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A Directional Relationship between Freight and Newbuilding Markets: A Panel Analysis

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ABSTRACT

This paper examines the dynamic relationship between international sea freight rate and newbuilding price, employing panel cointegration testing and estimating techniques. The primary question this paper addresses is whether the goods (new ships) price and service (sea freight) rate lead or lag one another in a Granger-cause sense, or simultaneously move together. Monthly panel data on 3 different bulk shipping market segments over the period 1998 to 2009 are exploited in empirical analysis. Various panel unit root tests demonstrate that the data variables are integrated with unit roots while panel cointegration techniques are used to estimate the dynamic relationship. A positive directional relationship from freight rate to newbuilding price is found and freight rate is more sensitive to market changes than newbuilding price. These results indicate that investment in new ships is encouraged by a strong freight market.

Keywords: Cross market analysis; Asset investment; Newbuilding price; Freight rate; Panel unit root; Panel cointegration; VECM

1. Introduction

This paper studies the dynamic relationship between newbuilding price and freight rate in the shipping industry. This directional relationship has not received sufficient attention in the maritime economics literature. In an equilibrium framework, freight rates are determined by the interaction of supply and demand for cargo carrying services, while newbuilding prices depend on the supply and demand of newbuilding capacities.

Despite being the primary means of changing the supply of cargo carrying capacity in the shipping industry, newbuilding price has seldom been studied as an economic factor in the shipping market. While one can imagine the existence of a relationship between newbuilding price and freight rate, the direction of causality between them is not known, that is, whether freight rate leads newbuilding price or vice versa or a bidirectional causality exists. The effects of ship size and contract duration on this lead-lag relationship have not been investigated in the literature, although insights into this dynamic relationship could provide vital implications for newbuilding strategies and policies. For example, Capesize ships are more vulnerable to market changes due to the trading inflexibility of larger vessels, and thus might exhibit different lead-lag relationship than ships of other sizes.

Newbuilding is commonly considered exogenous of freight markets, because its long cycle introduces long delays in the supply side. In the existing literature freight rate is determined by the demand for trade, the supply of ships and other macro-economic factors of the sea freight market (for example, *Evans and Marlow, 1990*). For example, Beenstock and Vergottis (1993) developed a complete model of freight rate relations and an integrated model of shipping markets. Assuming the efficient market hypothesis, they found the newbuilding market to resemble a forward market of ships in their models. Through simulation they discovered that an increase in freight rate results in a small response in newbuilding price and there is an absence of lags among prices. However, this conclusion cannot be verified by observable market data. Our preliminary analysis indicates a lag of several months between freight rate and newbuilding price.

A shipowner often faces difficult decisions on the timing of newbuildings. Since a ship needs to be designed, constructed and commissioned long before coming into service, a new ship is usually delivered into the freight market 18 months to 2 years after the initial decision. Market conditions can be totally different after such a long delay. Consequently, newbuilding decisions are inherently risky and wrong timing can turn a handsome expected profit into heavy losses.

Ships are categorised according to three major cargo types: dry bulk cargo, tanker (liquid bulk) cargo, and container cargo. The dry bulk shipping market is considered close to perfect competition because this market is believed to consist of a multitude of small players, shipowners or charterers, and the market rate is set by the aggregate action of all market participants and free from government intervention. Shipowners and charterers are numerous and relatively small to influence the market price (that is, freight rates) substantially. By focusing on the market-driven dynamic relationship between freight rate and newbuilding price in the dry-bulk shipping sector, this paper makes the following contributions to the literature. First, we find a strong positive one-way causal mechanism from freight rate to newbuilding price in contrast to most existing studies, where a reverse relationship from newbuilding price to second-hand ship price to freight rate is claimed (e.g. *Hawdon, 1978; Beenstock and Vergottis, 1989; Tsolakis et al, 2003*). Second, our results are further verified using panel data and associated panel techniques while previous analyses of freight rate and newbuilding price have been conducted using time series data or cross-sectional data only. Third, this paper explains clearly the differences between different freight markets, classified by ship size, in the relationships between freight rate and newbuilding price.

The paper is organised as follows. Firstly, the related literature in the shipping markets and theoretical considerations are reviewed. Secondly, the research framework and data are discussed. Thirdly, we discuss the empirical results and implications. Finally, we summarise the findings and outline areas of future study.

