Dynamic Earnings within Tanker Markets: An Investigation of Exogenous and Endogenous Structure Breaks

Wessam Abouarghoub

Iris Biefang-Frisancho Mariscal

Peter Howells

Centre for Global Finance
Bristol Business School
United States of America

Abstract

This study examines the possibility of tanker spot freight rates being state dependent and whether structure breaks are exogenous or endogenous. Thus, structure-break tests and a multi-state Markov-switching regime framework are implemented. Furthermore, conditional stationarity of tanker freight rates is investigated. In general empirical maritime literature suggest, non-stationary of freight price-levels, contrast to maritime theory, which implies that in perfect competitive conditions, freight rates revert to a long-run mean. Working from the postulate that freight earnings switch between two distinct states, a high volatility state and a low volatility state, we propose a multi-state Markov-switching regime framework. The inclusion of addition states is to identify structure-breaks and shifts in tanker earnings and volatilities levels. Empirical findings are aligned with maritime economic theory, in regards to freights being mean reverting and stationary. Furthermore, there is clear evidence of significant shifts in freight dynamics for the tanker market and that tanker freight rates are state dependent, influenced by endogenous and exogenous shocks.

1. Introduction

The shipping industry consists of four main markets these are the new-building, freight markets, second-hand and demolition markets. These markets integrate together prevailing perfect competitive market conditions, for details see Stopford, (2009, p. 175). Sea transport is traded in freight markets with spot and derivative markets being subdivisions. Activities in these markets influence demand and supply of vessels in second-hand and new-build markets, with the latter exhibiting a time lag in the speed of adjusting to excess in demand for transport, due to delays between orders and delivers of vessels, this causes high persistent of freight rates. Perfect competitive conditions in shipping markets imply that freight rates below operating levels coincide with oversupply of vessels and that high freight coincide with undersupply of vessels. Oversupply and undersupply of the number of employed vessels is equilibrium adjusted through activities within the scrap and new-build markets, respectively. When freight rates are at low levels, ship-owners earnings are below breakeven levels and supply of freight is very elastic in the short-run, due to an increase in numbers of unemployed vessels (lay-up). In the long-run supply becomes inelastic as freight rates increases, these high freight levels remove vessels from lay-out conditions and increase steaming speed. More details can be found in Adland and Cullinane (2006) and the references within. Therefore, level of freight earnings trigger activities within shipping markets, as ship-owners continue to better speculate on shipping cycles to make a financial decision of purchase or resale or scrap an asset.

To improve the quantitative techniques used in maritime economics literature, we recognize the importance of studying freight dynamics. This better understanding of freight's characteristics should improve measures and forecasts of freight risk, leading to better shipping operations and risk management techniques. To this end, this study revisits the issue of stationarity and attempt to add to the existing literature by examining the usefulness of Markov-switching regime models in identifying structure changes within the tanker freight market and testing the postulate of freight markets being state dependence. Additionally, exogenous and endogenous structure break tests are implemented to test the significance of such breaks. The remaining of this paper is organised as follows: subsection (1.1) briefly considers the effect of oil seaborne trade on the tanker market. Section (2) covers a brief literature review and applied methodology. Section (3) covers empirical finding. Finally section (4) concludes.

1.1. Oil seaborne trade and the tanker markets

Oil seaborne trade represent 95 per cent of the global oil movement and consists of two main sub-trades; crude oil and oil products, these liquid cargos are transported on special vessels referred to as tankers, in general terms large tankers are associated with transporting crude oil and smaller vessels are associated with transporting oil products such as; kerosene and gasoline known as clean product trade, while dirty product trade refer to transporting lower distillates and residual oil. For more details see Glen and Brendan (2002).

Seaborne trade is an important block of world economical growth, between the years of 1994 and 2010 a measure of correlation between percentage changes in GDP and oil seaborne trade was 76 per cent, with the latter accounting for approximately 33 per cent of total seaborne trade. During the most recent economical boom period between the years of 2003 and 2007 total seaborne trade had increased by nearly 21.5 per cent to amount for 7.9 billion tonnes of cargo transported by shipping means, corresponding to an increase of more than 20 per cent in worlds GDP. While between the years of 2007 and 2010 oil seaborne trade had dropped by 3.65 per cent from 2.7 billion tonnes, corresponding to a 0.6 per cent drop in worlds GDP. In respect to oil sub-trades, crude oil shipments for 2009 were 38 million barrels per day and 16 million barrels per day for oil product. This amounted for 2.6 billion[1] tonnes of oil seaborne trade for 2009.[2] Thus, continuous changes to demand for oil seaborne trade have a profound affect on tankers earning levels. For example average daily earning's for a VLCC vessel in March 2000 was $29,778 before rising to $86,139 by December, for a 45 day voyage, earning a ship-owner an excess of 2.5 million dollars in December compared to March of the same year. In the context of our analysis, these earnings belong to distinct regime states, a VLCC employed in March would have been operating in a low volatility state freight market with average daily earnings of $22,000 and a fluctuation possibility of around $6000. While a VLCC employed in December would have been operating in a high freight volatility state market with average daily earnings of $63,000 and a fluctuation possibility of around $31,000. Therefore, timing is crucial for ship-owners and charters, as they are on different sides of a coin.

2. *Literature review and methodological framework*

Visual inspection of a plot of tanker freight earnings clearly identifies a significant change in freight dynamics post-2000, which is consistent across all tanker segments. This motivated the use of a multi-state Markov-switching regime framework to capture shifts in freight dynamics and volatility levels. This framework depends on the stationarity of variables. Therefore, we make use of an augmented Dickey-Fuller (ADF) test, Dickey and Fuller (1979, 1981), for linear unit-root against linear stationary, to test freight earnings at price-level for unit-root. Furthermore, the significance of such structure breaks is tested. In this section we review the relevant literature and methodology used in this study.

2.1. Maritime economic theory

The concept that shipping services are derived demand is an agreed on concept among maritime economists, Alderton and Rowlinson (2002). Thus, demand for tankers is influenced by demand for crude oil and oil products. With the oil market characterised as being mean-reverting and not shock persistent and the price of crude oil more than doubled since 2000, with a significant increase in 2006. Thus, most stochastic models of oil prices include time-varying trends convenience yields, volatility and mean reversion, for more details see Y.H. Lee *et al* (2010) and the references within.

On the one hand, maritime economists agree that shipping business cycles are driven by combinations of external and internal factors. Their disagreements are on the different components and sequences. More details can be found in Stopford (2009, p. 136-141). On the other hand, shipping practitioners' view that cyclicality and volatility are caused exogenously, with clear emphasis on the volatility and unacknowlegment of the regularity (cyclicality), contrast to Randers and Göluke (2007) view that endogenous factors shape the changes in long-term shipping cycles. In summary, a general concession that exogenous factors channel the dynamic changes prevails in shipping markets. These never ending challenges in the shipping industry are due to global economical, political and logistics forces.

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[1] Barrels per day are converted as follows; 38,000,500 + 15,969,000 = 53,969,500 × 49.8 (converter factor) = 2,687,681,100 tonnes for 2009.

[2] BP statistics review of world energy 2009.

More details can be found in Randers and Göluke (2007). Klovland (2002) argues that world output is the fundamental factor on the demand side, generating a strong positive correlation between freight rates and business cycles. When freight rates are at low levels supply is relatively flat in the short-run and slops upwards steeply in the long-run, with increases in activities, demand side shifts right intersecting with a steeply supply curve, generating high freight rates, this removes ships from unemployment and increase optimal steaming speed. The interaction between demand and supply in maritime economic theory has been well documented in Stopford (2009, p. 135-174).

