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Investors' Behavior and Dynamics of Ship Prices: A Heterogeneous Agent Model

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Abstract

Distinguishing investors into speculators and operators, and classifying the former group into momentum and contrarian investors, we develop a heterogeneous agent model (HAM) to examine the dynamics of price of second-hand dry bulk ships. The results suggest that momentum strategies based on short-term measures of earnings perform significantly better than the contrarian or passive (buy-and-hold) strategies. The HAM seems to capture the dynamics of vessel prices and the investors' behavior in the market for ships very well. Finally, an increase in participation of momentum investors tends to increase price volatility, whereas higher demand from contrarian investors seems to lower price variability.

Keywords: heterogeneous agent model**,** investor behavior, shipping investment, momentum and contrarian strategies

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1. Introduction

The competitive and capital intensive shipping industry is characterized by cyclical fluctuations, high volatility and periods of extraordinary returns (Stopford, 2009). This combination makes investment in ships very attractive for both regular investors and speculators. The latter are grouped usually under the term “asset-players” looking to benefit from ship value volatility. Asset-players - or any newer types of investors - have not, however, eclipsed the mainstay of shipowners who concentrate on generating income from ship operations and freight services and known as “operators”. The interaction of the trading behavior of shipping investors with the characteristics of shipping industry results in complex dynamics of highly volatile and unpredictable asset (ship) values.

The inherent lags in capacity adjustment, through newbuildings, and response of supply of shipping fleet to expected demand for freight services have often resulted very high levels of freight and asset prices, while delays in permanent capacity retirement have led to excess supply and depressed freight market and ship prices. Kalouptsidi (2014) shows that the time lags in shipbuilding and their lengthening in periods of high investment activity lead to temporary sharp freight recoveries and hikes, along with steep increases in vessel values and price volatility. Conversely, the recovery of the markets for sea transportation and for ships is hindered by shipping’s operational flexibility; i.e. slow steaming or temporary capacity retirement of tonnage in the form of the lay-up of vessels during market downturns. Such possibilities allow to exercise a “wait-and-see” strategy and delay the clearing of the excess capacity which could come about otherwise through scrapping. In addition, dynamics of international trade, technological advances leading to operational efficiency, new regulation or environmental issues may exacerbate the fluctuation of asset values.

Throughout the post-war era banks often assumed most of the financing of vessel orders which still continued to add to the growth of the world fleet despite the economic and shipping environment of late as discussed in Puscaciu et al. (2015). In recent decades – before and after the financial crisis - tax incentives, public listings and, lately, the involvement of funds and private equity have extended the range of potential investors in shipping.[1] These may include now: i)

[1] As tax and investment incentives for shipping investment are today limited compared to the past (Gardner et al, 1996), and as the persisting ones have more relation to investment in containers and specialized shipping (outside the

Traditional shipping investors and ship-owners, ii) Large individual investors from other sectors, iii) Small investors placing savings in individual shares or in investment schemes (tax-related or not) and shipping bonds, and, finally, iv) institutional investors, hedge funds and private equity firms.

Investors in the market for ships follow different investment strategies and timing tactics for investment and divestment depending on their experiences, beliefs, and expectations regarding future ship prices. For instance, a group of investors may follow the trend in asset prices and base their investment strategy on market momentum; others may believe more in the inherent cyclicality of shipping and follow a countercyclical investment strategy (Thanopoulou, 1996) alternatively termed as "contrarian". The latter strategy involves investing when the market has declined and - in the view of contrarian investors - reached the bottom, exiting when asset prices have recovered enough to justify a reasonable return. Such a group of investors may eventually use market fundamentals - in the form of expected freight market conditions - as the basis of their investment strategy: They would invest in ships when market prices are below fundamental values (e.g. discounted present value of expected earnings) and exit when vessel prices are above fundamental values. The diversity in terms of beliefs and actions of shipping investors, combined with shipbuilding delays and resistance to retirement, can have significant impact on asset values and market dynamics such as cyclicality, volatility, and long-term trends.

The diversity in terms of beliefs and actions of shipping investors, combined with shipbuilding delays and resistance to retirement, can have significant impact on asset values and market dynamics such as cyclicality, volatility, and long-term trends. Therefore, the aim of this paper is to develop a model to explain short-term dynamics of ship prices based on heterogeneous investor behaviors and explore their impact on ship values. In this respect, firstly we classify participants in the market for dry bulk ships according to their investment strategies into momentum and contrarian (i.e. countercyclical) investors and examine the performance of each of these investment strategies against the passive, or "buy-and-hold" strategy; secondly, we define an equilibrium model for short term changes in second-hand ship prices based on the heterogeneous agent model (HAM). The HAM specification allows for defining and incorporating demand functions for

dry bulk market), the model has been constructed in its simpler form. However, this does not make the model or the market for ships less complex.

different types of investors depending on their respective expectations. Finally, we investigate the impact of investor participation on volatility of ship values. The estimation results reveal significant evidence supporting the existence of an impact of agents with heterogeneous investment behavior and of the proportion of participation of each type of investor on the dynamics of ship values.

This paper makes a number of contributions to the existing literature on shipping investment and asset pricing. First, by evaluating the performance of different investment strategies on dry bulk ships, we highlight the significance of adapting different investment policies by ship owners and operators. Second, to the best of the authors' knowledge, this is the first study to recognize investors' heterogeneous beliefs and behaviors, and incorporate such information on the formation of asset values in the market for ships. Considering that we study the market for ships, our study also contributes to the literature by investigating the theory of heterogeneous agent behavior in a market for real assets. Third, by applying the HAM to different sub-sectors of dry bulk tonnage we compare the extent of differences in the role of investors' heterogeneity across size-specific segments of the dry bulk market. This is a most competitive sector of the shipping industry and its high volatility does not elude investors either positively or negatively as indicated by distinctly different beta volatilities between main shipping segments, calculated by Drobetz et al. (2016).

The paper is structured as follows: After the introduction, section 2 presents the review of literature on shipping investment theory, investment timing and investor expectations. The structure of the HAM model and the methodology are discussed in section 3. The dataset used for empirical analysis is presented in section 4. Section 5 reports the empirical results and discusses findings, while the final section concludes.

2. Review of literature

2.1. Markets for ships: The traditional models

Traditional studies in the shipping economic literature attempt to model ship prices such as Beenstock and Vergottis (1989), Strandenes (1984), Hawdon (1978) and Haralambides et al (2004), Gkochari (2015), and Rau and Spinler (2016), among others. All these studies are based on the assumptions that ships are capital assets and reward the investors with operational revenue as well as capital gains or losses. In addition, they assume rational expectations in price formation in the sense that investors are rational profit-maximizing agents who use all the available information to their advantage for timing their investment, divestment as well as for arbitraging any inefficiency in the market. Consequently, the market for ships is assumed to be efficient.

Kavussanos (1997) compares dry bulk carrier price volatilities across sectors while Kavussanos and Alizadeh (2002) examine the efficiency of the market for dry bulk ships and find that while there are deviations from the efficient market hypothesis (EMH), such deviations could be explained by the presence of time-varying risk premia. Koekebakker and Adland (2004) argue that if the market for dry bulk ships is efficient, then trading rules based on publicly available information should not produce superior returns to a simple buy-and-hold strategy. Using a large number of technical trading rules, they report that trading rules are generally not capable of producing excess wealth over the buy-and-hold benchmark when accounting for transaction costs and the potential price slippage in an illiquid market. However, Sodal et al. (2009) examine the performance of trading rules with analytical ship valuation techniques under the assumptions of stochastic freight rates and of switching between tanker and dry bulk market investments. They report that although the market for second-hand dry bulk ships seemed to be efficient for periods, there are periods where excess profit could be made and that generally agents are slow in adjusting their expectations.

Adland et al. (2007) investigate whether the boom in the dry bulk market between 2003 and 2005 was due to rational bubbles. Using the Vector Error Correction Model (VECM) framework, they test the instantaneous equilibrium relationship between the freight market and second-hand and newbuilding prices for Capesize vessels considering the time-varying delivery lag in the newbuilding market. They report that second-hand ship values were closely cointegrated with the freight market and newbuilding prices with no evidence of a short-term asset 'bubble' in the form of prices deviating from fundamentals.

In a recent study, Kalouptsidi (2014) argues that the dynamics of the ship building industry in terms of variations in construction time-lag and changes in deliveries can impact investment levels and asset price volatility. Kalouptsidi develops a dynamic model and investigates the fluctuations in shipping markets incorporating the impact of time to build and of demand uncertainty on investment and ship prices. Using realized second-hand ship values, her empirical results suggest that reducing construction time reduces prices, but significantly increases both the level and volatility of investment. Kou et al. (2014) explore the lead–lag relationship between new-building and second-hand ship prices and report the existence of a one-directional lead–lag effect from second-hand price to new building price across different dry bulk ships. The lagged reaction of newbuilding price compared to second-hand price to market information could be due high speculative nature of this market which makes second-hand prices more sensitive compared to new-building prices.

2.2. Behavioral finance and shipping investment

Traditional asset pricing models are based on the assumption that agents are rational in the sense that they correctly process all the available information, that there are no market frictions and asset prices should reflect their fundamental values. One hypothesis based on this notion is the Efficient Market Hypothesis (EMH), proposed by Friedman (1953) and Fama (1970), postulating that rational traders very quickly exploit arbitrage opportunities and their actions remove any mispricing due to any irrational investors' actions. However, the EMH has been challenged on several fronts and alternative theories have been proposed to explain the deviation from EMH and abnormalities in the asset price and fundamental value relation. While Fama (1998) claims that any empirical results failing to support the EMH could be due to chance or even methodological deficiencies, a number of studies explain deviations from the EMH through alternative theories; these take into account investors' behavior and market structure. Shiller (2003) and Barberis and Thaler (2003) provide thorough reviews of the new theories put forward to explain the deviation from EMH. These explanations are mainly based on "*limits to arbitrage*" and "*investors' behavior or psychology*", which in general originate from the area of behavioral finance.