Literature Review

In this study, we attempt to examine the interdependence of freight and newbuilding markets, where the sea freight market trades sea transport services and the newbuilding market trades new ships. Two areas of the literature are pertinent to this study: the research on freight rates and newbuilding prices, and the dynamic relationship between the two markets.

Freight rates have been considered the most critical indicators for shipping markets because they represent the principal source of earnings for the shipping industry. Many existing studies have focused on the characteristics of freight rates and looked at factors influencing these rates (*Hawdon, 1978; Beenstock and Vergottis, 1993);*

their stationarity *(Koekebakker, Adland and Sodal, 2006*); cointegration (*Borger and Nonneman, 1981*); and term structure (*Kavussanos, 1996; Veenstra, 1999*).

These studies showed that the freight rate is not stationary like most economic and financial time series (see *Kavussanos and Visbikis 2006*, *Alizadeh and Nomikos 2009*) and that the freight rate is determined by the demand for transport, the supply of tonnage and other macro-economic factors of the sea freight market (for example, *Hsu and Goodwin, 1995; Evans and Marlow, 1990*). Existing studies on shipping market focus on freight market models, and we find only a few studies looking into the interactions between newbuilding markets and freight markets (e.g. *Haralambides et al., 2004; Tsolakis et al., 2003; Tsolakis, 2005*). They focused on the forecasting of freight rate and estimated the supply and demand of shipping. *Beenstock and Vergottis (1989)* concluded a regression analysis of shipping market and found that newbuilding price responds very little to the freight rate and no time delay is observed across shipping markets. These two findings are different from our observations, and new studies are needed to examine and clarify the dynamic relationships between freight rate and newbuilding price.

Ships have been studied as capital assets, with asset pricing determined by measuring the net present value of expected earning potential (for example, *Dikos, 2004; Alizadeh and Nomikos, 2007*). The existing literature contributes to the forecasting of ship prices but the directional relationship between the newbuilding price and freight rate is left unexamined. Thus, rather than estimating ship prices (e.g. *Dikos, 2004*; *Mulligan 2008*), we investigate this directional causality relationship by using the Granger causality test and impulse response analysis.

Directional causality relationships between freight markets have been studied, such as spot versus period, and spot versus futures (*Kavussanos and Nomikos, 2003; Kavussanos and Visvikis, 2004; Batchelor, Alizadeh and Visvikis 2005; Glen 2006*). 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.

As ships (capital goods) are used to provide freight services (production), the freight rate should depend on newbuilding price, among other variables. This idea is incorporated in the previously mentioned regression studies (for example, *Beenstock and Vergottis 1989*). Meanwhile, from the point of view of shipowners' cash-flow, Stopford (2009) explains the cycle of the freight market. He describes how shipowners who have earned cash in the freight market will order new ships due to their confidence on the future of the freight market. We examine these two views by determining how freight rates and newbuilding prices are related.

In order to explore the existence of directional relationships between freight rates and newbuilding prices, reduced form models of freight rates and newbuilding prices are used. We provide conclusive evidence of the validity of the freight-led newbuilding hypothesis. A cointegration relationship, that is, a long-run equilibrium relationship among the variables in the regression equation, is found by heterogeneous panel cointegration tests.

In recent years, Hardi (2000), Breitung (2000), Levin, Lin & Chu (2002), Im, Pesaran & Shin (2003) and others developed panel unit root tests. They showed that panel unit root tests are more powerful (or less likely to commit a Type II error) than traditional unit root tests applicable to a single time series. Their finding supports our use of the panel time series technique in this study. Excellent surveys on unit roots and cointegration in panels are available in Breitung and Pesaran (2008) and Baltagi (2008, Ch. 12).

Research Framework and Data Description

To determine the interrelationships between newbuilding price and freight rate, a three-stage approach is taken with each step being a prerequisite for the next. Firstly, the unit root test is performed to check whether the freight rate and newbuilding price time series are stationary. Secondly, the test for cointegration is conducted to determine the existence of long-term relationships between the two time series. Finally, the Granger causality test is conducted to determine the cause-effect relationship with variables.

The time series data used covers the newbuilding prices and freight rates over the period 1998 to 2009, depending on availability (source: Clarkson 2009). The time series of newbuilding prices (*SBP*) are monthly data in US dollars per compensated gross ton. The freight rate (*FRT*) time series are quoted in 3 different terms:

- Baltic Dry Indices (*BDI*) for spot contracts;
- One-year time charter rate (*TC1*) for one-year term contract, and
- Three-year time charter rate (*TC3*) for three-year term contract.