2.2. Shipping business cycles

Burns and Mitchell (1946, p.3) definition of business cycles is the prevailing one in shipping, in which business cycles are viewed as recurrent but not periodic, Klovland (2002). This is aligned with the concept that shipping business cycles are of irregular length and unpredictable and that each cycle is unique.

Fayle (1933) suggested that booms and busts of the world economy combined with random events trigger the build up of shipping cycles and that a short boom is usually followed by a prolonged slump, pointing out that shortage of ships cause high freight rates attracting new investors, this leads to an increase in shipping capacity. Therefore, tramp shipping is characterised by wide fluctuations in demand for freight, speculator ship-owners and disproportion between supply and demand. Cufley (1972) argues that because of the uncertainty within cycles, forecasting freight rates are an impossible task and that underlying trends might be more predictable. While, Hampton (1991) suggests that shipping markets are influenced by the way investors behave and that they do not act rationally causing over reaction of markets to price signals. In respect of shipping cycles, Kirkaldy (1914) focused on competition within ship-owners, while Fayle was more concern with the mechanism of the cycle.
Martin Stopford (2002) in an effort to identify shipping cycle's characteristics and their relevance to the economics of shipping markets, he studies the driving forces behind shipping cycles focusing on the economic mechanisms and demonstrates the importance of understanding this for ship-owners.

He finds a high positive correlation between the market value of a vessel and its corresponding earnings across all different phases of shipping cycles, for example he compares a one year time charter rate for a five year-old Aframax Tanker with its market value, concluding that a price of a shipping asset is correlated with its earning capacity. In his analysis a cycle is measured from peak to peak and variations of cycles across time is assist by a simple standard deviation statistic. For example, analysis of shipping cycles for a period from 1872 to 2000, shows that average shipping cycles have a frequency of 7 years agreeing with a shipping folk law that shipping cycles last seven years, even though, his further analysis show that this rule of thumb has little merit. However, he accepts the fact that there is clear variations in cycles lengths and that they vary between 2.5 years and 11 years. He uses a supply and demand model to analyse the forces driving shipping cycles, stressing the importance of distinguishing between endogenous and exogenous factors, such that an endogenous factor is an internal mechanism that trigger the cycle, while an exogenous factor is an external event that triggers the cyclical pattern, Stopford (2002). Thus, on the demand side, the most important exogenous demand force, which drives the shipping cycle, is the business cycle of the world economy, in agreement with Klovland (2002).

This causes changes into seaborne trade, injecting a cyclical pattern into demand for freight services. On the supply side, the main influence is the investment cycle, in which the time lag between ordering and delivery of a new vessel is crucial. He concludes that shipping cycles are generated by business cycles in the world economy and reinforced by the time-lag between supply and demand. Additionally, he drives a comparison between seaborne trade and freight rates, to study the effect of business cycles on freights, by computing the deviation of the actual observation from a five-year trend and identifying upswings and downswings relative to a zero threshold. His analysis is based on a postulate that shipping business cycle consists of four stages, a trough stage, followed by a recovery stage, leading to a peak stage, followed by stage of collapse. He argues that a trade boom accompanied with a short shipping boom, during which there is over ordering of new builds, is followed by a prolonged slump. Thus, he views shipping market cycles with a Darwinian purpose, creating an environment in which weak shipping companies are forced out and strong ones survive and prosper, creating efficient shipping markets, Stopford (2009, p. 94-134). In summary the common theme is that freight markets exhibit clear clusters and that understanding exogenous and endogenous forces that drive shipping cycles is important in improving vessels performances and operations. In other wards, understanding shipping cycles will improve techniques of managing freight risk.

2.3. The three-step framework

The framework structure is based on the following steps. First, we examine stationarity of the constructed data. Second, a multi-state Markov-switching regime is used to investigate the postulate of freight rates being state dependent and to identify exogenous and endogenous structure-breaks. Third, the significance of these endogenous and exogenous time-breaks are examined by structure-break tests. On the one hand, the significance of such a dynamic change and asymmetry of pre and post an exogenous structure break are tested using a Chow test and an equivalent variances test, respectively. On the other hand, the time-break and significance of endogenous structure breaks are tested using Perron's modified unit-root test.

2.3.1. Stationarity of Freight Earnings

With perfect competitive conditions prevailing in shipping freight markets, freight rates are considered to revert to a long run mean. This concept is widely accepted in maritime literature, for more details see; (Zannetos, 1966; Strandenes, 1984; Tvedt, 1997; Adland and Cullinane, 2005; Koekebakker, S. et al 2006). Thus, according to maritime economic theory freight prices cannot exhibit an explosive behaviour implied by a non-stationary process. By contrast, most maritime empirical studies conclude that freight rates are non-stationary. Koekebakker, S. et al (2006) argue that these findings are due to the weak power of the used tests. While, Adland and Cullinane (2006) explain the difficulties in rejecting a non-stationary hypothesis, and conclude that the spot freight rate process is globally mean reverting as implied by economic theory, and over all stationary. Additionally, a Markov-switching framework depends on the stationarity of the used variables. Therefore, testing freight earnings for unit-root is of importance. An augmented Dickey-Fuller (ADF) test for linear unit-root against linear stationary is provided by a *t*-statistic for an estimated β in:

$$\Delta f_t = \alpha + d_t + \beta_0 f_{t-1} + \sum_{i=1}^{k} \beta_i \Delta f_{t-i} + u_t \quad (1)$$

This is a one-tailed *t*-test, such that the null hypothesis is $H_0: \beta_0 = 0$ and the alternative null is $H_1: \beta_0 < 0$. Where f_t refers to tanker freight earnings (price-level) at time *t*, Δ symbol is the lag operator so that $\Delta f_t = f_t - f_{t-1}$, α is a constant, d_t is a drift and u_t is white noise. The facilitation of ADF test is determent by the computation of a *t*-statistic $t_{stat} = \hat{\beta}_0 / Se_{\widehat{\beta_0}}$. The purpose of additional lags k is to reduce autocorrelation within the residuals. Where β_0 coefficient is estimated by OLS and *Se* refers to the estimated standard deviation. The selection of the appropriate lag length is based on a minimization of the Schwartz information criterion. Critical values are derived from the response surfaces in MacKinnon (1991). Overall, reported results in the empirical section support the stationarity of tanker spot freight rates, aligned with maritime economic theory.

2.3.2. Markov-switching models

Markov-switching models were originally introduced by Hamilton (1988, 1989) and since then, there have been a wide range of contributions, including Engle and Hamilton (1990), Hamilton and Susmel (1994), Hamilton and Lin (1996), and Gray (1996). These models introduce state dependent within their estimated variables, allowing the mean and variance to differ between expansions and contractions, capturing market dynamics, upward and downward movements. For a recent overview of regime switching models see Teräsvirta (2006). The use of such a framework in our analysis was motivated by inspecting a simple plot of the data, where a significant jump in the mean and volatility of tanker earning levels is visible post-2000. We examine the usefulness of a multi-state Markov-switching model in capturing exogenous and endogenous structure-breaks within tanker freight markets, thus, testing the postulate of state dependence. Furthermore, this procedure identifies recessions and expansions within each regime, these upper and lower bounds are computed by adding/subtracting the estimated volatility from the estimated average earnings. This can be very useful for forecasting turning points in freight markets. Therefore, our multi-state MSR framework is twofold. First, we apply the following simple regime switching model for the full data sample, to empirically capture the observed exogenous structure-break, this is expressed as:

$$\begin{bmatrix} Regime1: y_t = \mu_1 + \epsilon_{1t} & \epsilon_{1t} \sim N[0, \sigma_1^2] \\ Regime2: y_t = \mu_2 + \epsilon_{2t} & \epsilon_{2t} \sim N[0, \sigma_2^2] \\ Regime3: y_t = \mu_3 + \epsilon_{3t} & \epsilon_{3t} \sim N[0, \sigma_3^2] \end{bmatrix} \quad (2)$$