Jegadeesh and Titman (1993) explore profitability of a variety of momentum strategies applied to US stocks. They report that buying stocks with high returns and selling stocks with poor returns in the past produces significant excess returns over the following **3** to 12 months. In a follow up paper, Jegadeesh and Titman (2001) re-examine excess returns of momentum strategies; they relate their superior performance to behavioral models that suggest momentum profits are due to delayed overreactions which are eventually reversed as suggested by Hong and Stein (1999). Although the first part of our analysis has similarities to the one of Jegadeesh and Titman (1993) for the stock market, we apply the momentum investment strategies to a market for real assets where short selling is not possible, transactions costs are high, and the market is fully international. We also examine the contrarian investment strategy based on the difference between the actual value of the asset and its fundamental value rather than poor performance in terms of asset returns. However, we also find evidence that momentum investment strategies perform well in the market for ships.

The research on shipping markets and ships values from the perspective of the behavioral finance is sparse. Bulut et al. (2013) and Duru (2013) discuss the irrational behavior of dry cargo freight rates and argue that ship investment deviates from the optimal behavior. In particular, Duru (2013) argues that certain anomalies in the market for dry bulk ships could be due to irrational behavior of agents and investors. He proposes alternative theories to justify the behavior of investors in the market for ships in relation to what they know and what they do in practice, and its impact on asset values and ship building activity.

Papapostolou et al. (2014) use different variables which proxy market expectations, valuation, and liquidity, to construct an index reflecting the sentiment in the dry bulk market and its segments. These variables include the size of order-book, scrapping activities, second-hand and newbuilding values, and freight earnings. They report that the constructed sentiment index serves as a contrarian indicator for asset prices in all sub-sectors of the dry bulk market since asset prices generally decline after a period of high market sentiment and tend to rise after a period of low market sentiment. They also utilize the constructed sentiment index as an investment indicator, and report that investment strategies based on the constructed sentiment index can produce a superior return profile compared to the passive buy-and-hold strategy.

In a recent study Greenwood and Hanson (2015) propose a behavioral model for shipping investment which is based on inefficiency in investors' anticipation of changes in demand and supply, leading to overinvestment and excess variation in investment returns. Greenwood and Hanson (2015) argue that investors over-extrapolate exogenous demand shocks and partially neglect the endogenous investment response of their competitors. These modest expectations errors generate excess volatility in investment and prices while heavy investments during booms depress future earnings. This is in line with earlier hypotheses on the nature of expectations and their role in the inherent shipping market instability by Zannetos (1966) and with the essence of the cobweb theorem (Ezekiel 1938). Cobweb is applicable to competitive markets where exogenous shocks combine with lags in supply adaptation rendering - depending on supply and demand elasticities - the resulting instability even explosive.

2.3. Heterogeneous Agent Behavior

Following the seminal works of Kahneman and Tversky (1979) and Kahneman, Slovic and Tversky (1982), a large number of studies in the financial economics literature investigate the role of investors' heterogeneous beliefs and psychology in relation to speculative trading and investment behavioral biases. Such beliefs and behavioral elements may be overconfidence, optimism, anchoring, availability bias, herding, etc. as discussed in detail in Hirshleifer (2001), Shiller (2003), Barberis and Thaler (2003) and Hommes (2006) who provide excellent reviews of concepts and theories of investors' behavior.

Models capturing investors' beliefs and behavior are proposed by Brock and Hommes (1997 and 1998), Biais and Bossaerts (1998), Hong and Stein (1999), Scheinkman and Xiong (2003) and Palfrey and Wang (2012), amongst others. For instance, Palfrey and Wang (2012) propose a model for speculation in multi-period asset markets based on heterogeneous agent behavior. They argue that speculation is the result of traders' heterogeneous inferences on sequential information arrival leading to overpricing, which in turn leads to the asset price exceeding the most optimistic belief about its real value. This is consistent with the perennial "endemic tendency to overinvest" in shipping, a term coined by Metaxas (1971). In other words, it can be argued that active participation of speculators in the market for merchant ships and their investment strategies can lead to development of transitory and periodically collapsing asset price bubbles in the ship market.

The HAM has also been applied to investigate heterogeneous investors' beliefs and explain the dynamics of commodity prices. For example Baak (1999) and Chavas (2000) provide evidence on the heterogeneity of agents' expectations in agricultural commodities. Westerhoff and Reitz (2005) examine the impact of technical traders on US corn futures, while Reitz and Westerhoff (2007), Reitz and Slopek (2009) and Ter Ellan and Zwinkels (2010) examine the role of speculators in the oil market. In particular, Ter Ellan and Zwinkels (2010) adopt HAM to analyze the presence of investors with different beliefs and behavior in the crude oil futures market. They conclude that crude oil prices, at least partially, are determined by the various price expectations of the heterogeneous agents and, while fundamentalist investors' actions have a stabilizing effect on the market, chartists' investment strategies have a destabilizing effect on oil prices.

In a recent study, based on heterogeneous agent behavior, Lof (2015) supplements the standard Vectors Autoregression and present value model of Campbell and Shiller (1987 and 1988), which relates stock prices to expected dividends, with the existence of speculative agents who have different investment behavior. Lof assumes three types of agents - namely, fundamentalist, rational speculators, and contrarians - interacting in the market. The agents adjust their investment according to the evolutionary selection suggested by Brock and Hommes (1998) and the fraction of each type of agent increases when its predictions outperform the other types. Lof (2015) reports that the incorporation of heterogeneous agent behavior dramatically increases the explanatory power of the Vectors Autoregression and present value model of Campbell and Shiller (1987 and 1988), especially in explaining some of the most volatile episodes including the 1990s bubble, which can be considered evidence against the existence of a rational bubble.

3. The Heterogeneous Agent Model

The starting point in our model is the assumption that in terms of investment motives there are two basic types of investors in shipping markets: Speculators and Operators. This is close to what is believed to be the composition of investors in the shipping industry. Speculators (or "asset players" in industry terms) are defined as those investors whose main objective is to achieve capital gains. Speculators invest in ships when they believe ship prices will increase or increase further, with a view to reselling the asset. In contrast, operators are those investors in ships whose main objective is to generate returns through operating these vessels in the freight market. Although speculators may also operate the acquired ships over the holding period, their main goal is to benefit from changes in the asset values.

As with all investors, asset players in shipping markets can follow different investment strategies and have different investment horizons. However, generally and for the purposes of our analysis we can classify speculative investors in shipping into *momentum* and *contrarian* investors. The former group tends to follow the trend investing in ships when they see a period of growth in ship prices. This class of investors can also include those who follow others, which are known as “herders” due to their herding behavior. In contrast, the second group of speculators who follow contrarian strategies, try to follow market fundamentals and invest in ships when they *believe* asset prices are at their lowest level (below their fundamental values) and are bound to recover in the future and divest when asset prices are at peak (above the fundamental values).[2]

Assuming the demand for holding second-hand ships by speculative investors who follow the momentum in the market is based mainly on the expected price change (return) in vessel value, we can write

$$D_t^M = f\left(E_t^M\left(\Delta P_{t+1}\right)\right) \tag{1}$$

where D_t^M is momentum investors’ demand for assets, and $E_t^M\left(\Delta P_{t+1}\right)$ is the expectation formed by the momentum investors at time t about the change in asset prices in the next period. Further, we assume that speculators, who follow the market momentum to identify the trend in the market, invest when there is a positive trend and exit when the trend becomes negative. Therefore, momentum investors form their expectations about future prices based on changes in vessel values (or some other momentum indicators [3]) over the past *k* periods (e.g. *k*=6, 12, or 24 months); hence we can write

$$E_t^M\left(\Delta P_{t+1}\right) = \alpha_1\left(\Delta^k P_t > 0\right)^+ + \alpha_2\left(\Delta^k P_t < 0\right)^- \tag{2}$$

[2] Although, it could be possible that investors may switch between the two strategies at different points in time according to their beliefs, we do not consider such switching. However, the model is flexible enough to change the weight of demand by each type of investor depending on the profitability of each investment strategy.

[3] In reality, momentum investors may follow many different indicators for identifying the price momentum. Some of these indicators may be based on different market variables, such as freight rates and earnings, slope of FFA curve, trading volume, newbuilding orderbook, second-hand and scrap price differential, amongst others. Here we use the simplest indicator based on the sum of second-hand price changes and freight earnings over a period of time which indicate the direction of the market.

where α_1 and α_2 are positive constant coefficients, $\Delta^k P_t = \sum_{i=0}^{k} \Delta\ P_{t-i}$ indicates price changes over the past k period, while $\left(\Delta^k P_t > 0\right)^+$ signifies that a positive price change is expected following a positive k period price increase, and $\left(\Delta^k P_t < 0\right)^-$ indicates that a negative price change is expected following a negative k period of price decline.

Contrarian investors tend to follow shipping cycles - themselves unpredictable - to identify investment timing. In other words, they tend to base their decision on market fundamentals believing that ship values should reflect the expected supply-demand balance for freight services and that they are mean reverting. Contrarian investors compare prevailing vessel prices with fundamental values and form their expectations about the probable rise or fall in vessel prices accordingly. In principle, they expect prices to increase in the next period, if the current fundamental value is above the current market value, and prices to drop in the next period, if the current fundamental value is below the current market value. Thus, the demand function for contrarian investors can be written as

$$D_t^C = f\left(E_t^C\left(\Delta P_{t+1}\right)\right) \tag{3}$$

where again D_t^C is the contrarian investors' demand for assets, and $E_t^C\left(\Delta P_{t+1}\right)$ is the expectation formed by the momentum investors at time *t* about the change in asset prices in the next period. Assuming vessel values follow a mean reverting process, perhaps with a trend in the long run, we can set up a simple model of trading behavior of the fundamentalist speculators based on the deviation of the asset value from its long run mean as

$$E_t^C\left(\Delta P_{t+1}\right) = \beta_1 \left(F_t - P_t\right)^+ + \beta_2 \left(F_t - P_t\right)^- \tag{4}$$

where, F_t is the value of the vessel based on fundamentals at time t, β_1 and β_2 are positive constant coefficients, $(F_t - P_t)^+ = (F_t - P_t)$ if $(F_t - P_t) > 0$, and zero otherwise, and $(F_t - P_t)^- = (F_t - P_t)$ if $(F_t - P_t) < 0$, and zero otherwise.[4]