SBP and *FRT* are further categorised into three different ship sizes: Capesize vessels (120,000 deadweight tons), Panamax vessels (70,000 deadweight tons), and

Handymax vessels (50,000 deadweight tons). A remark on the recent conversion of *BDI* from handymax to supramax is reviewed in Appendix 1.

Summary descriptive statistics of monthly freight rates and newbuilding prices in logarithms for three sizes of dry bulk ships are shown in Table 1. All the time series data are transformed into natural logarithms. Because these variables are skewed and of different ranges, the use of logarithmic transformation can narrow the ranges of the variables and make the analysis less sensitive to extreme observations.

| Table 1 |

The mean values of spot freight rates (Baltic Dry Indices) for smaller vessels are higher than for larger ones. In contrast, time-charter rates are higher for the larger vessels than smaller ones. The standard derivations of freight rates and newbuilding prices seem to be higher for larger vessels than for smaller ones. The fluctuation of freight rates declines as the contract duration increases, but freight rates tend to be more volatile than newbuilding prices in terms of standard deviations.

Positive coefficients of kurtosis indicate the leptokurtic property in all time series. Positive coefficients of skewness indicate right skewed distributions; the only exception is the Baltic Capesize Index (BDI_c) with a negative coefficient of skewness, which indicates a left skewed distribution for this time series. *J-B* is the Jarque-Bera statistic for testing whether the series is normally distributed. The reported probabilities indicate that *FRT* and *SBP* are broadly not normally distributed at the 5% level in all ship types.

Results and Discussion

Tests of Non-stationarity

Before testing for cointegration between newbuilding prices and freight rates, their order of stationarity needs to be tested first. Six commonly used tests are applied to test panel unit root, namely, *LLC* test by Levin, Lin and Chu (2002), Breitung test by Breitung (2000), *IPS* test by Im, Pesaran and Shin (2003), ADF Fisher test and PP Fisher test by Maddala and Wu (1999), and Hadri test by Hadri (2001).

Table 2 shows the results of panel unit root tests under the six test methods. In the LLC, Breitung, IPS, ADF and PP tests, the null hypothesis is that the variables have unit roots. The null is accepted when variables are in their levels and rejected in their first differences. The Hadri test has the null of no unit root, and the null is rejected when variables are in their levels and accepted in their first differences. All variables are significant at the 1% level. Therefore, we conclude that all these variables are in *I*(1) form.

| Table 2 |

Cointegration between Newbuilding Prices and Freight Rates

Having established that all the variables possess *I*(1) characteristics for long-run equilibrium relationship, we proceed to test panel cointegration between *SBP* and *FRT*.

To examine whether there is a long-term equilibrium relationship between *SBP* and *FRT*, we perform the seven panel cointegration tests. As shown in Table 3, the seven tests give different results for the three contract terms (*FRT=BDI, TC1* or *TC3*). In the case of *BDI* and *SBP*, all the seven test statistics show that there is cointegration between the two variables. In the case of *TC1* and *SBP*, five out of seven tests are significant, rejecting the null of no cointegration. In the case of *TC3* and *SBP*, six out of seven tests show the cointegration. Therefore, it is reasonable to say that *FRT* and *SBP* are overall cointegrated.

| Table 3 |

Causal Directions

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*). The Granger causality test is conducted to find the direction(s) of the causal effect between the two variables. *Engle and Granger (1987)* pointed out that, if the variables are cointegrated, pure Vector Autoregressions (*VAR*) in differences, to test the existence of Granger causality, will be miss-specified. The Vector Error Correction Model (*VECM*) is suggested to estimate cointegrated data. To make the results more 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 Eq. (1) can be estimated by Ordinary Least Squares (OLS) regressions as denoted by Eq. (2) & (3):

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

where $y_t = (SBP_t \;\; FRT_t)'$

$$\Delta SBP_t = \sum_{i=1}^{p-1} a_{SBP,i} \Delta SBP_{t-i} + \sum_{i=1}^{p-1} b_{SBP,i} \Delta FRT_{t-i} + \alpha_{SBP} ECT_{t-1} + \varepsilon_{SBP,t} \quad (2)$$