Where the specification within each estimated state is linear and the resulting time-series model is non-linear. Moreover, regimes are arbitrary and the mean can be expressed as a function of s_t:

$$\mu(s_t) = \begin{bmatrix} \mu_1 \; if \; s_t = 1 \quad (Low \; volatility \; State \; Pre - ExSB) \\ \mu_2 \; if \; s_t = 2 \quad (High \; volatility \; State \; Pre - ExSB) \\ \mu_3 \; if \; s_t = 3 \quad (Boom \; shift \; Post - ExSB) \end{bmatrix} \quad (3)$$

Where *ExSB* represents the estimated exogenous structure-break and the unobserved random variable s_t follows a Markov chain, defined by transition probabilities between the *N* states:

$$p_{i|j} = P[s_{t+1} = i | s_t = j] \qquad i,j = 0,1, \ldots N-1. \quad (4)$$

The probability of moving from state *j* in one period to state *j* in the next depends only on the previous state, where the system sums to unity such that; $\sum_{i=0}^{N-1} p_{i|j} = 1$and the full matrix of transition probabilities is $P = (p_{i|j})$. An exception is made for Suezmax segment where we find that a four regime is more appropriate, the additional state is identified as a transitional period between the low and high volatilities states pre-2000.

Second, we examine the post exogenous-break period with a three-state MSR model. Trials of several MSR models have been undertaken by the authors with numerous states, the choice of a tree-state prevails empirically. This is expressed as:

$$\begin{bmatrix} Regime4: y_{t+PExSB} = \mu_4 + \epsilon_{4t} \quad \epsilon_{4t} \sim N[0, \sigma_4^2] \\ Regime5: y_{t+PExSB} = \mu_5 + \epsilon_{5t} \quad \epsilon_{5t} \sim N[0, \sigma_5^2] \\ Regime6: y_{t+PExSB} = \mu_6 + \epsilon_{6t} \quad \epsilon_{6t} \sim N[0, \sigma_6^2] \end{bmatrix} \quad (5)$$

Where *PExSB* is post the exogenous structure-break of 2000 and the mean is expressed as a function of s_t:

$$\mu(s_t) = \begin{bmatrix} \mu_4 \; if \; s_t = 4 \quad (Contraction \; State) \\ \mu_5 \; if \; s_t = 5 \quad (Transitional \; State) \\ \mu_6 \; if \; s_t = 6 \quad (Expansion \; State) \end{bmatrix} \quad (6)$$

This paper postulates that a multi-state Markov-switching regime framework is useful for testing the hypothesis of consistent and significant structure shifts within freight earnings, across different tanker segments. Assuming that freight level earnings are stationary and do fluctuate between two distinct regime states, low volatility state and high volatility state, we carryout a three-state MSR analyses on four different tanker segments. The inclusion of a third state aims to captures any significant structure shift in earning levels. This approach identifies a consistent and clear departure in the dynamics of freight earning post the second quarter of the year 2000, for all tanker markets. Therefore, a Chow test (1960) is implemented to examine the significance of such structure breaks. Thus, identifying a distinctive structure shift in freight earnings, referred to in this study as a super boom-cycle. Furthermore, Perron (1997) unknown endogenous time break test is carried out on the identified boom-cycle and once a time break has been identified the test is repeated starting from this point. Findings indicate three significant impacts on tanker earnings causing structure breaks that are consistent across all tanker segments. These coincide with an increase in shipping finance innovation and developments in the shipping industry, a global boom in trade and the financial crisis, respectively.

2.3.3. Structure change and testing for structure breaks

Perron (1989) argues that Dickey-Fuller procedure is biased in accepting the null hypothesis of a unit root for a time series with structures breaks and that this biased is more pronounced as the magnitude of the break increases. Perron (1989) proposed a modified DF test for a unit-root in the noise function with three different types of deterministic trend function, given a known exogenous structure break, he argues that most macroeconomic variable appear to be trend stationary coupled with structure breaks, suggesting that most these variables induced a one time fall in the mean caused by exogenous shocks (1929 financial crisis and the 1973 oil crisis). Perron's analysis is based on the assumption of only one break point occurring in a time series and the choice of this break point is based on the smallest t-statistic among all possible break points, for testing the null hypothesis of a unit root. In other words, these tests results do not rollout the possible existing of more than one breakpoint, therefore, pointing out the most significant of all. Furthermore, suggesting that Dickey-Fuller framework is not adequate to test for unit root in the presence of structure breaks and that the test statistics are biased towards the non-rejection of a non-stationary, Perron (1989). One shortcoming of Perron's procedure is that the test is based on a known (exogenous) structure-break; this is a serious drawback as the point of structure break in most studies is the point of investigation, as it is in this thesis.

Improving on his previous work, Perron modifies his unit root test to test for an unknown (endogenous) structure-break, Perron (1997). This improved procedure to test a time series for unit root in the presence of one unknown structure break does not rollout the presence of more than one structure break. Therefore, this test in our analysis is used to investigate the most significant structure shift in a time series. The optimal break date T_b is chosen by minimizing the *t*-statistic for testing $\beta_0 = 1$, in the following regression:

$$\Delta f_t = \alpha + \theta DU_t + \delta D(T_b)_t + \beta d_t + \gamma DT_t + \beta_0 f_{t-1} + \sum_{i=1}^{k} \beta_i \Delta f_{t-i} + u_t \quad (7)$$

Where both a change in intercept and the slop is allowed at time T_b. The test is performed using the *t*-statistic for the null hypothesis that $\beta_0 = 1$ and include dummy variables that take value of one as; $D(T_b)_t = 1$ if $t = (T_b + 1)$, $DU_t = 1$ if $(t > T_b)$ and $DT_t = 1$ if $(t > T_b)t$. The number of lags for k is selected on a general to specific recursive procedure based on the t-statistic on the coefficient associated with the last lag in the estimated autoregression, for details see, Perron (1997).

Testing freight earnings for significant structure breaks by implement the above test on the whole sample identifying the most significant break point in the series, this revels a significant upward structure shift in earning levels that is consistent across all tanker routes. Therefore, we repeat the procedure starting from the identified time break to investigate the boom period for any structure breaks.

3. *Empirical Findings*

3.1. Data description and analysis

The analysis of this study is based on a constructed data set that better represent spot freight rates, for four tanker segments and also a series representing the overall tanker freight market. These series' are average time-charter-equivalent (TCE)[3], a measure of freight earnings in dollars per day, representing the cost of daily hire for a tanker vessel, excluding voyage (variable) costs such as bunker cost. This data set was provided by Clarkson intelligence network for four tanker segments; VLCC, Suezmax, Aframax and Panamax, in addition, to a weighted average of the overall tanker sector.

The data sample under investigation starts from May 5, 1990 through December 31, 2010. Clarkson network provide two time series' that represent average earnings for three tanker segments, reflecting freight earnings, for vessels built in early nineties and another for modern vessels. Therefore, our sample starts with average 1990 tankers series and than is rolled over to modern tanker series to obtain a longer and more comprehensive time series'. This constructed data set for three segments better represents freight earnings for the last 20 years, as most vessels that were built in the nineties were phased out and current employed vessels are of the modern type, these vessels are more efficient, reliable and comply with the International Maritime Organisation (IMO) safety and environment regulations.

Table 1: Rollover points for the constructed data set

	Average Earnings Built 1990/91	Average Earnings Modern
VLCC	05/01/1990 to 27/12/1996	03/01/1997 to 31/12/2010
Suezmax	05/01/1990 to 27/12/1996	03/01/1997 to 31/12/2010
Aframax	05/01/1990 to 27/12/1996	03/01/1997 to 31/12/2010
Panamax	Dirty Products 50K Average Earnings	
WATE	Weighted Average Earnings All Tankers	

Note: Table 1 illustrates the rollover points between the two sets for three segments to provide the series used in this study.