Finally, *operators* in the shipping markets can be classified as consumers of the asset since their main purpose for investing in ships is to obtain income and profits from their use in charter servicing. However, their expectations will come into play in a similar manner as those of speculators, although boundaries to buying prices may be deemed to lower their demand assuming they are more conservative than speculators. We assume that operators' demand is a negative and linear function of vessel value in the following form

$$D_t^O = \gamma_0 - \gamma_1 P_t \tag{5}$$

where again D_t^O is operators' demand for assets, and γ_0 and γ_1 are constant coefficients. At any point in time the sum of all the demand functions should be equal to the stock of fleet, S_t; however, the proportion of demand from each type of investors changes according to their expectations about future ship prices. Therefore, the total market demand for second-hand ships can be written as the sum of real demand from operators and the weighted average of the speculators' demand.

$$D_t^T = W_t^M D_t^M + W_t^C D_t^C + (1 - W_t^M - W_t^C) D_t^O \tag{6}$$

Where W_t^M and W_t^C are the proportion of demand for ships by momentum and contrarian investors respectively, subject to $0 < W_t^M < 1$, $0 < W_t^C < 1$, and $(1 - W_t^M - W_t^C) = W_t^O$ represents the proportion of demand by operators. At the same time, each group of investors adjusts demand according to expectations on vessel price movement. Thus, the investment share of momentum and contrarian

[4] Once again, contrarian investors may follow a variety of indicators for identifying the right moment to invest or exit including variables such as current earnings relative to long term average earnings, second-hand and scrap price differentials, the slope of FFA curve and many others. Here, in line with the literature (e.g. Ter Ellen and Zwinkels, 2010), we use a moving average of second-hand prices over the past k periods as the simplest proxy for fundamental value. Further, the difference between the current second-hand price and the long run average price is considered as an indicator observed by fundamentalist investors.

investors can be written as a logistic function of variables used in formation of their respective expectations.

Assuming a competitive market for second-hand ships, the change in price could be defined by aggregate supply-demand balance for second-hand ships, which can be written as

$$\Delta P_{t+1} = \theta\left(D_t^T - S_t\right) + \varepsilon_t \tag{7}$$

Furthermore, the supply for second-hand ships is constant at any point time as the number of vessels in the fleet is fixed at that point in time, . Any adjustment to the size of the fleet will be $S_t \equiv S$, due to ship building and scrapping activities which normally take a considerable period of time (more than one year for shipbuilding). Thus, it is fair to assume that in the short term, changes in second-hand ship prices are dependent on changes in demand for second-hand ships which itself is dependent on expectations formed by participating agents on the future direction of ship values. Therefore, substituting the total demand function of equation (6) in equation (7) and assuming supply is constant, we can write

$$\Delta P_{t+1} = \theta\left(W_t^M D_t^M + W_t^C D_t^C + (1 - W_t^M - W_t^C) D_t^O - S\right) + \varepsilon_t \tag{8}$$

Equation (8) specifies a model for changes in second-ship values conditional on demand from different types of investors who have dissimilar beliefs and investment strategies, while W_t^M , W_t^C and W_t^O can be considered as time-varying parameters representing demand by each investor type. The complete empirical model for equation (8), can be written as

$$\begin{cases} \Delta P_{t+1} = \theta_0 + W_t^M D_t^M + W_t^C D_t^C + \theta_1 p_t + \varepsilon_t \\ D_t^M = \left(\alpha_1 \left(\Delta^k P_t\right)^+ + \alpha_2 \left(\Delta^k P_t\right)^-\right) \quad ; \; W_t^C = 1 \Big/ \mu_0 \left(1 + e^{-\mu_1((1/k)\sum_{i=1}^{k} P_{t-i} - P_t)}\right) \\ D_t^C = \left(\beta_1 (F_t - P_t)^+ + \beta_2 (F_t - P_t)^-\right) \; ; \; W_t^M = 1 \Big/ \eta_0 \left(1 + e^{-\eta_1 \sum_{i=0}^{k-1} \Delta P_{t-i}}\right) \end{cases} \tag{9}$$

Equation (9) can be estimated using Maximum Likelihood estimation technique, subject to the constraint, and the time-varying proportion of investment demand by each investor type (W_t^M, W_t^C and W_t^O) can be obtained.

Having defined the interest of each investor type at any point in time, the estimated investment interest variables can be used to assess the impact of the participation of each type on the dynamics of prices and the volatility of ship values. In this setting, the proportions of investment by each type of investors, W_t^M and W_t^C are used as explanatory variables in the mean and variance equations of the EGARCH-X model[5]

$$\Delta p_t = \lambda_0 + \lambda_1 z_{t-1} + \varepsilon_t \qquad ; \qquad \varepsilon_t \sim \text{iid}(0, \sigma_t^2, v) \tag{10}$$

$$\sigma_t^2 = \exp\left(\phi_0 + \phi_1 \frac{|\varepsilon_{t-1}|}{\sigma_{t-1}} + \phi_2 \frac{\varepsilon_{t-1}}{\sigma_{t-1}} + \phi_3 \ln \sigma_{t-1}^2 + \phi_4 z_{t-1}\right)$$

where z_{t-1} represents the proportion of investment by each type of investor W_t^M and W_t^C. In the above EGARCH-X specification, estimated coefficients of λ_z and ϕ_z measure the effect of investors' participation on changes in ship values and volatilities, respectively. In addition, the estimated coefficient of ϕ_1 measures the asymmetric impact of shocks with different magnitude on

[5] Because of high negative correlation between W_t^M and W_t^C, we do not use both variables in the same equation to avoid the problem of multicollinearity.

ship price volatility; the ϕ_2 coefficient captures the asymmetric impact of shocks with different signs on ship price volatility. Furthermore, the use of EGARCH specification ensures that the non-negativity constraints on the parameters of the model are not violated and the use of student-t distribution with v degrees of freedom allows for deviation from normality and fat tails.

4. Description of data

For this study, monthly prices for second-hand 5-year old ships are collected for three different size dry bulk ships (Capesize, Panamax and Handysize)[6] from Clarkson's Shipping Intelligence Network (SIN) covering the period from January 1991 to December 2016. All prices are quoted in million dollars and represent the average value of "standard vessels" traded in each category in any particular month.[7] In shipping, operating profits is be defined as the time-charter equivalent (TCE) of spot rates when a vessel is operating in the spot market, minus operating costs. In this study, we use average earnings or time-charter equivalent of spot rates as a proxy for earnings. Monthly earnings for different types of dry bulk vessels over the period January 1991 to December 2016 are also obtained from Clarkson's Shipping Intelligence Network. [8]

Table 1 reports descriptive statistics of levels and logarithmic first differences of second-hand prices (P and Δp), as well as operational earnings (TCE) and operating profit as a percentage of price (Π^*) for Capesize, Panamax and Handysize vessels. [9] The results indicate that the mean levels

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[6] Three vessel categories are distinguished in dry bulk tramp shipping: Handysize vessels (around 32,000 dwt) are mainly engaged in transportation of a variety of dry bulk commodities including grain, bauxite and alumina, fertilizers, rice, sugar, and many others, around the world. Panamax vessels (around 76,000 dwt) are used primarily in coal and grain and to some extent in iron ore transportation. The majority of the Capesize (around 180,000 dwt) fleet is engaged in transportation of iron ore and coal. There is a negative relationship between vessel size and operational flexibility in dry bulk shipping. This is because smaller vessels can be used for the transportation of a large number of commodities and over many more routes compared to larger vessels, which are mainly involved in the transportation of a limited number of commodities over fewer routes,

[7] Monthly vessel values are assessed and published based on the average of transactions for "standard type vessel" (explained in footnote 6) provided by a panel of sale & purchase brokers in a particular month, if such vessels are traded, or the best assessments of price of such vessels by the panel.

[8] All prices and freight rates are not inflation adjusted as it is normal and well accepted to use nominal rather real values in the analysis of shipping markets. This is because of two reasons. Firstly, it is more common to inflation-adjust financial assets but not real assets such as ships. Secondly, due to the high cyclicality and volatility of shipping freight rates and ship values (as much as 150% in freight and 60% in ships values), inflation is not considered to be a significant factor.

[9] Operating profits are calculated as the difference between monthly earnings and operating expenses for each month the vessel is in the portfolio. Monthly TCE earnings are estimated on the assumption that the vessel will be on-hire 29 days per month or 348 days per year. The remaining 17 days per year represent off-hire time for repairs and

of prices for larger vessels are higher than for smaller ones. Unconditional volatilities of prices (standard deviation) also follow a similar pattern i.e., prices for larger vessels fluctuate more than prices for smaller vessels. Jarque and Bera (1980) find significant departures from normality for TCE earnings and price returns in all markets, while price levels for all size classes seem to be normally distributed. The Ljung and Box (1978) LB-Q statistics for 12th order autocorrelations in levels and logarithmic first differences of earnings are all significant, indicating that serial correlation is present in all price and profit series.

Panels A, B and C of Figure 1 present the historical prices second-hand prices and operational earnings for 5 year old Capesize, Panamax and Handysize dry bulk ships, respectively. It can be seen that while prices and earnings move together in the long run, they tend to vary over time and under different market conditions. In addition, comparison of behavior of prices and earnings across different vessel sizes reveals that earnings seem to have higher fluctuations than second-hand prices for all three categories of dry bulk ships. Furthermore, second-hand ship prices and operational earnings follow similar long run trends across the three bulk carrier segments. This is because not only the three dry bulk markets are related through the world economic activity and seaborne trade, but they are partially inter-substitutable and linked.

5. Empirical results

The first stage of the analysis involves assessing the performance of momentum and contrarian strategies which are assumed to be used by investors in the dry bulk market. The momentum strategy is based on a simple rule which assumes a "buy" signal when price changes or returns over the past *k* periods (e.g. *k*=6, 12, and 24 months) exceed α%, and a "sell" signal when price change over past *k* periods is less than -α%.[10] Following Alizadeh and Nomikos (2007) we use changes in earnings to construct the momentum indicator based on the same momentum rule. For the contrarian investment rule, we consider the moving average of the vessel price over the past *k*

maintenance. We consider flat operating expenses of $6,000, $5,500 and $5,000 per day for Capesize, Panamax and Handysize vessels, respectively. These figures reflect the average operating costs of ships across the industry for each vessel and are in line with what is reported by Drewry Maritime Research (Ship Operating Cost: Annual Review and Forecast 2011 to 2015)

[10] The momentum indicators on price and earnings (y) are constructed as: $I_t^M = \sum_{i=0}^{k} \Delta y_{t-i}$ where Δy_t are changes in price or earnings (k= 6, 12 and 24 months).

period (e.g. *k*=6, 12, and 24 months) as fundamental value and use the difference between the actual price and the fundamental value at any point of time as the investment indicator.[11] Under this strategy, a "buy" signal is triggered when the actual value is α% below the fundamental value, and a "sell" signal when the actual value is α% above the fundamental value. It should be noted that since there is no possibility of short-selling in this market where real assets are traded, investors can only take long positions and invest in T-Bills when the funds are not invested in ships. The choice of 6, 12 and 24 months is deemed appropriately representing a range from the very short term to a reasonably longer time-horizon but also matches the range of holding periods of buy-to-sell transactions as witnessed during the previous shipping cycles (Thanopoulou, 2010).