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

The null hypothesis that the freight rate (*FRT*) does not Granger-cause the newbuilding price (*SBP*) in the first regression Eq. (2) is formed as H_0: $b_{SBP,i} = 0$. Similarly, in the second regression Eq. (3), the null hypothesis that SBP does not Granger-cause *FRT* is H_0: $a_{FRT,i} = 0$. The test statistic is the usual *F*-statistic. $a_{SBP,i}$, $b_{SBP,i}$, $a_{FRT,i}$ and $b_{FRT,i}$ are short-run coefficients and 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 4 illustrates *VECM* Granger causality tests for three sizes of bulk ships. The results show a positive correlation between the freight market and the newbuilding market, and confirm a causal relationship that *FRT* leads *SBP*.

| Table 4 |

Table 4 shows the Granger causality test results through *VECM*. The null hypothesis that *FRT* (= *BDI*, *TC1* or *TC3*) does not Granger-cause *SBP* is rejected at 1% critical value, while that the null hypothesis that *SBP* does not Granger-cause *FRT* is accepted at 10% critical value for three sizes of ships. Therefore, *FRT* are statistically significantly Granger-cause *SBP*.

Response to impulse change

The impulse response analysis provides a more detailed insight in depicting the system dynamics. It is conducted to demonstrate the dynamic response of the system, which illustrates the two-way dynamic relations of the variables. An impulse response function provides a different way to depict the system dynamics by tracing the effects of the shock of an endogenous change on the variables in the *VECM*. The impulse response analysis shows how variables in the *VECM* system respond to a standard exogenous change of one variable. By providing a finer characterization of the causal relationship, the impulse response analysis indicates whether the impacts are positive or negative, and whether such impacts are temporary or long-term.

The impulse response analysis traces the effect of a one standard deviation shock to one of the innovation on current and future values of the endogenous variables. A shock to the *i*-th variable directly affects the *i*-th variable itself, and is also transmitted to all of the endogenous variables through the dynamic structure of the *VECM*. Sims's (1980) original approach depended on the ordering of the variables in a system (Lutkepohl, 1991). Pesaran and Shin (1998) suggested the use of generalised impulse responses by constructing an orthogonal set of innovations which resolved the problem of dependence on the ordering of the variables in the system.

Figure 1 depicts the generalised impulse responses of *SBP* and *BDI* to one standard deviation innovation in Capesize case.

| Figure 1 |

A positive shock to *SBP* brings about an immediate increase in *FRT* (= *BDI*, *TC1*, *TC3*), and dies off very soon in about 12 months. A positive shock to *SBP* also brings about an increase to itself, but adjusts gradually to equilibrium, the overshooting of *SBP* dies off in about 6 months after *FRT* reaches the peak.

On the *FRT* to *SBP* direction, a positive shock to *FRT* brings about an immediate increase of itself in the first month and adjusts to equilibrium in a much shorter time than SBP. A positive shock to *FRT* also brings about an increase in *SBP* and adjusts gradually to equilibrium in about 18 months, which is a longer period of adjusting than the impact of *SBP* to *FRT*.

Both results of the impact of *SBP* to *FRT* and that of *FRT* to *SBP* indicate that *SBP* needs a longer adjustment time to equilibrium than *FRT does*. In other words, freight market responds to new information more rapidly than the newbuilding market. This result is in line with the previous Granger causality test that freight rates seem to be more sensitive to market changes; freight rates play a price-leading role in incorporating new market information.

These results suggest that a positive shock of *SBP* or *FRT* will bring about a positive adjustment to each other, however, with a stronger respond of freight rates to market shocks. This shows that there is a long-term relationship between freight and newbuilding markets. However, the freight market is in the lead in price discovery, since new information tends to be processed more rapidly in the freight market than in the newbuilding market.

Sensitivity Analysis

As a further robustness check, we shorten the observation period (1998:05 – 2007:12) and replicate the preceding analysis. This period is chosen due to the freight market boom of 2003-2005, and the recent financial crisis (2008). It is expected that there may be fundamental changes from the market boom in 2005 to the financial crisis in 2008. This sensitive result (reported in Table 5) basically confirms and is consistent with the earlier analysis. There is no clear evidence that the freight market condition (boom and crisis) has substantially changed the directional relationship from freight to newbuilding markets.

| Table 5 |

Conclusion and Further Research

This study establishes an econometric model of newbuilding prices and freight rates to examine their dynamic relationship. Similar to many financial and economic time series, shipping time series are non-stationary. However, it has previously been believed that there exists a cointegration relationship between freight rates and newbuilding prices, so that the two rates are related to form an equilibrium relationship in the long run. Our results have revealed a positive correlation between the freight- and the newbuilding market, and demonstrated a causal relationship, whereby freight rates lead newbuilding prices.