In general terms the cost of shipping services are expressed through two distinct transactions; the freight voyage contract; and the time charter contract, where in the latter ships are hired by the day for a specific period of time and expressed in dollars per day.

[3] For details of calculation of TCE and the associated assumptions see Sources and Methods document at shipping intelligence network website, www.clarksons.net

The TCE weakly spot freight earnings calculated by Clarkson is similar to time charter contracts measures, and is considered to be an accurate estimate of vessels net earnings that had formed the bases of empirical work within maritime literature, for more example see Koekenakker *et al* (2006) ,Adland *et al* (2006) and Alizadeh and Nomikos (2011).

Basic statistics for TCE spot freight earnings clearly indicate a positive correlation between the size of tanker vessels and their four statistic moments, the larger the size of the tanker vessel the higher the daily mean earnings, volatility levels and excess returns. Excess freight volatility is evident in the wide spread between minimum, mean and maximum values for freight price-level earnings. All routes show signs of positive skewness, high kurtosis and departure from normality represented by the Jarque-Bera test. There is also clear evidence of ARCH effects in freight price-levels and returns, with different lag levels, shown by Engle's ARCH test (1982).

Table2: Basic Statistics for Segments of Tanker Freight Prices/Returns.

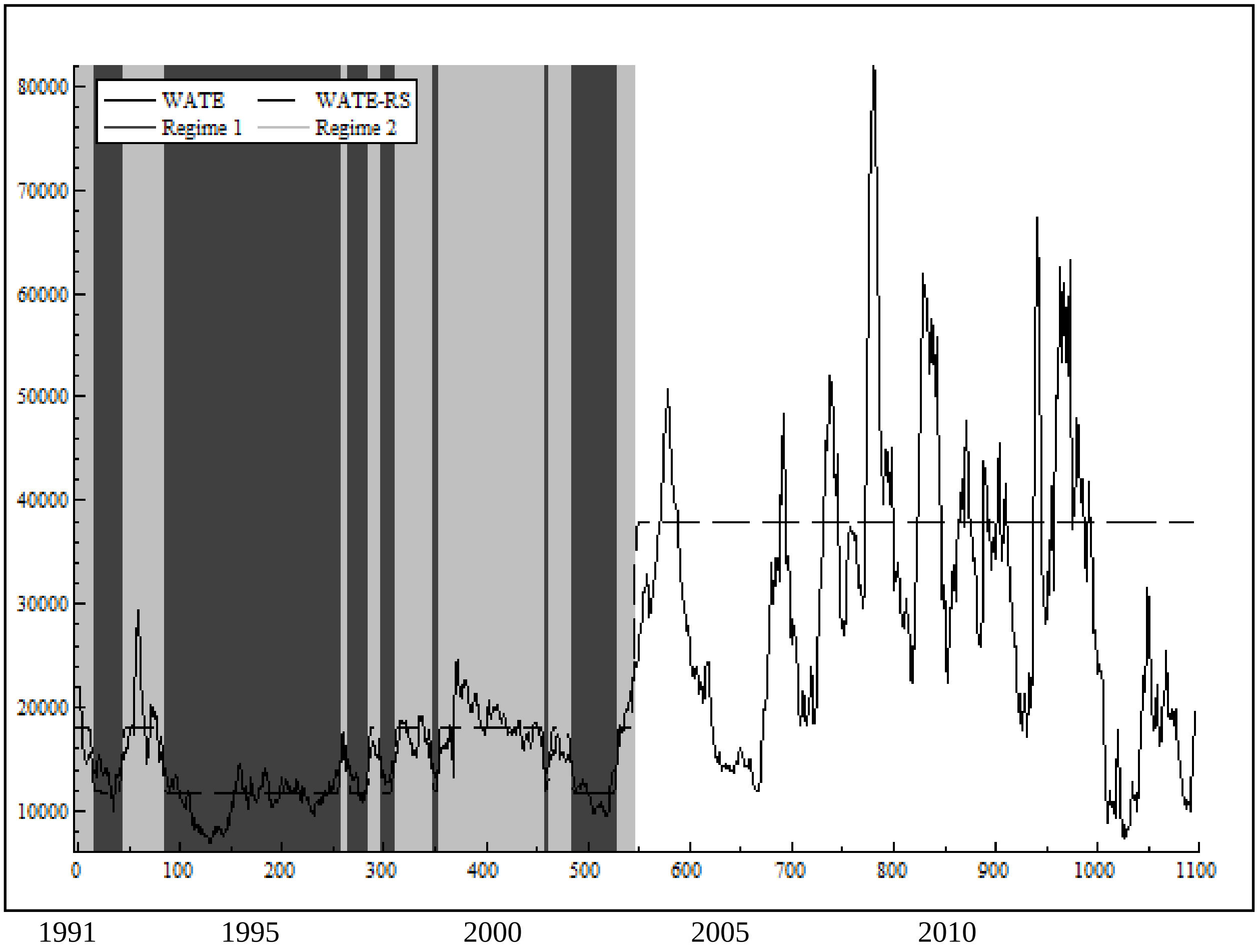
Freight Price Level Earnings 05-01-1990 to 31-12-2010 (1096 observations)					
Segments	VLCC $/Day	Suezmax $/Day	Aframax $/Day	Product $/Day	WAT $/Day
Minimun	$8,785	$6,535	$8,625	$3,577	$6,861
Mean	$42,596	$32,178	$28,939	$20,823	$22,621
Maximum	$229,480	$155,120	$126,140	$76,703	$81,999
Std Dev	$31,410	$23,323	$18,599	$13,206	$12,987
Skewness	2.3074 (31.23)**	1.8697 (25.31)**	1.8264 (24.72)**	1.4759 (19.97)**	1.441 (19.50)**
Excess Kurtosis	7.471 (50.60)**	4.140 (28.04)**	4.078 (27.62)**	2.112 (14.30)**	2.016 (13.66)**
ARCH (1-2)	3177.3 [0.00]	2685.9 [0.00]	6027.9 [0.00]	9469.5 [0.00]	11112 [0.00]
ARCH (1-5)	1373.3 [0.00]	1070.3 [0.00]	2411.5 [0.00]	3788.2 [0.00]	4508.5 [0.00]
ARCH (1-10)	691.19 [0.00]	577.21 [0.00]	1240.2 [0.00]	1909.8 [0.00]	2310.8 [0.00]
ARCH (1-20)	346.04 [0.00]	291.04 [0.00]	629.08 [0.00]	986.45 [0.00]	1192.5 [0.00]
Normality Test	3521.4 [0.00]	1421.4 [0.00]	1368.7 [0.00]	601.5 [0.00]	564.90 [0.00]

Note: Table 2 Reports summary of basic statistics of price-level earnings for weekly shipping freight rates, for four tanker segments. Total observations are 1096. It is clear from minimum, maximum and standard deviation of freight prices the large spread and high volatility in freight prices. All routes show signs of positive skewness, high kurtosis and departure from normality represented by the Jarque-Bera test, the 5% critical value for this statistic is 5.99. Values ( ) are t-statistics, and ** represent significance level at 1%. Values in [ ] are p values, which are significance for all routes. Engle's ARCH (1982) test is used to examine the presence of ARCH effects in freight series, with 2,5,10 and 20 Lags.