To estimate the return on investment under each strategy, we consider both the return on vessel value and operational earnings during the holding period. Also, in assessing the performance of different investment strategies, we consider transaction costs (2% per transaction), as well as the 6%pa depreciation in the value of the vessel, equivalent to 0.5% per month.[12] It should also be noted that the proposed strategy is structured and implemented in a way that is entirely forward looking, i.e. investment decisions at any point in time are decided on the basis of information available to investors at that specific point in time. This way we provide a more realistic and accurate representation regarding the performance of the trading strategies.

The results of comparison of performance of alternative investment strategies in the form of annualized average return, standard deviation of returns, Sharpe Ratio of investment strategy, and the utility function for Capesize, Panamax, and Handysize vessels are presented in Tables 2 to 4, respectively. The Sharpe Ratio for each investment strategy is computed as the ratio of the average returns to the Standard Derivation (StDev) of the strategy. The utility function is computed as the difference between average return and the weighted variance according to the coefficient of risk aversion ($U_{i,j} = \bar{r}_{i,j} - \lambda\sigma^2_{i,j}$), where $U_{i,j}$ is the computed utility value for strategy *j* in sector *i*,

[11] The contrarian indicators on price and earnings (y) are constructed as: $I^C_{t} = \ln\left(\sum_0^k \Delta y_{t-i} / \Delta y_t\right)$ with k=6, 12, and 24.

[12] Transaction costs are incurred every time a buy or sell decision is implemented; these typically come in the form of brokerage commission for the sale & purchase as well as legal, registration and other admin fees. Depreciation represents the reduction in the value of the vessel due to wear-and-tear each month the investor holds the vessel in her/his portfolio. In this study we assume 6% annual deprecation rate estimated as the average decline in the value between a 5-year old and a 10-year old vessel.

while $\bar{r}_{i,j}$ and $\sigma^2_{i,j}$ is the average return and variance of investments strategy *j*, in sector *i*, and λ is the constant coefficient of risk aversion assumed to be 4.

The comparison of the results of trading strategies for the Capesize market, reported in Table 2, reveals some interesting points. For each strategy, the average and standard deviation of returns, Sharpe Ratio, the bootstrapped p-value of excess Sharpe Ratio, and utility function are reported. For instance, comparison of average returns suggests that momentum trading strategies produce superior results than the buy-and-hold passive investment rule when the short-term (6 and 12 months) earnings are considered as a momentum indicator. The average returns of momentum investment strategy - based on a 6 months' move in the market and 10%, 25%, and 40% trigger thresholds - are 14.10%, 11.76%, and 11.29%, respectively, with Sharpe Ratios of 0.895, 0.743 and 0.737. Similarly, the average return on momentum investment based on 12 months' move in the market are 14.43%, 14.34%, and 13.48%, respectively, with Sharpe Ratios of 0.917, 0.879 and 0.854. This is compared with an average return of 7.23% and a Sharpe Ratio of 0.287 for the static buy-and-hold strategy. However, the momentum strategies based on vessel values do not seem to outperform the buy-and-hold strategy. Contrarian investment strategies seem to work better when indicators are based on ship values with a longer time lag (e.g. 24 months). For instance, the average returns for 10%, 25%, and 40% trigger levels are 4.91%, 2.51% and 4.26%, respectively. Although, the average returns are lower than the buy-and-hold strategy, the computed values of Sharpe Ratios as risk-adjusted returns are 0.391, 0.294, 0.819 in comparison to 0.287 for the buy-and-hold strategy. Moreover, the values of the utility function for the three trigger levels increase to -0.0140, -0.0042, and 0.0318, in comparison to the buy-and-hold rule utility value of -0.1818.

In order to statistically verify the performance of investment strategies, we perform a bootstrap exercise and compare the Sharpe Ratio of different investment strategies with the buy-and-hold one. In this respect, we use the stationary bootstrap technique of Politis and Romano (1994) to regenerate random samples for price and earnings while retaining their time-series properties.[13]

[13] The stationary bootstrap procedure is based on re-sampling blocks of random length from different locations of original sample. This procedure generates random samples which preserve the serial dependence property of the original series and are also stationary. This is important since vessel prices and earnings show significant correlation and well as autocorrelation. The stationary bootstrap is performed using 100 regenerations of price and earnings samples, and implementing the trading strategies. The robustness checks used in the paper follow the same approach as Brock et al. (1992), Levich et al. (1993), Sullivan et al. (1999), and Alizadeh and Nomikos

We then implement the proposed investment strategies on the simulated price and earnings series and obtain the returns and Sharpe Ratios. The difference between the simulated Sharpe Ratios of any investment strategy and the buy-and-hold strategy is tested using a Diebold and Mariano (1995) approach under the null that the Sharpe Ratios of an investment strategy are less than the Sharpe Ratios of the buy-and-hold. The results, also presented in Table 2 for the Capesize market as p-values of the bootstrapped tests, clearly indicate that momentum investment strategies - based on 6 and 12-month changes in earnings - significantly outperform the passive investment rule; contrarian strategies based on long term (24 months) price variable and a higher trigger level (40%) perform better than the buy-and-hold rule.[14]

The empirical results of the momentum and contrarian investment strategies applied to Panamax and Handysize vessels, presented in Tables 3 and 4 respectively, are very similar to those for the Capesize market. Once again, momentum investment strategies tend to yield superior results when short-term (6 and 12 months) momentum indicators - on the basis of operational earnings - are used, while contrarian strategies produce marginally better results on the basis of longer term (24 month) indicators based on vessel prices. For instance, in the case of the Panamax market, the average returns of the momentum trading rules, based on 6-month changes in the market and 10%, 25%, and 40% trigger thresholds, are 10.84%, 8.89%, and 6.10%, respectively, with Sharpe Ratios of 0.769, 0.617 and 0.396 compared to the buy-and-hold strategy which yields an average return of 2.05% with a Sharpe ratio of 0.078. The contrarian strategy, based on the 24- month price indicator yields average returns of 2.71%, 3.13%, and 4.27% - for 10%, 25%, and 40% threshold triggers, respectively - with corresponding Sharpe ratios of 0.230, 0.336, and 0.844 compared to the Sharpe ratio of 0.078 for the passive buy-and-hold strategy.

Having obtained the information on the performance of momentum and contrarian strategies, we estimate next the HAM of equation (9) to investigate the involvement and demand of investors with different investment strategies in each of the dry bulk sub-markets. The equation is highly non-linear, therefore the maximum likelihood method is used to estimate the coefficients; results are reported in Table 5. Diagnostic test results for autocorrelation and ARCH indicate that the

(2007), being currently the state of the art technique to assess the profitability of trading rules and strategies in the literature. The technique is based on the repetition of the investment rule using bootstrapped random samples which are regenerated from the original sample data and retain the properties of the initial sample. Regression based robustness tests are used for forecasting evaluation exercises and asset pricing models.

[14] Detailed bootstrap results are not presented here but available from the authors on request.

models are well specified. The adjusted R-squared of 21.9%, 21.7% and 12.3% for the Capesize, Panamax, and Handysize sectors respectively, indicate that the investment behavior of agents can explain a higher proportion of variation in price of larger vessels compared to smaller vessels. In other words, the market for larger vessels could be more influenced by investment activities of agents compared to the market for smaller dry bulk ships. Estimated coefficients of the constant of the regression, θ_0, are all positive and significant across all models indicating an average growth in value of 5-year old ships over the sample. Negative and significant coefficients of lagged log price, θ_1, are consistent with the theoretical model, where demand is negatively related to price (operators' demand function; equation 5). According to the proposed HAM model, the scaling coefficients of investors' demand functions, α_1, α_2, β_1 and β_2, reflecting the importance of the indicator (I) for each investment strategy, should all be positive. The estimated coefficients of α_1, α_2, β_1 and β_2 are all positive and significant, with the expectation of α_2, β_1 in the Capesize model and α_2 in the Panamax and Handysize models. In general, the significance of α_1 and β_2 across all three vessel size suggests that a market upturn is more important to momentum investors while market downturn is more relevant to contrarian or fundamental investors. The estimated coefficients of μ_0, μ_1, η_0 and η_1 in the logistics function - explaining the dynamics of demand by each investor type - are all positive and significant across all vessel sectors, with the exception of μ_1 for the Handyszie equation.

The historical values of these functions along with vessel prices are illustrated in Figure 2 panels A, B, and C for Capesize, Panamax and Handysize dry bulk ships, respectively. There are several comments that can be made at this point. Firstly, it can be seen that for all ship sizes, as expected, the demand from momentum and contrarian investors tends to move in opposite direction. Secondly, operators' and contrarian investors' demand seems to move in the same direction as both investor categories tend to base their demand for vessels on fundamentals, rather than on market momentum. Thirdly, although the dynamics of these demand functions seem to be similar across different shipping sectors over time, nevertheless they present differences in the short term due to specific supply, demand and price dynamics within each sector. As shown in Figure 1, second-hand ship prices follow similar trends across the three bulk carrier segments. This is because the three dry bulk markets are related, as dry bulk ships of different sizes are partially inter-substitutable. Finally, it can be seen that during the shipping market boom of 2003 to 2008 and prior to the 2008 crash, there is a significant demand from momentum investors across all these markets which led to very high ship values and excessive price volatilities. Whereas after the 2008 collapse of the market and over the recession period afterwards, there seems to be more interest from contrarian and fundamental (operator) investors.