This study establishes the interdependence of two shipping markets, where the sea freight market trades cargo-carrying services and the newbuilding market trades new ships. The results of Granger causality test reject the directional relationship from newbuilding prices to freight rates. More specifically, our findings imply that, due to the long delivery time, the newbuilding price does not lead freight rates. The sensitivity analysis shows no clear evidence that the freight market condition (boom and crisis) has substantially changed the directional relationship from freight to newbuilding markets.

The time lags from freight rate to newbuilding price are approximately three to six months (see Figure 1). The existence of time lags implies that the information flow between these two markets may not be as efficient as that expected by the Efficient Markets Hypothesis. This information delay is however expected because market players are essentially different in these two markets, despite the fact that they are related. The market players in the freight market are ship operators and cargo owners who trade in cargo-carrying services, while shipowners and shipbuilders buy and sell newbuilding tonnage in the shipbuilding market. One needs to analyse the respective price-setting mechanisms in the two markets to clearly explain these time lags.

This study contributes to the general understanding of price interdependences between production markets (cargo-carrying service) and capital markets (new ships). The modern analysis of price interdependence among markets has been typically focused on the foreign exchange market, equity market and derivative markets, in which equilibrium pricing appears for the arbitrage free relationship among the markets. This paper extends the area of price interdependence across markets from financial derivatives markets into two apparently stand-alone markets. Our results indicate that the investment behaviour in physical assets for future service capacity is encouraged by a strong service market. They further imply that market inefficiency is expected across markets, as the service market is more sensitive to market changes than the asset market, while the latter market is much more capital intensive than the service market.

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

	N	*Mean*	*Std.Dev.*	*Skewness*	*Kurtosis*	*J-B*	*Probability*
Capesize Bulker series (1999:03-2009:05)							
BDI_C	123	8.084	0.794	0.186	2.093	4.922	0.085
$TC1_C$	123	10.239	0.787	0.414	2.041	8.222	0.016
$TC3_C$	123	10.068	0.647	0.708	2.450	11.821	0.003
SBP_C	123	7.539	0.359	0.306	1.689	10.728	0.005
Panamax Bulker series (1998:05-2009:05)							
BDI_P	133	7.693	0.740	0.378	2.108	7.584	0.023
$TC1_P$	133	9.477	0.709	0.874	2.757	17.245	0.000
$TC3_P$	133	9.275	0.532	1.372	3.934	46.546	0.000
SBP_P	133	7.356	0.339	0.419	1.757	12.453	0.002
Handymax Bulker series (2000:09-2009:05)							
BDI_H	105	9.753	0.666	-0.028	2.034	4.098	0.129
$TC1_H$	105	9.632	0.714	0.625	2.352	8.675	0.013
$TC3_H$	105	9.366	0.561	1.080	3.111	20.473	0.000
SBP_H	105	7.590	0.329	0.139	1.653	8.270	0.016

Note:

- All series are measured in logarithms.
- BDI, TC1 and TC3 denote the freight rate for spot-term, 1-year term and 3-year term contracts
- SBP denotes the newbuilding price.
- The subscripts *C*, *P* and *H* denote Capesize, Panamax and Handymax ship sizes, respectively.
- 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.

Table 2
Panel Unit Root Tests (1998:05 to 2009:05)

Variables	Tests assuming common root LLC	Breitung	Hadri	Tests assuming individual root IPS	ADF	PP
	H_0: Unit root	H_0: Unit root	H_0: No unit root	H_0: Unit root	H_0: Unit root	H_0: Unit root
Levels						
BDI	-0.082	-0.890	6.940*	-1.136	11.958	7.487*
TC1	-0.635	-1.287	8.511*	-2.285	14.719	3.445*
TC3	-1.366	-0.354	7.634*	-1.822	11.966	2.953*
SBP	0.386	1.841	12.465*	-0.241	5.191	4.725*
First Differences						
△BDI	-12.952*	-2.552*	-1.270	-11.537*	106.837*	109.932
△TC1	-12.857*	-4.892*	-0.880	-10.617*	96.133*	89.278
△TC3	-14.548*	-9.548*	-0.315	-11.055*	101.924*	82.253
△SBP	-9.432*	-7.784*	-0.332	-9.531*	83.965*	123.099

Note:
- In the tests of Levin, Lin and Chu (2002, L.L.C.), Breitung (2000), Im, Pesaran and Shin (2003, IPS), ADF Fisher (ADF), PP Fisher (PP), the null hypothesis is with unit root. In the Hadri (2001) test, the null hypothesis is with no unit root.
- * denotes rejection of the null hypothesis at 1% critical value levels.
- The lag lengths of the ADF test is determined by Schwarz Info Criterion (SIC).