3.2. Freight earnings expressed in regime states

A visual inspection of tanker earnings in figure 1 clearly identifies two prolonged recessions, the first, post the dot-com crisis, third quarter of 2001, lasting for 15.5 months, the second, post the financial crisis, first quarter of 2009 and still going on. Additionally, an outstretched and extreme volatile period of expansion is determined between the last quarter of 2003 and third quarter of 2007. Furthermore, average earnings and freight volatilities pre-2000 had fluctuated between two regime-states, high and low, and that post- 2000 clear structures shift occurred causing a significant change in the dynamics of freight earnings. On one hand, this shift in the structure of freights post the boom time break is most likely to be a permanent one simply because of the innovations that followed, for example; the growing use of freight derivatives and the new methods in financing new built. On the other hand, if this was a temporary shift representing a shipping business cycle and affected by random events and with freight rates reverting to the previous structure levels, this could have serious implications for shipping finance as low volatility levels coinciding with low demand will damage the derivatives markets. We examine pre and post periods of the structure-break through a multi-state Markov-switching regime model.

Figure 1: A Three-State Regime for Tanker Earnings



Note: the graph illustrates tanker market state dependency, were structure change is represented by a three-state regime, the dashed line. Tanker earnings are represented by a weighted average for all tanker earnings, the solid line, for the period from 05/01/1990 to 31/12/2010. The shaded areas represent high and low volatility states pre-2000 and the white area represents structure shift post-2000. This is based on output of a markov-switching regime model.

3.2.1. Analysis of structure breaks and volatility levels in freight earnings

Implementing a Markov-switching regime framework on four segments of the tanker market clearly indicate that tankers' earnings in general terms switch between two distinct sates; low earning state and high earning state, these states exhibit low and high fluctuations in their earnings, respectively. Put into perspective, daily earnings for a VLCC can fluctuate between $14,500 and $38,700 this is an excess/deficiency of $24,000 a day depending on the current market regime state. As for a product vessel, daily earnings for a Panamax fluctuate between just under $8,000 and $18,700 with an excess/deficiency of $10,000 a day. On average daily earning in the tanker segment increase/decrease by nearly 100% when market freight conditions shift from a low/high regime state to a high/low regime state. Averages and volatilities of freight price-levels are consistent with basic statistics findings and maritime literature, in respect of their positive correlation with the size of employed vessel.

Thus, larger tanker vessels exhibit higher freight earnings and volatilities in comparison to smaller tankers, which is consistent across all regime states. This finding is aligned with maritime economic theory, stating that while demand for shipping services is inelastic, the supply of shipping services is highly elastic when freight rates are at low levels and highly inelastic when freight rates are at high levels due to the restricted supply of shipping services.

Thus, on one hand, low freight earnings accompanied by low volatilities are explained by excess of shipping services in comparison to demand, hence, low freight rates due to efficient shipping markets, causing low steaming of vessels to save on fuel costs and an increase in the number of vessels exiting the markets by taking either the option of layup (that cant be maintained for a long time, especially for ships financed by expensive loans) or exiting through the scrapping market.

On the other hand, high freight earnings accompanied by high volatilities are explained by deficient shipping services in comparison to demand, market conditions characterised by fast steaming, short ballast hauls and an increase in new built orders.

Moreover, there is a distinct and consistent shift in level of earnings and volatilities of freights for all tanker segments, which had occurred at the second quarter of the year 2000, this coincided with the boom period that had lasted on average for 550 weeks. The results indicate that tanker freight average daily earnings and volatilities levels had shifted from $18000 to $38000 and from $2400 to $11000, respectively. This is an increase in freight earnings and its volatilities for all tanker segments of more than 100% and 350%, respectively. Furthermore, the segment sector is an important influence on the magnitude of these shifts which is clearly positively correlated with the size of tanker. The results of the MSR framework is reported in table 3. Tanker freight earnings pre the boom-cycle from 1990 to 2000, is better captured by a distinct two state regimes, while post the 2000 structure shift, a more volatile distinct structure is appropriate.

The post-boom structure breaks are not explored in this paper and is recommended for future research. Furthermore, the significance of these structure breaks is tested to adequately question this framework, the results for these tests are reported in table 4. A Chow test for a single known structure break is conducted to examine the hypotheses of a significant structure shift in tanker freight earnings during the second quarter of 2000. The results are consistent and significant across all tanker segments, in other words these structure shifts are significant breaks. This is aligned with the equal variance tests which indicate that pre and post boom periods are distinct periods. In our analysis we refer to the period post this distinct structure break as the super boom-cycle that coincided with the most recent world economical boom.

As for examining stationarity, a Unit-Root test indicates that a unit root hypotheses are rejected at 5% significant level for all tanker routes. We also carry out the Perron (1997) unit root test with an unknown endogenous break; this test is implemented to investigate the most significant structure break, as this is a one break test that does not rollout the possibility of more than one structure break. Results point out that for all segments there are two distinct structure breaks around the 4th quarter of 2003 and the 4^{th} quarter of 2007, coinciding with the global economical boom and the recent financial crisis, respectively. All structure tests are reported in table 4.

Table 3: Markov-Switching Conditional Variance Regime Models Estimations for Weekly Tanker Freight Earnings.

	VLCC	Suezmax	Aframax	Product 50k	WATE
Regime 1 MWP	18347.4 (90.8)†	13091.2 (84.1)†	14183.3 (70.6)†	9812.17 (56.5)†	11769.8 (44.8)†
Regime 2 MWP	33226.4 (154.0)†	19440.4 (85.4)†	22576.6 (97.6)†	16325.5 (80.2)†	18147.0 (47.7)†
Regime 3 MWP	76121.2 (69.8)†	30669.8 (127.0)†	50000.6 (60.4)†	36307.7 (91.7)†	37922.2 (49.5)†
Regime 4 MWP		65508.8 (85.1)†			
Volatility Regime 1	3810.98 (21.8)†	2486.81 (21.0)†	2235.54 (13.4†)	1841.82 (12.7)†	1916.50 (20.5)†
Volatility Regime 2	5531.26 (31.7)†	1800.71 (19.6)†	3425.15 (19.6)†	2430.30 (24.0)†	2389.45 (11.3)†
Volatility Regime 3	33337.8 (297.0)†	5494.32 (46.0)†	17834.9 (69.8)†	11484.1	11132.0 (71.0)†
Volatility Regime 4		22280.3 (77.0)†			
Transition $\pi11$	0.959711 (72.9)†	0.947027 (53.6)†	0.976462 (103.0)†	0.969859 (90.3)†	0.976579 (108.0)†
Transition $\pi22$	0.959126 (73.8)†	0.907758 (42.0)†	0.969323 (78.2)†	0.960465 (76.4)†	0.967851 (83.4)†
Transition $\pi33$	1.0	0.934066 (35.3)†	1.0	1.0	1.0
Transition $\pi44$		1.0			
Transition $\pi12$	0.040289	0.052973	0.023538	0.030141	0.023421
Transition $\pi13$	0	0	0	0	0
Transition $\pi14$		0			
Transition $\pi21$	0.0373000 (2.99)†	0.0588513 (3.3)†	0.0267289 (2.3)*	0.0355206 (2.9)†	0.0281118 (2.59)†
Transition $\pi23$	0.0035743	0.033391	0.0039484	0.004014	0.0040373
Transition $\pi24$		0			
Transition $\pi31$	0	0	0	0	0
Transition $\pi32$	0	0.0565277 (2.3)*	0	0	0
Transition $\pi34$		0.0094068			
Transition $\pi41$		0			
Transition $\pi42$		0			
Transition $\pi43$		0			
Avg Weight Regime 1	23.72%	21.53%	26.46%	26.64%	27.28%
Avg Duration Regime 1	23.64 Weeks	21.45Weeks	48.33 Weeks	32.44 Weeks	42.71 Weeks
Avg Weight Regime 2	25.46%	18.80%	22.90%	22.90%	22.45%
Avg Duration Regime 2	23.25 Weeks	11.44 Weeks	35.86 Weeks	25.1Weeks	30.75 Weeks
Avg Weight Regime 3	50.82%	9.49%	50.64%	50.46%	50.27%
Avg Duration Regime 3	557 Weeks	14.86 Weeks	555 Weeks	553 Weeks	551.0 Weeks
Avg Weight Regime 4		50.18%			
Avg Duration Regime 4		550 Weeks			

Note: Table 3 reports summary of Markov-Switching Regime model estimations, for different segments of tanker weekly fright price-level earnings, illustrating statistics for each regime state, in the form of; average earning, fluctuating range (volatility), average weight, average duration transition probabilities between all states according to the following form; Transition probabilities $\pi_{i|j} = P(\text{Regime } i \text{ at } t \mid \text{Regime } j \text{ at } t+1)$. A transition probability of 1.0 represents the probability of staying in the boom state. Estimation is based on the sample 05/01/1990 to 31/12/2010, number of Observations are 1096. † and * represents significance level at 1% and 5%, respectively.