Furthermore, we examine the effect of the participation of investors with different investment behavior on ship values and volatility by estimating equation (10) over the sample period from January 1991 to December 2014. The estimation results of the model for different size dry bulk ships, reported in Table 6, reveal several interesting points. First, negative and significant coefficients of lagged participation level by contrarian inventors in the mean equations suggest that as contrarian investors increase their investment share, vessel prices tend to fall, whereas their exit marks ship price increases. Similarly, the positive estimated coefficients of lagged participation of momentum investors in the mean equation (although only significant in the Capesize market) suggest that an increase (decrease) of interest for investment by momentum investors can lead to an increase (decrease) in ship values. In addition, negative and significant coefficients of lagged participation level by contrarian investors in the variance equations for the Panamax and Handysize markets suggest that, when contrarian investors increase their investment share, the volatility of vessel prices tends to fall, whereas their exit marks an increase in ship price volatility. Finally, positive and significant coefficients of lagged participation of momentum investors in the variance equations for Panamax and Handysize markets, suggest that an increase (decrease) of interest for investment by momentum investors can lead to an increase (decrease) in ship price volatility. In terms of magnitude and the economic significance of the results, we can infer that everything else being constant, every 1% increase in demand for ships by momentum investors, the volatility of Capesize, Panamax and Handysize vessels is expected to increase by 0.6650%, 0.1818% and 02329%, respectively. Performing same for the contrarian investors - again with everything else being constant - every 1% increase in demand for ships by contrarian investors, is expected to decrease the volatility of Capesize, Panamax and Handysize vessels by -0.5724%, -0.1989% and -0.1280%, respectively. These figures also point out to the possibility that the volatility of prices for larger vessels are more sensitive to the dynamics of investors' demand than price volatility of smaller vessels, which is consistent with what is reported in Kavussanos (1996).

These findings are somewhat expected and observed equally in the market for dry bulk ships over the past decade. In particular, one can recall the extraordinary shipping market conditions from

2003 to 2008, which attracted significant interest and demand from momentum investors and excessive shipbuilding activities across all shipping markets and led to very high ship values as well as high price volatility. However, after the 2008 collapse of the market and over the recession period afterwards, there seems to be more interest from contrarian and fundamental (operator) investors, amongst which are now private equity firms also which believed asset prices to be undervalued and pointing to the right time to invest in ships.

Some unique institutional factors differentiate the ship market from other asset markets: Firstly, this is a market where real assets are traded and investors may follow different investment strategies or have different goals (e.g. asset play against operations). Secondly, ships are very expensive assets therefore their sale and purchase is always a critical decision in the shipping industry and availability of finance is a key factor in investment and divestment decisions. Thirdly, shipping related data are freely available and accessible, thus, investors operate under minimal information asymmetry in the market for ships. Differences in investors' behavior could be more due to investors' psychology and to the role of different investor beliefs than to lack of information. Hence, the HAM proves a good tool for explaining dynamics of prices for second-hand vessels, as different types of investors with different objectives and strategies exist in the market for dry bulk ships.

6. Conclusions

We have considered two major heterogeneous investor groups in the second-hand ship markets, and found that the vessel prices can be dynamically modeled by a HAM. Our analysis has shown that, in general, momentum strategies produce significantly superior results when indicators are based on short term measures of earnings, whereas contrarian strategies seem to produce marginally better results when longer term indicators - based on vessel values - are considered. Results provide further evidence on the existence of two basic investment strategies in the international dry bulk market, adding to the growing body of research based on a HAM; the latter proves suitable for the market for ships which is marked by excessive fluctuations. In addition, the results show that the participation of investors with different beliefs and investment strategies can have significant impact on ship values and their volatility over time. In particular, an increase in the participation of momentum investors tends to increase price volatility, whereas higher demand from contrarian investors seems to lower price variability. This has implications for ship-value modeling as well as theoretical implications for further research.

We performed the analysis under a very limited number of investments strategies, while the number of strategies and tactical asset allocations which shipping investors may follow under the HAM can be wide-ranging. Hence, further research on the extent of the influence of past returns on strategy selection in shipping - as investigated for example for the financial markets by Boswijk et al. (2007) - is one intriguing direction that the present research opens. Moreover, the lack of consistent long data series for some medium and smaller tonnage sizes - as Kamsarmax and Supramax- limited the research to the segments for which consistent data were available on a long term basis. Finally, the creation of a sentiment index introducing an appropriately weighed measure of the impact of heterogeneous agent beliefs on the market for ships may prove a more complex research problem but would equally contribute to the understanding and modeling of this market.

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Appendix 1

Description and source of variables used in the analysis.

Variable	Description	Source	Period
Vessel values	5-year old second-hand vessel values for Capesize, Panamax and Handysize dry bulk ships	Clarksons Shipping Intelligence Network	January 1991 to December 2016
Freight Earnings	Average spot earnings in $ per day (time-charter equivalent) for Capesize and Panamax vessels and 6-month time-charter rates for Handysize ships	Clarksons Shipping Intelligence Network	January 1991 to December 2016
US TBill	3-month US Tbills	Federal Reserve Bank of St Luis website	January 1991 to December 2016
Operating Costs	Average of the reported OPEX by Drewry (Ship Operating Cost: Annual Review and Forecast 2011 to 2015). Average values of $5000/day, $5500/day and $6000/day for Handysize, Panamax and Capesize ships, respectively.	Drewry Maritime Research	2000 to 2015
Depreciation	The average difference between the price of 5 and 10 year old ship (6%pa) calculated based on Clarksons SIN data.	Clarksons Shipping Intelligence Network	January 1991 to December 2016

Appendix II

Bootstrap test for evaluation of investment strategies

The stationary bootstrap technique used to test the significance of investment strategies follows Brock et al. (1992), Levich et al. (1993), Politis and Romano (1994), Sullivan et al. (1999) and Alizadeh and Nomikos (2007). The description of the algorithm here follows from Appendix C of Sullivan et al. (1999) and Alizadeh and Nomikos (2007).

The stationary bootstrap is calculated as follows: Given the original sample of T observations, X(t), t = {1,…,T} , we start by selecting a "smoothing parameter", $q = q_T$, $0 < q_T <= 1$, $Tq_T \to \infty$ as $T \to \infty$, and then form the bootstrapped series, $X(t)^*$, as follows:

1. At t = 1, select $X(1)^*$ at random, independently and uniformly from {X(1),…,X(T)}. Say for instance that $X(1)^*$ is selected to be the Jth observation in the original series, $X(1)^* = X(J)$ where 1 . J . T .
2. Increment t by 1. If t > T, then stop. Otherwise, draw a standard uniform random variable U independently of all other random variables
    a. if U < q, then select $X(2)^*$ at random, independently and uniformly from {X(1),…,X(T)}
    b. if U > q, then expand the block by setting $X(2)^* = X(J+1)$, so that the $X(2)^*$ is the next observation in the original series following X(J). If J+1 > T, then reset J + 1 to 1, so that the block continues from the first observation in the sample.
3. Repeat step 2 until we reach $X(T)^*$
4. Implement the investment strategies including buy-and-hold, calculate the return, standard deviation of returns and Sharpe ratio for each investment strategy, and save the results
5. Repeat steps 1-4, 100 times to obtain 100 mean return, standard deviation of return and Sharpe ratios
6. Apply the Diebold and Mariano (1995) type test by regressing the difference in the Sharpe ration of an investment strategy and the buy-and-hold strategy.

Therefore, the stationary bootstrap re-samples blocks of varying length from the original data, where the block length follows a geometric distribution, with mean block length 1/q. In general, given that $X(t)^*$ is determined by the Jth observation X(J) in the original series, then $X(t+1)^*$ will be equal to the next observation in the block X(J+1) with probability 1-q and picked at random from the original observations with probability q.

Table 1: Descriptive statistics of price (P) and operational earnings for different size dry bulk ships

	Mean	S.D.	Skew.	Kurt.	J-B	LB-Q(12)
Capesize						
Second-hand Prices P ($m)	44.580	27.562	2.446	9.180	745.67	2424.1
Operational Earnings Π ($m)	0.863	0.938	2.386	9.340	756.90	1789.2
Log price change Δp (%)	-0.010	0.239	-2.621	27.340	7440.45	62.9
Operating Profit Π* (%)	0.144	0.035	0.926	3.750	47.95	1407.0
Panamax						
Second-hand prices P ($m)	27.288	16.064	2.330	8.680	648.98	2355.8
Operational Earnings Π ($m)	0.444	0.389	2.314	8.430	610.91	1852.5
Log price return Δp (%)	-0.012	0.255	-4.534	52.150	29981.90	54.1
Operating Profit Π* (%)	0.093	0.024	1.151	4.150	79.69	1651.6
Handysize						
Second-hand prices P ($m)	18.470	8.717	1.941	7.400	414.13	2538.5
Operational Earnings Π ($m)	0.316	0.206	2.453	9.310	767.50	2075.1
Log price return Δp (%)	-0.006	0.203	-4.599	53.960	32186.32	42.1
Operating Profit Π* (%)	0.085	0.018	1.091	3.850	65.89	2112.6

- Sample period is January 1991 to December 2016, 312 observations.
- Operating profit is calculated as the ratio of operational earning minus operating cost by vessel price, $\Pi^* = \left((\Pi - OC)/P\right)$ in percentage. Mean and standard deviation of log price change and operating profits are annualized.
- Skew and Kurt are the estimated centralised third and fourth moments of the data, denoted $\hat{\alpha}_3$ and $(\hat{\alpha}_4 - 3)$, respectively. Their asymptotic distributions, under the null, are $(\sqrt{T}/6)(\hat{\alpha}_3) \sim N(0,1)$ and $(\sqrt{T}/24)(\hat{\alpha}_4 - 3) \sim N(0,1)\ \sqrt{T}/24(\hat{\alpha}_4 - 3) \sim N(0,1)$.
- J-B is the Jarque - Bera (1980) test statistics for normality; it is $\chi^2(2)$ distributed, with 5% critical value of 5.99.
- LB-Q(12) is the Ljung-Box (1978) Q statistic on the 12th order sample autocorrelations of the raw series, distributed as $\chi^2(12)$.