Table 3
Panel Cointegration Tests (1998:05 to 2009:05)

Pedroni Panel Cointegration Tests		BDI vs. SBP		TC1 vs. SBP		TC3 vs. SBP	
		Stats.	Prob.	Stats.	Prob.	Stats.	Prob.
Panel cointegration Tests	Panel v-Statistic	5.008	0.000**	4.597	0.000**	4.363	0.000**
	Panel rho-Statistic	-2.526	0.006**	-2.165	0.015**	-2.948	0.002**
	Panel PP-Statistic	-2.122	0.017**	-1.309	0.095*	-1.540	0.062*
	Panel ADF-Statistic	-3.268	0.002**	-3.506	0.000**	-3.464	0.000**
Group mean cointegration tests	Group rho-Statistic	-1.595	0.055*	-1.172	0.121	-1.860	0.032**
	Group PP-Statistic	-1.928	0.027**	-0.877	0.190	-1.160	0.123
	Group ADF-Statistic	-3.258	0.007**	-3.573	0.000**	-3.432	0.000**

Note:

- All tests are under the null hypothesis of no cointegration.
- *(**) denotes rejection of the null hypothesis of a unit root at 10% (5%) critical value levels.
- The lag lengths of the ADF test is determined by Schwarz Info Criterion (SIC).

Table 4
Granger causality test: Capesize, Panamax and Handymax ships

Walt tests	*H₀:* $b_{SBP,i}=0$	*H₀:* $a_{BDI,i}=0$	*Walt tests*	*H₀:* $b_{SBP,i}=0$	*H₀:* $a_{TC1,i}=0$	*Walt tests*	*H₀:* $b_{SBP,i}=0$	*H₀:* $a_{TC3,i}=0$
Capesize Bulker series (1999:03-2009:05)								
	ΔBDI_{C_t}	ΔSBP_{C_t}		$\Delta TC1_{C_t}$	ΔSBP_{C_t}		$\Delta TC3_{C_t}$	ΔSBP_{C_t}
	31.535** (0.000)	13.669 (0.091)		19.213** (0.000)	10.252* (0.036)		14.864** (0.005)	12.010* (0.017)
Panamax Bulker series (1998:05-2009:05)								
	ΔBDI_{P_t}	ΔSBP_{P_t}		$\Delta TC1_{P_t}$	ΔSBP_{P_t}		$\Delta TC3_{P_t}$	ΔSBP_{P_t}
	53.128** (0.000)	3.011 (0.222)		34.501** (0.000)	3.363 (0.186)		46.924** (0.000)	4.119 (0.128)
Handymax Bulker series (2000:09-2009:05)								
	ΔBDI_{H_t}	ΔSBP_{H_t}		$\Delta TC1_{H_t}$	ΔSBP_{H_t}		$\Delta TC3_{H_t}$	ΔSBP_{H_t}
	50.778** (0.000)	2.498 (0.287)		42.075** (0.000)	3.118 (0.210)		42.711** (0.000)	3.169 (0.205)

Note:

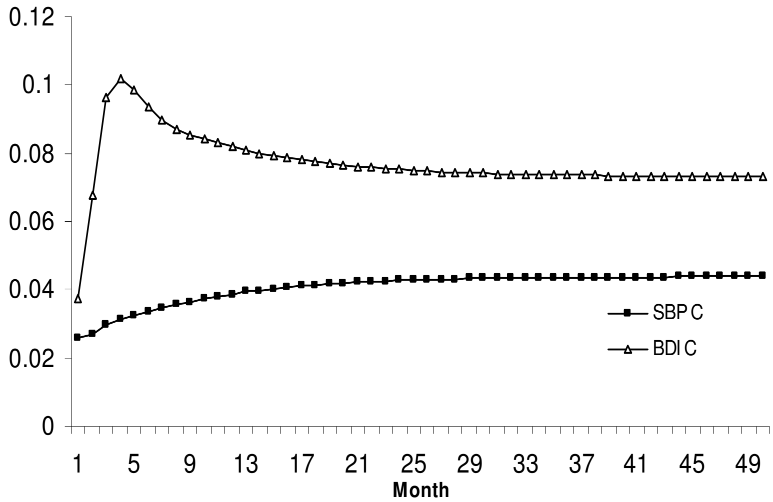
- Figures in ( ) stands for p-values.
- The lag length of the VECM model is determined by Schwarz Info Criterion (SIC).
- *(**) denotes rejection of the null hypotheses at 5% (1%) critical value levels.

