply of ships is not consistently interpreted in the freight market at the micro level so that the shipbuilding price appears not to depend on freight market outlook.

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