Table 4: Unit-Root and Structure-Breaks Tests for Tanker Freight Earnings

Test	VLCC	Suezmax	Aframax	Product 50k	WATE
A Chow Test for a Single known (Based on a MSR framework) Significant Structure Break					
Total Obss	1096	1096	1096	1096	1096
Chow T	F(2,1092)= 4.33 [0.0133]	F(2,1092)= 6.34 [0.0018]	F(2,1092)= 3.51 [0.030]	F(2,1092)= 3.91 [0.020]	F(2,1092)= 2.24 [0.106]
Equal Var T	F(555,537)= 20.88 [0.000]	F(548,544)= 21.75 [0.000]	F(553,539)= 25.25 [0.000]	F(551,541)= 9.48 [0.000]	F(549,543)= 12.02 [0.000]
Break Date	05/05/2000	23/06/2000	19/05/2000	02/06/2000	16/06/2000
Time Break	540	547	542	544	546
ADF Unit-Root Test with only a Constant					
ADF(Lags)	-5.161**(5)	-3.439*(16)	-3.250*(19)	-3.081*(17)	-3.220*(20)
AIC	18.237	17.781	16.617	15.689	15.344
BIC	18.27	17.865	16.715	15.777	15.446
HQ	18.25	17.813	16.654	15.722	15.383
Unit-Root Critical Values 5% =-2.86* 1% =-3.44** MacKinnon (1991)					
ADF Unit-Root Test with a Constant & Trend					
ADF(Lags)	-5.934**(5)	-4.276**(16)	-4.103**(20)	-3.792*(17)	-3.887*(20)
AIC	18.231	17.777	16.614	15.686	15.342
BIC	18.269	17.865	16.654	15.779	15.448
HQ	18.245	17.81	16.654	15.721	15.382
Unit-Root Critical Values 5% =-3.42* 1% =-3.97** MacKinnon (1991)					
A Unit-Root Test with an Unknown Endogenous Time Break Perron (1997) Examining the sample 5/01/1990-31/12/2010					
ADF-TB(Lags)	0.91106 (-6.654)** (5)	0.90243 (-6.5851)** (8)	0.93235 (-6.4371)** (10)	0.92188 (-8.3056)** (2)	0.95072 (-5.9258)** (11)
Break Date	10/10/2003	26/09/2003	26/09/2003	31/10/2003	17/10/2003
Time Break(1)	719	717	717	722	720
Unit-Root-TB Critical Values 5% =-5.08* 1% =-5.57**					
A Unit-Root Test with an Unknown Endogenous Time Break Perron (1997) Examining the sample From the Time-Break(1) to the End of the Sample					
ADF-TB(Lags)	0.85058 (-6.4549)** (3)	0.82062 (-5.3527)* (8)	0.87327 (-5.4493)* (8)	0.88627 (-6.1191)** (1)	0.91230 (-5.5429)* (3)
Break Date	07/12/2007	09/11/2007	02/11/2007	26/12/2008	23/11/2007
Time Break(2)	936	932	931	991	934
Unit-Root-TB Critical Values 5% =-5.08* 1% =-5.57**					

Note: Table 4 Reports in four parts a summary of structure-breaks and Unit-Root tests statistics for weekly price-level earnings for tanker shipping freight rates, this represents four tanker segments. The first part: illustrate chow and equal variance tests with known time-breaks, this time-break and date-break is based on the starting of the boom cycle for each segment, indicated by the output of the MSRCV model. the second and third parts: illustrates outputs of ADF tests with constant and constant & trend, respectively. The final part; illustrate Perron (1997) Unit-Root procedure with unknown time-break. * and ** represents significance level at 5% and 1%, respectively.

3.2.2. The Tanker Freight Super-Boom Period

Finding indicate that tanker freight earnings post the year 2000 structure break follow periods of expansions and contractions constructing a 10 year cycle; this consists of eight boom and recession mini-cycles. The dynamics of these cycles are well documented and illustrated in table 6, and graphs 4, 5 and 6. Furthermore, estimated results for the used three-state Markov-switching regime framework are well pronounced in table 5. It is interesting to examine the 5th cycle that lasts for nearly 45 months marking the longer expansion period in the last decade for shipping, starting from the 4th quarter of 2003 through out the 3rd quarter of 2007, in respond to a 17.3% boost in oil seaborne trade, this is part of a nearly 21.5% increase in total seaborne trade between the years of 2003 and 2007.

On the other hand, the 8th cycle, which lasts for more than 21 months indicate the longer extraction period in the last decade[4], from the 1st quarter of 2009 until the 4th quarter of 2010. The seventh cycle lasted for a one year and four months starting from the last quarter of 2007 ending in the first quarter of 2009, representing the most rewording expansion period during the 10 year cycle, with a daily earning average of nearly $41,529 fluctuating by nearly $11,965. In graphs 5 and 6, we demonstrate dynamic changes in freights during the boom-period, these are upwards and downwards changes in average earnings and average volatilities, respectively. Highlighting structure changes across all regime states, for tanker segments earnings, in which large parcel size tankers exhibit an increasing higher volatilities levels pre and post the structure shift.

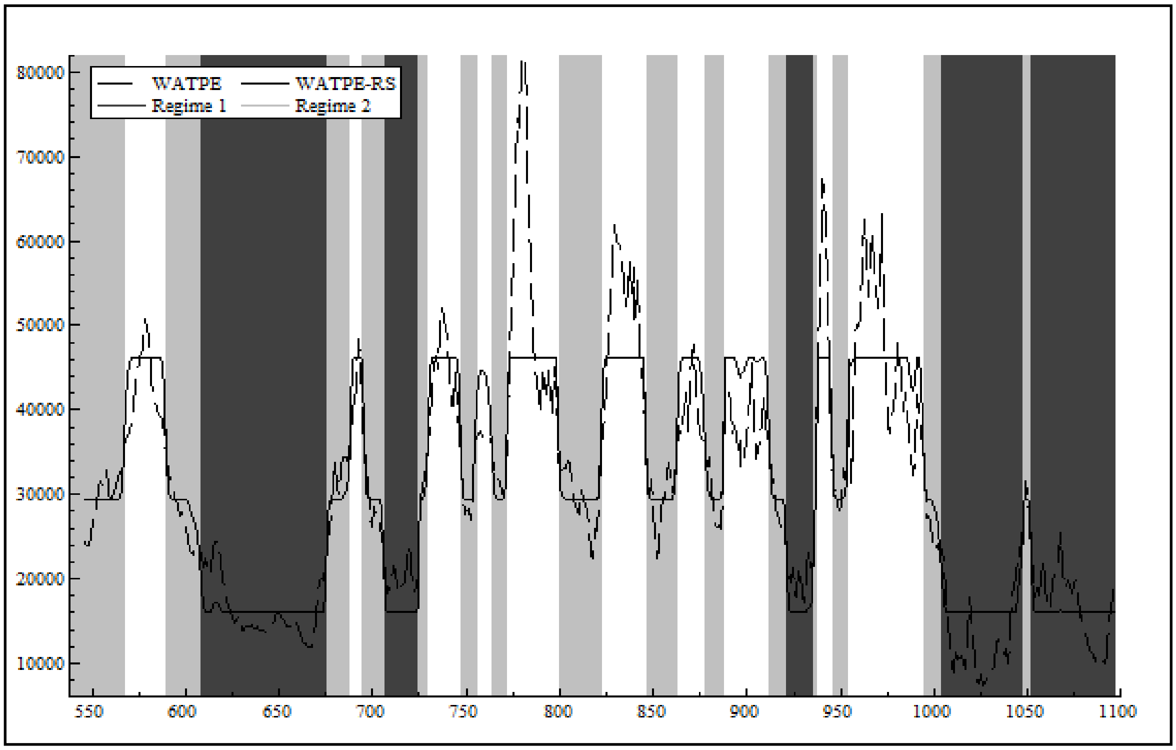
Table 5: Markov-Switching Conditional Variance Regime Models Estimations for Weekly Tanker Freight Earnings (Boom-Cycle)