Table 5
Sensitivity test: Granger causality test (1998:05 – 2007:12)

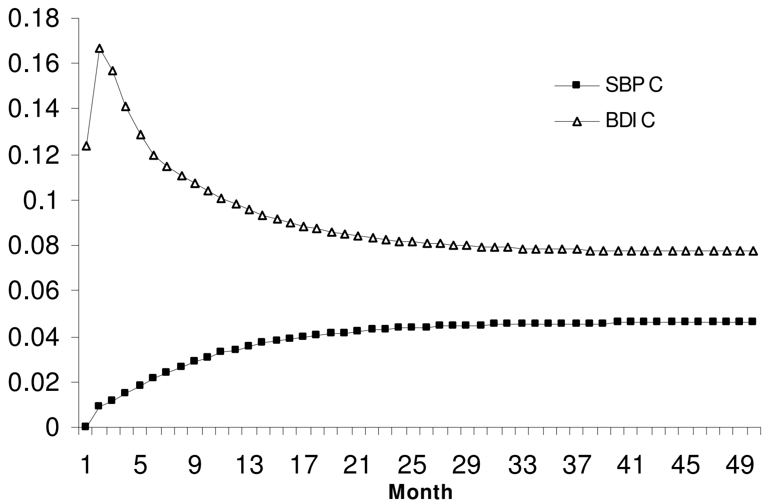
Walt tests	*H0:* $b_{SBP,i}=0$	*H0:* $a_{BDI,i}=0$	*Walt tests*	*H0:* $b_{SBP,i}=0$	*H0:* $a_{TC1,i}=0$	*Walt tests*	*H0:* $b_{SBP,i}=0$	*H0:* $a_{TC3,i}=0$
Capesize Bulker series (1999:03-2007:12)								
	ΔBDI_{C_t}	ΔSBP_{C_t}		$\Delta TC1_{C_t}$	ΔSBP_{C_t}		$\Delta TC3_{C_t}$	ΔSBP_{C_t}
	6.461*	4.642		7.326*	5.467		4.483	3.832
	[0.040]	[0.098]		[0.026]	[0.065]		[0.106]	[0.147]
Panamax Bulker series (1998:05-2007:12)								
	ΔBDI_{P_t}	ΔSBP_{P_t}		$\Delta TC1_{P_t}$	ΔSBP_{P_t}		$\Delta TC3_{P_t}$	ΔSBP_{P_t}
	7.899*	2.228		19.581**	1.858		46.467**	2.339
	[0.019]	[0.328]		[0.000]	[0.395]		[0.000]	[0.311]
Handymax Bulker series (2000:09-2007:12)								
	ΔBDI_{H_t}	ΔSBP_{H_t}		$\Delta TC1_{H_t}$	ΔSBP_{H_t}		$\Delta TC3_{H_t}$	ΔSBP_{H_t}
	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:

- Figures in [ ] stands for p-values.
- The lag length of the VECM model is determined by Schwarz Info Criterion (SIC).
- *(**) denotes rejection of the null hypotheses at 5% (1%) critical value levels.



In the equation for SBP_C



In the equation for BDI_C

Figure 1
Generalised Impulse Responses of SBP_C & BDI_C to one S.D. innovations; Capesize ships

Appendix 1

It is worth noting that the Baltic Handymax Index (*BHI*) was replaced by the Baltic Supramax Index (*BSI*) on 23 December 2005. During the transition period, there was a dual reporting period of both the *BHI* and *BSI* from 1 July 2005 to 23 December 2005. In this paper, we use the following Conversion Factor suggested by the **International Maritime Exchange** to convert BSI to BHI after 23 December 2005:

$$Conversion\ \ Factor = \left.\frac{Average\ of\ \ BHI}{Average\ of\ \ BSI}\right|_{During\ the\ dual\ reporting\ \ period\ (\ 1\ Jul\ to\ 23\ Dec\ 2005\ )} \tag{A1}$$