Table 2: Results of different Momentum and Contrarian investment strategies for Capesize dry bulk ships

	B&H	6-month Momentum			12-month Momentum			24-month Momentum		
		10%	25%	40%	10%	25%	40%	10%	25%	40%
Price as Indicator										
Return	7.23%	7.39%	9.86%	6.86%	6.69%	7.87%	6.92%	3.10%	6.38%	3.96%
StDev	25.20%	19.59%	20.45%	16.27%	20.05%	18.75%	18.42%	22.42%	21.88%	21.22%
Sharpe Ratio	0.287	0.377	0.482	0.421	0.334	0.419	0.376	0.138	0.291	0.186
BS p-val		0.999	0.999	0.999	1.000	0.999	0.999	1.000	1.000	1.000
Utility (λ=4)	-0.1818	-0.0796	-0.0687	-0.0373	-0.0939	-0.0620	-0.0665	-0.1701	-0.1278	-0.1406
Earnings as Indicator										
Return	7.23%	**14.10%**	**11.76%**	**11.29%**	**14.43%**	**14.34%**	**13.48%**	6.70%	4.71%	4.23%
StDev	25.20%	**15.76%**	**15.83%**	**15.33%**	**15.73%**	**16.32%**	**15.79%**	19.50%	18.75%	18.72%
Sharpe Ratio	0.287	**0.895**	**0.743**	**0.737**	**0.917**	**0.879**	**0.854**	0.344	0.251	0.226
BS p-val		**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	0.003	0.831	0.797
Utility (λ=4)	-0.1818	**0.0417**	**0.0174**	**0.0189**	**0.0454**	**0.0369**	**0.0351**	-0.0850	-0.0935	-0.0979
	B&H	6-month Contrarian			12-month Contrarian			24-month Contrarian		
Price as Indicator										
Return	7.23%	1.04%	2.80%	**2.80%**	0.32%	1.47%	**3.21%**	**4.91%**	**2.51%**	**4.26%**
StDev	25.20%	7.02%	3.14%	**3.14%**	11.29%	7.10%	**4.44%**	**12.56%**	**8.57%**	**5.21%**
Sharpe Ratio	0.287	0.148	0.890	**0.890**	0.028	0.206	**0.722**	**0.391**	**0.294**	**0.819**
BS p-val		0.999	0.063	**0.015**	0.427	0.959	**0.002**	**0.004**	**0.000**	**0.003**
Utility (λ=4)	-0.1818	-0.0093	0.0240	**0.0240**	-0.0478	-0.0055	**0.0242**	**-0.0140**	**-0.0042**	**0.0318**
Earnings as Indicator										
Return	7.23%	-7.47%	-4.17%	-4.05%	-5.03%	-2.74%	-1.56%	-2.35%	-1.93%	-0.08%
StDev	25.20%	19.54%	13.68%	11.61%	19.82%	14.86%	13.61%	15.84%	15.57%	14.37%
Sharpe Ratio	0.287	-0.382	-0.305	-0.349	-0.254	-0.184	-0.115	-0.148	-0.124	-0.006
BS p-val		0.999	1.000	1.000	0.999	0.999	1.000	0.999	0.999	1.000
Utility (λ=4)	-0.1818	-0.2275	-0.1166	-0.0945	-0.2074	-0.1157	-0.0898	-0.1239	-0.1163	-0.0834

- Adjusted sample used for performing the trading strategies is from Jan 1993 to December 2016, total of 288 observations.
- A 2% transaction cost for each buy or sell trade and annual depreciation rate of 6% are considered for calculation of returns.
- The momentum indicators on price and earnings (y) are constructed as: $I_t^M = \sum_0^k \Delta y_{t-i}$ where Δy_t are changes in price or earnings (k= 6, 12 and 24 months). The contrarian indicators on price and earnings (y) are constructed as: $I_t^C = \ln\left(\sum_0^k \Delta y_{t-i} / y_t\right)$ for k= 6, 12 and 24 months.
- 10%. 25% and 40% represent the increase or decrease level in the indicators for triggering entry of exit under each investment strategies, respectively. For instance, 10% 6-month momentum indicator (I_t^M) signals a buy when the indicator is above 10%, and sell when it is below -10%. Similarly, the -10% 6-month contrarian investment strategy signals a buy when indicator, I_t^C drops by more than 10% and sell when the indicator has increased by more than 10%.
- The BS p-val is the stationary bootstrapped p-value for the significance of excess Sharpe Ratio of the investment strategy compared to the Sharpe Ratio of buy-and-hold strategy. The stationary bootstrap is performed using 100 regenerations of price and earnings samples, and implementing the trading strategies. The null is that the Sharpe Ratio of investment strategy is less than or equal to the Sharpe Ratio of the buy-and-hold strategy.
- Bold figures highlight the strategies where the p-value of bootstrapped Sharpe Ratios indicate the strategy significantly outperforms the passive buy-and-hold strategy.

Table 3: Results of different Momentum and Contrarian investment strategies for Panamax dry bulk ships

	B&H	6-month Momentum			12-month Momentum			24-month Momentum		
		10%	25%	40%	10%	25%	40%	10%	25%	40%
Price as Indicator										
Return	2.05%	5.66%	3.60%	5.47%	3.00%	2.40%	1.72%	1.48%	4.38%	2.57%
StDev	26.29%	22.11%	21.37%	20.51%	22.20%	20.99%	20.76%	22.50%	22.92%	22.38%
Sharpe Ratio	0.078	0.256	0.168	0.267	0.135	0.114	0.083	0.066	0.191	0.115
BS p-val		0.717	1.000	0.999	1.000	1.000	1.000	1.000	1.000	1.000
Utility (λ=4)	-0.2560	-0.1390	-0.1467	-0.1135	-0.1672	-0.1523	-0.1552	-0.1877	-0.1663	-0.1747
Earnings as Indicator										
Return	2.05%	**10.84%**	**8.89%**	**6.10%**	**12.74%**	**10.56%**	**8.43%**	1.68%	1.24%	3.02%
StDev	26.29%	**14.09%**	**14.40%**	**15.40%**	**14.16%**	**14.54%**	**14.96%**	21.70%	21.63%	21.30%
Sharpe Ratio	0.078	**0.769**	**0.617**	**0.396**	**0.900**	**0.726**	**0.564**	0.077	0.057	0.142
BS p-val		**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	0.362	0.916	0.996
Utility (λ=4)	-0.2560	**0.0290**	**0.0059**	**-0.0339**	**0.0472**	**0.0210**	**-0.0052**	-0.1715	-0.1748	-0.1514
	B&H	6-month Contrarian			12-month Contrarian			24-month Contrarian		
Price as Indicator										
Return	2.05%	-0.81%	**3.00%**	**3.00%**	-1.10%	3.46%	**3.52%**	**2.71%**	**3.13%**	**4.27%**
StDev	26.29%	8.82%	**2.49%**	**2.49%**	11.54%	7.50%	**3.82%**	**11.78%**	**9.34%**	**5.06%**
Sharpe Ratio	0.078	-0.091	**1.205**	**1.205**	-0.095	0.461	**0.921**	**0.230**	**0.336**	**0.844**
BS p-val		0.123	**0.007**	**0.012**	0.999	0.314	**0.002**	**0.000**	**0.000**	**0.002**
Utility (λ=4)	-0.2560	-0.0392	**0.0275**	**0.0275**	-0.0643	0.0121	**0.0294**	**-0.0284**	**-0.0035**	**0.0324**
Earnings as Indicator										
Return	2.05%	-8.79%	-1.87%	1.35%	-8.91%	-5.03%	-0.22%	-2.83%	-0.43%	2.54%
StDev	26.29%	20.88%	11.21%	8.67%	21.71%	21.21%	10.78%	14.87%	13.98%	11.18%
Sharpe Ratio	0.078	-0.421	-0.167	0.156	-0.411	-0.237	-0.020	-0.190	-0.030	0.227
BS p-val		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.999
Utility (λ=4)	-0.2560	-0.26224	-0.06896	-0.01657	-0.27758	-0.23024	-0.04862	-0.1167	-0.08241	-0.02463

- Adjusted sample used for performing the trading strategies is from Jan 1993 to December 2016, total of 288 observations.
- A 2% transaction cost for each buy or sell trade and annual depreciation rate of 6% are considered for calculation of returns.
- The momentum indicators on price and earnings (y) are constructed as: $I_t^M = \sum_0^k \Delta y_{t-i}$ where Δy_t are changes in price or earnings (k= 6, 12 and 24 months). The contrarian indicators on price and earnings (y) are constructed as: $I_t^C = \ln\left(\sum_0^k \Delta y_{t-i} / y_t\right)$ for k= 6, 12 and 24 months.
- 10%. 25% and 40% represent the increase or decrease level in the indicators for triggering entry of exit under each investment strategies, respectively. For instance, 10% 6-month momentum indicator (I_t^M) signals a buy when the indicator is above 10%, and sell when it is below -10%. Similarly, the -10% 6-month contrarian investment strategy signals a buy when indicator, I_t^C drops by more than 10% and sell when the indicator has increased by more than 10%.
- The BS p-val is the stationary bootstrapped p-value for the significance of excess Sharpe Ratio of the investment strategy compared to the Sharpe Ratio of buy-and-hold strategy. The stationary bootstrap is performed using 100 regenerations of price and earnings samples, and implementing the trading strategies. The null is that the Sharpe Ratio of investment strategy is less than or equal to the Sharpe Ratio of the buy-and-hold strategy.
- Bold figures highlight the strategies where the p-value of bootstrapped Sharpe Ratios indicate the strategy significantly outperforms the passive buy-and-hold strategy.