Markov-Switching Conditional Variance Model Estimations for Tanker Price Earnings (Boom-Period)					
	VLCC	**Suezmax**	**Aframax**	**Product 50k**	**WATE**
Start of Boom-Period	**05/05/2000**	**23/06/2000**	**19/05/2000**	**02/06/2000**	**16/06/2000**
Regime 1 MWP	24821.2 (34.7)†	20763	19431.5 (7.99)†	14287.1 (48.5)†	16085.5 (49.4)†
Regime 2 MWP	52751.6 (48.6)†	41836.1 (18.6)†	37302.7 (8.02)†	27661.9 (78.4)†	29390.9 (47.4)†
Regime 3 MWP	97167.5	74560.5 (17.8)†	62111.6	44721.3 (65.0)†	46219.7 (33.7)†
Volatility Regime 1	7822.43	6278.17 (23.5)†	5236.1	4106.46 (25.2)†	4141.00 (11.5)†
Volatility Regime 2	6977.36	5854.95 (21.5)†	4776.44	3603.85 (18.4)†	3566.23 (17.5)†
Volatility Regime 3	35415.8	22019.6	17677.9	10391.4 (57.0)†	9822.79 (34.3)†
Transition π11	0.938542 (51.7)†	0.943408 (46.5)†	0.970532 (72.0)†	0.964014 (68.3)†	0.977972 (89.3)†
Transition π22	0.866625 (31.1)†	0.848180 (25.1)†	0.900141 (38.3)†	0.891186 (35.9)†	0.907244 (38.9)†
Transition π33	0.93642	0.9108	0.93361	0.93397	0.94418
Transition π12	0.0513827 (3.02)†	0.056592	0.029468	0.035986	0.022028
Transition π13	0.010076	0	0	0	0
Transition π21	0.0707885 (3.51)†	0.0573336 (2.77)†	0.0343439 (2.46)*	0.0386606 (2.51)*	0.0302588 (2.25)*
Transition π23	0.062587	0.094487	0.065515	0.070154	0.062497
Transition π31	0	0	0	0	0
Transition π32	0.0635785 (3.19)†	0.0891973 (2.92)†	0.0663949 (2.45)*	0.0660337 (3.52)	0.0558200 (3.10)†
Avg Weight Regime 1	33.03%	31.82%	33.51%	34.36%	34.48%
Avg Duration Regime 1	15.33 Weeks	14.58 Weeks	31 Weeks	27.14 Weeks	38 Weeks
Avg Weight Regime 2	30.88%	32.73%	33.69%	32.37%	30.31%
Avg Duration Regime 2	8.19 Weeks	6.21 Weeks	11 Weeks	8.95 Weeks	11.13 Weeks
Avg Weight Regime 3	36.09%	35.45%	32.79%	33.27%	35.21%
Avg Duration Regime 3	18.27 Weeks	12.19 Weeks	16.55 Weeks	15.33 Weeks	19.4 Weeks

Note: Table 5 Reports summary of Markov-Switching Regime model estimations, for different segments of tanker weekly fright price-level earnings, illustrating statistics for each regime state, in the form of; average earning, fluctuating range (volatility), average weight, average duration transition probabilities between all states according to the following form; Transition probabilities π_{i|j} = P(Regime i at t | Regime j at t+1). A transition probability of 1.0 represents the probability of staying in the boom state. Estimation is based on the sample 05/01/1990 to 31/12/2010, number of Observations are 1096. † and * represents significance level at 1% and 5%, respectively.

[4] There are no clear evidence that this cycle had ended yet, as the end of the cycle represents the end of the data sample.

Figure 4: A Three-State Regime for Tanker Earnings



Note: the graph illustrates regime states for different tanker segments imposed on average tanker earnings price levels for the super boom-cycle period from 16/06/2000 to 31/12/2010

Table 6: Expansions and Contractions during the Super Boom-Cycle period

	VLCC		Suezmax		Aframax		Product 50k		WATE	
	Avg	SD	Avg	SD	Avg	SD	Avg	SD	Avg	SD
Cycle 1	65,934	14,173	53,501	11,749	44,490	8,255	30,418	5,024	33,461	7,734
Cycle 2	21,797	9,620	19,540	6,221	18,897	5,213	15,183	3,372	16,389	3,508
Cycle 3	60,547	15,446	47,642	13,042	41,257	8,963	29,962	8,217	32,708	6,377
Cycle 4	33,335	14,184	20,085	5,647	22,284	4,597	17,337	2,926	19,976	1,625
Cycle 5	73,247	34,518	57,964	23,632	50,832	18,591	**40,449**	**12,498**	39,320	11,742
Cycle 6	29,847	5,068	24,126	7,085	23,460	3,780	20,871	3,209	20,219	1,890
Cycle 7	**95,840**	**45,757**	**70,267**	**28,490**	**58,635**	**21,593**	37,114	9,795	**41,529**	**11,965**
Cycle 8	37,346	17,223	26,324	11,464	22,194	8,752	14,373	5,713	15,550	5,497