Table 4: Results of different Momentum and Contrarian investment strategies for Handysize dry bulk ships

	B&H	6-month Momentum			12-month Momentum			24-month Momentum		
		10%	25%	40%	10%	25%	40%	10%	25%	40%
Price as Indicator										
Return	1.77%	**3.48%**	5.37%	4.77%	**3.05%**	1.48%	5.37%	1.28%	4.30%	1.67%
StDev	20.71%	**17.13%**	15.92%	15.71%	**17.46%**	18.62%	15.92%	18.43%	17.97%	17.65%
Sharpe Ratio	0.085	**0.203**	0.337	0.304	**0.175**	0.079	0.337	0.069	0.239	0.094
BS p-val		**0.000**	0.195	0.598	**0.004**	1.000	0.999	1.000	0.981	1.000
Utility (λ=4)	-0.1539	**-0.0825**	-0.0477	-0.0510	**-0.0915**	-0.1239	-0.0477	-0.1232	-0.0862	-0.1080
Earnings as Indicator										
Return	1.77%	**10.21%**	**5.85%**	2.69%	**6.31%**	**4.98%**	5.68%	2.86%	1.57%	3.68%
StDev	20.71%	**11.26%**	**17.94%**	18.10%	**16.98%**	**17.34%**	16.91%	17.37%	17.11%	16.43%
Sharpe Ratio	0.085	**0.906**	**0.326**	0.149	**0.372**	**0.287**	0.336	0.165	0.092	0.224
BS p-val		**0.000**	**0.000**	0.981	**0.000**	**0.010**	0.189	0.942	0.973	0.776
Utility (λ=4)	-0.1539	**0.0514**	**-0.0702**	-0.1041	**-0.0522**	**-0.0705**	-0.0576	-0.0920	-0.1014	-0.0712
	B&H	6-month Contrarian			12-month Contrarian			24-month Contrarian		
Price as Indicator										
Return	1.77%	-2.03%	2.14%	2.14%	-1.52%	2.51%	**2.51%**	**-0.64%**	**3.07%**	**3.66%**
StDev	20.71%	7.01%	2.38%	2.38%	9.58%	2.87%	**2.87%**	**9.87%**	**7.60%**	**3.65%**
Sharpe Ratio	0.085	-0.289	0.903	0.903	-0.158	0.874	**0.874**	**-0.065**	**0.404**	**1.002**
BS p-val		1.000	0.115	0.052	1.000	0.443	**0.008**	**0.000**	**0.000**	**0.003**
Utility (λ=4)	-0.1539	-0.0400	0.0192	0.0192	-0.0519	0.0218	**0.0218**	**-0.0454**	**0.0076**	**0.0313**
Earnings as Indicator										
Return	1.77%	-3.34%	1.11%	1.92%	-5.41%	0.99%	2.20%	-1.50%	1.90%	3.55%
StDev	20.71%	8.04%	3.49%	2.15%	10.45%	4.89%	2.47%	11.08%	8.74%	5.85%
Sharpe Ratio	0.085	-0.416	0.317	0.893	-0.518	0.202	0.892	-0.136	0.218	0.606
BS p-val		1.000	0.999	0.762	1.000	1.000	0.067	0.403	0.896	0.224
Utility (λ=4)	-0.1539	-0.0593	0.0062	0.0174	-0.0978	0.0003	0.0196	-0.0641	-0.0115	0.0218

- Adjusted sample used for performing the trading strategies is from Jan 1993 to December 2016, total of 288 observations.
- A 2% transaction cost for each buy or sell trade and annual depreciation rate of 6% are considered for calculation of returns.
- The momentum indicators on price and earnings (y) are constructed as: $I_t^M = \sum_0^k \Delta y_{t-i}$ where Δy_t are changes in price or earnings (k= 6, 12 and 24 months). The contrarian indicators on price and earnings (y) are constructed as: $I_t^C = \ln\left(\sum_0^k \Delta y_{t-i} / y_t\right)$ for k= 6, 12 and 24 months.
- 10%. 25% and 40% represent the increase or decrease level in the indicators for triggering entry of exit under each investment strategies, respectively. For instance, 10% 6-month momentum indicator (I_t^M) signals a buy when the indicator is above 10%, and sell when it is below -10%. Similarly, the -10% 6-month contrarian investment strategy signals a buy when indicator, I_t^C drops by more than 10% and sell when the indicator has increased by more than 10%.
- The BS p-val is the stationary bootstrapped p-value for the significance of excess Sharpe Ratio of the investment strategy compared to the Sharpe Ratio of buy-and-hold strategy. The stationary bootstrap is performed using 100 regenerations of price and earnings samples, and implementing the trading strategies. The null is that the Sharpe Ratio of investment strategy is less than or equal to the Sharpe Ratio of the buy-and-hold strategy.
- Bold figures highlight the strategies where the p-value of bootstrapped Sharpe Ratios indicate the strategy significantly outperforms the passive buy-and-hold strategy.

Table 5: Estimated parameters of the HAM for different size dry bulk ships

$$\begin{cases} \Delta P_{t+1} = \theta_0 + W_t^M D_t^M + W_t^C D_t^C + \theta_1 p_t + \varepsilon_t \\ D_t^M = \left(\alpha_1 \left(\Delta^k P_t\right)^+ + \alpha_2 \left(\Delta^k P_t\right)^-\right) \quad ; \; W_t^C = 1 \Big/ \mu_0 \left(1 + e^{-\mu_1 ((1/k) \sum_{i=1}^{k} P_{t-i} - P_t)}\right) \\ D_t^C = \left(\beta_1 (F_t - P_t)^+ + \beta_2 (F_t - P_t)^-\right) \; ; \; W_t^M = 1 \Big/ \eta_0 \left(1 + e^{-\eta_1 \sum_{i=0}^{k-1} \Delta P_{t-i}}\right) \end{cases} \quad \text{Equation (9)}$$

Parameters	Capesize	Panamax	Handysize
θ_0	0.0128^{**}	0.0440^{**}	0.0326^{***}
	(0.0059)	(0.0211)	(0.0090)
θ_1	-0.0003^{**}	-0.0009^{**}	-0.0020^{***}
	(0.0001)	(0.0004)	(0.0004)
α_1	0.0632^{***}	0.0870^{*}	0.1818^{***}
	(0.0078)	(0.0479)	(0.0218)
α_2	-0.0603	1.1176^{***}	0.2872^{*}
	(0.0656)	(0.1032)	(0.1640)
β_1	-0.0141	0.0082	-0.0250
	(0.0240)	(0.0495)	(0.0393)
β_2	5.8376^{***}	4.0295^{***}	1.0612^{***}
	(0.4615)	(0.2118)	(0.2835)
μ_0	1.8998^{***}	2.4577^{***}	1.7417^{***}
	(0.2125)	(0.6617)	(0.1475)
μ_1	4.9719^{*}	2.7258^{***}	4.4753
	(2.8631)	(0.4417)	(2.9443)
η_0	1.7440^{***}	1.9832^{***}	1.7999^{**}
	(0.3222)	(0.6324)	(0.7179)
η_1	21.8778^{**}	14.4465^{***}	14.1335^{**}
	(9.4381)	(4.5852)	(6.7535)
Diagnostics			
R-bar sq	0.219	0.217	0.123
LL	398.51	379.36	428.89
SBIC	367.36	348.20	397.74
LB-Q (6)	17.584	9.577	18.542
ARCH (6)	2.478	0.218	0.8100

- Sample period is from January 1993 to December 2016. Sample adjusted for estimation of fundamental values based on 24 month moving average of price.
- Figures in () heteroscedasticity and autocorrelation consistent standard errors. *, ** and *** indicate significance at 10%, 5% and 1% levels, respectively.
- SBIC is the Schwarz (1978) Bayesian Information Criterion for model selection. LL is the log-likelihood.
- ARCH(6) is the Engle (1982) test for 6th order Autoregressive Conditional Heteroscedasticity, with the 5% critical value of 12.59. LB-Q(6) is the Ljung and Box (1978) test for 6th order autocorrelation in residuals with the 5% critical value of 12.59.

Table 6: Impact of investors' demand on ship values and volatilities

$$\Delta p_t = \lambda_0 + \lambda_1 z_{t-1} + \varepsilon_t \qquad ; \qquad \varepsilon_t \sim \text{iid}(0, \sigma_t^2, v)$$

Equation (10)

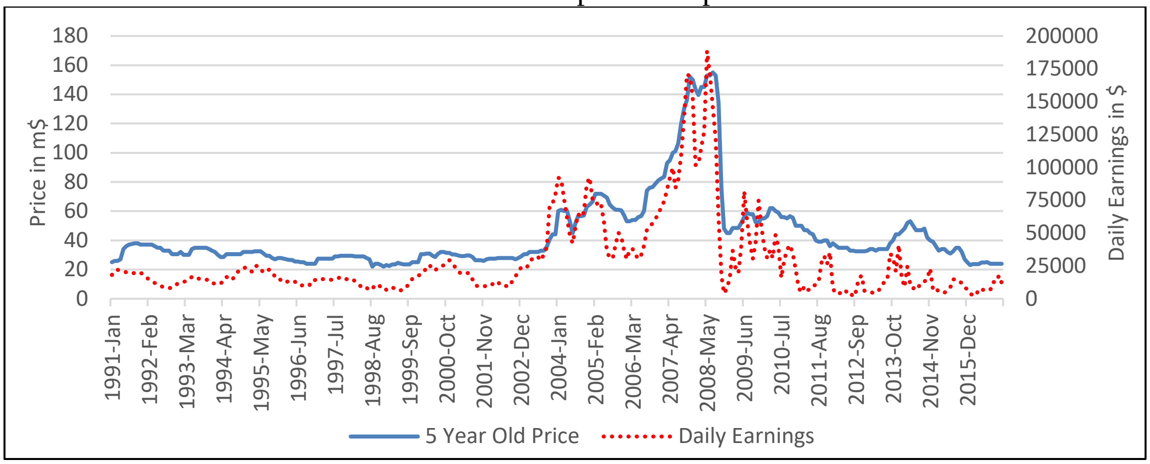
$$\sigma_t^2 = \exp\left(\phi_0 + \phi_1 \frac{|\varepsilon_{t-1}|}{\sigma_{t-1}} + \phi_2 \frac{\varepsilon_{t-1}}{\sigma_{t-1}} + \phi_3 \ln \sigma_{t-1}^2 + \phi_4 z_{t-1} \right)$$