Figure 5: Average Tanker Freight Earnings during the Boom Cycle

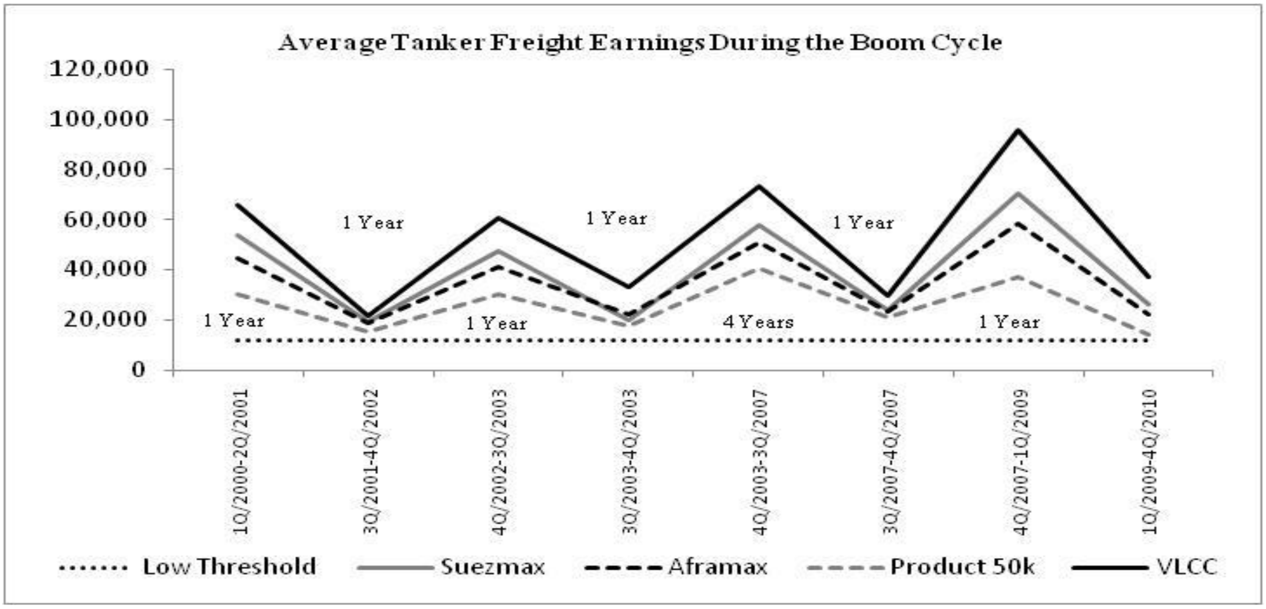
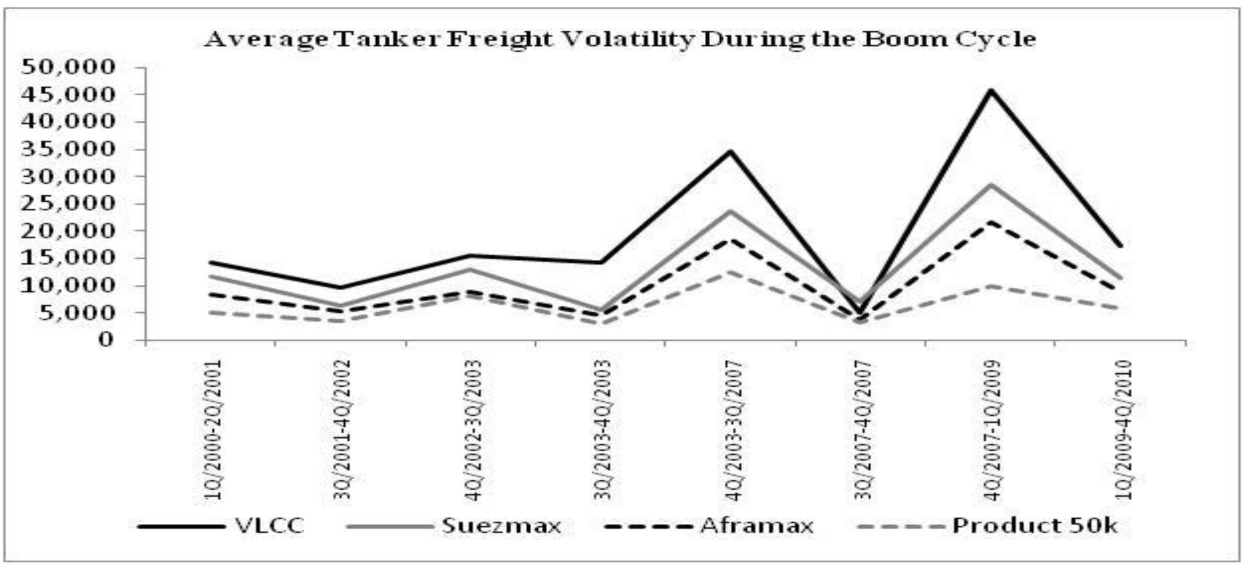


Figure 6: Average Tanker Freight Volatility during the Boom Cycle



4. Exogenous and endogenous factors affect on shipping business cycles

It is hard to see long-term cycles in shipping markets to be determined endogenously, as suggested by Randers and Göluke (2007). Our view is that, freight dynamics are driven by the interaction of both endogenous and exogenous factors and that the magnitude of these affects depends entirely on prevailing market conditions at the time. This postulate is supported by our empirical findings, that exogenous structure-breaks within the freight markets are caused by macroeconomic events (the fact that demand for freight services are derived by demand for seaborne trade), these exogenous effects generate a change in shipping business cycles that are represented through endogenous breaks, due to equilibrium adjustments in freight services. In other words, a global economical event such as the most recent global boom or the financial crisis (exogenous effect), lead to significant changes in global trade effecting global shipping by increasing/decreasing demand for shipping services, with shipping being efficient markets, supply of shipping adjusts to changes in demand, the level of adjustment depends on the capacity and utilization of the current fleet (endogenous effect).

On one hand, low freight earning levels lead to slow steaming of vessels to reduce bunker costs, these low levels of earnings trigger an increase in laid-up vessels, coinciding with lower freight volatility levels. On the other hand, high freight earning levels lead to short ballast haul[5], this causes an increase in the number of employed vessels, which leads to a shift in the elasticity of the supply side, and this causes high volatility levels in freight earnings. For further research, this framework could provide empirical insight into the mechanisms of shipping cycles, Thus, the emphasis is clear on the importance of taken this in account when modelling and forecasting freight volatilities and in improving techniques of risk management.

An economical shock such as the most recent financial crisis caused a sudden reduction in demand for sea transport, triggering an end to a prolonged boom period. The question is how long it will take the shipping markets to react to such economical shock? Our view is that, here where endogenous factors come to play, as the capacity adjustment and utilization of the current fleet determine the time lag. In addition to the timing of the economical event in relation to market phase. For example the recent financial crisis had occurred in a time that shipping markets had enjoyed four years of expansions in, fleet capacity, shipping finance and freight derivatives markets, during this time extreme high, freight levels and volatility prevailed attracting new players, such as hedge funds, traders and the like.

5. Conclusion

Empirical evidence support the postulate that freight price-level and freight volatility fluctuate in general between high and low states.

Furthermore, one cannot overlook an observed upward shift in tanker earning levels across different tanker segments. Therefore, a multi-state Markov-switching regime model was implemented to further examine the existence of structure shifts within the tanker freight market and to capture freight dynamics. This framework provides the flexibilities' for averages and volatilities to switch between different states with distinct characteristics reflecting the state of the market. What's more, unit root tests indicate that our constructed time series data is stationary overall at 5 per cent significance level. Even though, primarily unit-root tests indicate that tanker freight earnings are satisfactory stationary, it is clear that a modified unit-root test to accommodate for endogenous structure breaks improve our results.

A three-state markov-switching model applied to weekly freight rates for the full sample, indicate that post the second quarter of 2000, the structure of the tanker freight markets shift to a much more volatile state with a higher mean across all tanker segments, this shift had lasted for more than 10 years. This fits with part of maritime literature, where it is suggested that shipping cycles consist of three events; a trade boom, a short shipping boom that triggers overbuilding, followed by a prolonged slump. While Fayle (1993) disagrees on the sequence, he argues that the boom is usually followed by a prolonged slump.For more details see Stopford (2009, p. 100). Furthermore, analysis of the boom period reveals two significant breaks. These shifts mark the start of the longer and most significant expansion cycles during the boom period. The former responded to an increase in oil seaborne trade of 17.3% between the years of 2003 and 2007. While the latter was in response to the turmoil in the banking sector caused by the financial crisis, leading to uncertainty and creating massive pressure on ship-owners that had financed their purchase with expensive loans. This triggered numerous exits leading to a temporarily prolonged period of excess in demand for shipping services.

This paper argues that shipping business cycles are derived endogenously and that changes in their dynamics are influenced exogenously. In other words, a global economical phenomenon triggers a change in, the length, the duration of the stages and the level of volatility, for the prevailing business cycle. Moreover, adjustments of supply to demand are determent endogenously, depending on the capacity and utilization of the fleet at the time.

[5] A vessel that is in a ballast haul refers to a vessel that has no loaded cargo and is ballasted and not earning any income.

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