Ship size-class	Capesize		Panamax		Handysize	
Strategy	Momentum	Contrarian	Momentum	Contrarian	Momentum	Contrarian
Mean equation						
γ_0	-0.0049*	0.0009	-0.0076***	-0.0007	-0.0057***	0.0001
	(0.0027)	(0.0032)	(0.0004)	(0.0014)	(0.0001)	(0.0022)
γ_1	0.1204**	0.1314***	0.1435***	0.1967***	0.0877***	0.1201***
	(0.0477)	(0.0420)	(0.0402)	(0.0542)	(0.0033)	(0.0413)
γ_z	0.0176***	-0.0054	0.0451***	0.0023	0.0185***	0.0003
	(0.0089)	(0.0079)	(0.0015)	(0.0060)	(0.0002)	(0.0069)
Variance						
ϕ_0	-1.1347**	-0.8702*	-0.0244***	0.0616***	-0.0653***	-0.0550
	(0.5035)	(0.4994)	(0.0008)	(0.0014)	(0.0016)	(0.0583)
ϕ_1	0.5916	0.8380	-0.4237***	-0.4015***	-0.2496***	0.6475***
	(0.4244)	(0.8020)	(0.0035)	(0.0157)	(0.0003)	(0.0263)
ϕ_2	-0.4649	-0.6194	0.3012***	-0.0626***	0.9866***	0.9886***
	(0.3177)	(0.5980)	(0.0169)	(0.0201)	(0.0004)	(0.0134)
ϕ_3	0.8321***	0.8042***	0.9784***	0.9784***	-0.0738***	0.0545***
	(0.0989)	(0.1162)	(0.0006)	(0.0009)	(0.0008)	(0.0121)
ϕ_z	0.6649***	-0.5724**	0.1818***	-0.1988***	0.2421***	-0.1346**
	(0.2277)	(0.2353)	(0.0029)	(0.0108)	(0.0066)	(0.0630)
v	2.1295***	2.0897***	2.0395***	2.0455***	2.0493***	2.0111***
	(0.1477)	(0.1422)	(0.0034)	(0.0049)	(0.0028)	(0.0091)
Diagnostics						
R-bar sq	0.103	0.088	0.109	0.106	0.0568	0.0502
LL	490.822	488.544	481.506	482.430	551.23	536.06
SBIC	465.339	463.061	456.023	456.946	525.75	510.58
LB-Q (6)	11.071	10.888	10.700	8.728	17.424	17.528
ARCH (6)	1.973	1.617	4.118	3.761	0.9200	1.5540

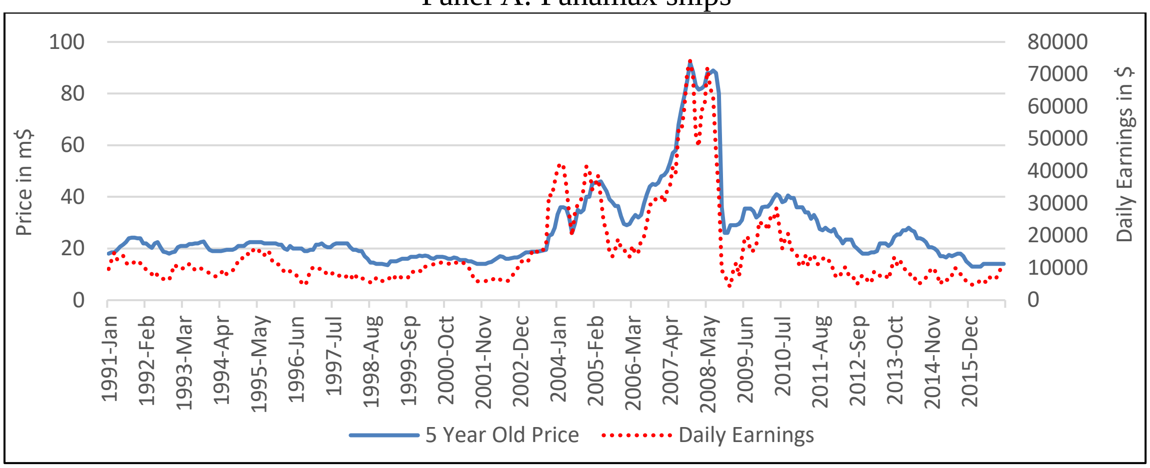
- z_t is the variable representing the proportion of interest from investor type (momentum or contrarian).
- *, ** and *** indicate significance at 10%, 5% and 1% levels, respectively.
- SBIC is the Schwarz (1978) Bayesian Information Criterion for model selection. LL is the log-likelihood.
- ARCH(6) is the Engle (1982) test for 6th order Autoregressive Conditional Heteroscedasticity, with the 5% critical value of 12.15. LB-Q(6) is the Ljung and Box (1978) test for 6th order autocorrelation in residuals with the 5% critical value of 12.15.

Figure 1: Historical prices and operational earnings of different size dry bulk ships

Panel A: Capesize ships



Panel A: Panamax ships



Panel A: Handysize ships

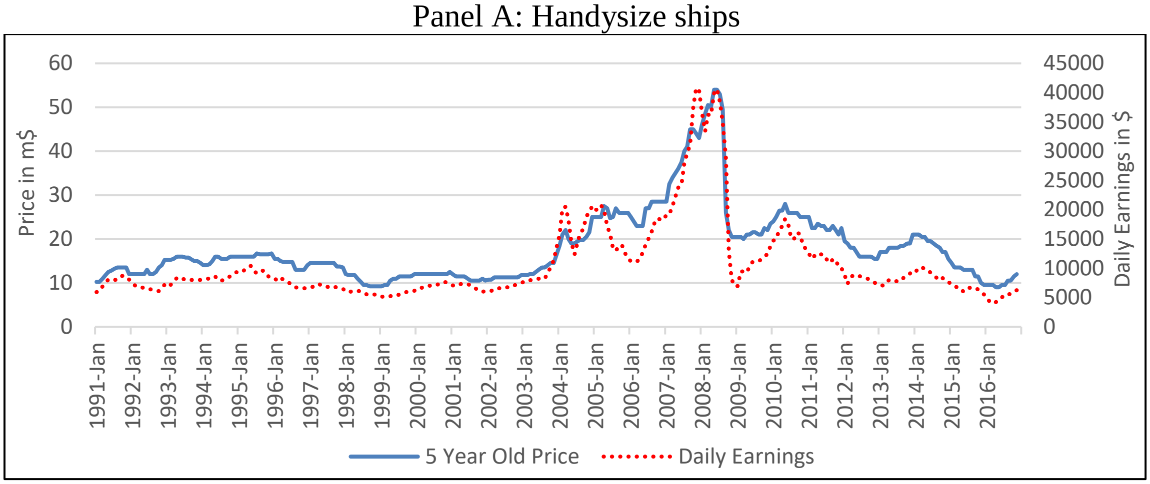
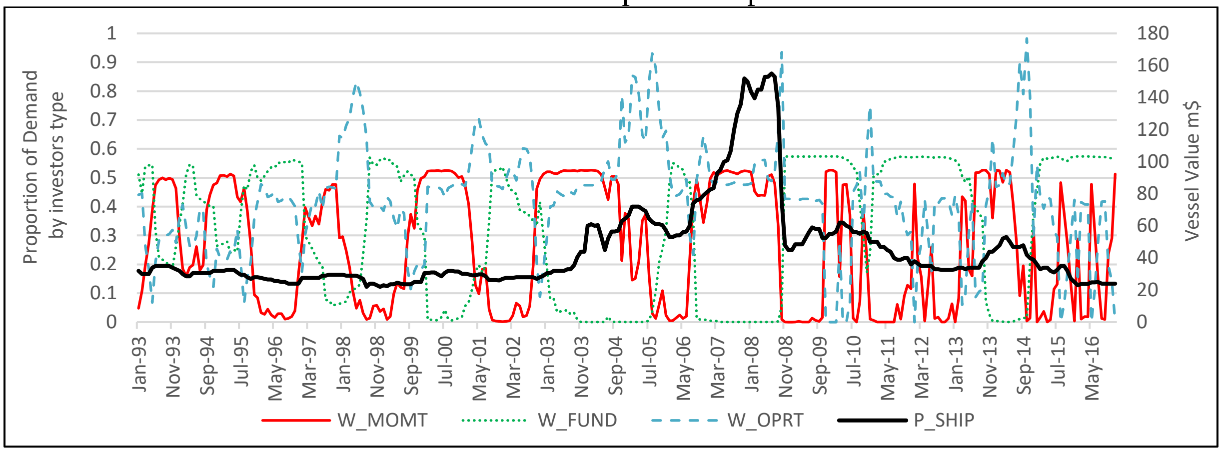


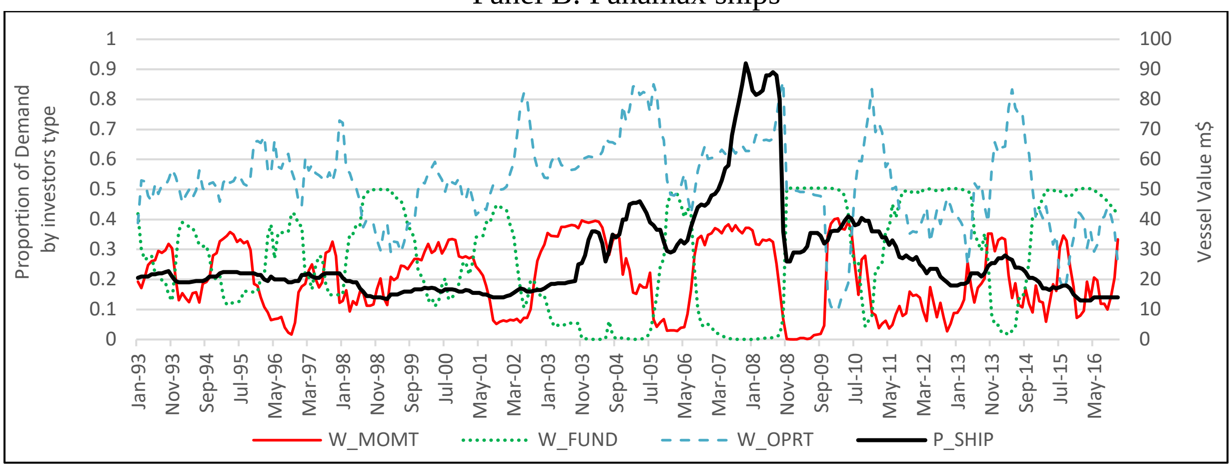
Figure 2: Proportion of demand for second-hand ships by investor type

W_MOMT, W_FUND and W_OPRT represent the proportion of demand for ships by momentum, fundamentalist investors and operators in the market according to the estimated HAM model (measured on the left axis). P_SHIP is the value of 5-year old second-hand ship in each sector (measured on the right axis).

Panel A: Capesize ships



Panel B: Panamax ships



Panel C: Handysize ships