**The Dynamics of fleet size and shipping profitability: The role of steel scrap prices.**

## 1. Introduction

The shipping industry has witnessed the phenomenon of an increasing number of vessels to be sold for scrap. These vessels are not necessarily at the end of their lives. The lower economic activity over the past ten years (contractionary phase of the shipping cycle), as well as regulatory requirements (ballast water system), has fostered this phenomenon, by making the operation of older ships inefficient. As a result, the ship-demolition industry has been thriving and decisively contributed to two important outcomes. First, it contributed to the adjustment of the fleet growth rate so that demand-supply imbalances are substantially reduced in the shipping sector and, second, it contributed to the growth of the emerging economies where it is located.

The ship recycling industry is an integral part of shipping. It can be thought of as a driving force in reinstating equilibrium in the supply and demand for vessels. When ship supply is greater than demand, freight rates drop. As a result, ship owners' earnings fall and this often leads to the selling of older vessels for scrap. Consequently, the fleet growth rate reduces so that supply adjusts to demand conditions, nurturing and moving towards an uprising phase of the shipping cycle.

The ship-recycling industry -valued at about $17 billion in 2017 (Clarksons 2017)- is mostly located in the South-East Asia, with countries like India, Bangladesh, Pakistan, and China accounting for over 96% of the scrapping market. As a land-based industry in these countries, demolition contributes to their economic growth, generating employment and income. The market price for scrap is determined within these countries by factors that play a significant role in their development process, like steel scrap and oil. Issues of environmental standards and safety have been of major concern in the operation of this industry, HKC (2009). China, one of the four largest ship dismantling countries, is considered ahead in implementing the relevant regulations. India has also made substantial progress through investment in safety measures and environmental protection (European Union, 2016). It is widely accepted that ship recycling exhibits lower cost in countries like Bangladesh and Pakistan where IMO regulations on safety standards are very slow to be implemented and also the activity of demolition is maintained through social embeddedness and strong family ties (Rahman and Mayer, 2015). In general, Southeast Asia has a competitive advantage over more industrialized countries in the ship-recycling industry for a number of reasons. First, there is lower labour cost since recycling attracts people from a pool of unemployed and is embedded in the social life of these countries. Second, they have lower compliance cost since they do not apply the costly regulations to a satisfactory level or do not apply them at all. Third, the recyclers have the advantage to getting better prices for re-rollable steel which is derived from ship scrap, as it can be used without any further processing.

The process of selling a ship for scrap involves three parties: the ship owner, the cash-buyer, and the recycler. The cash-buyers serve as mediators between the supplier and the shipyard where the ship is to be demolished. Cash-buyers bear financial risk by purchasing the vessel -which can be located anywhere in the world- from the ship owner. They are faced with two options, they can either sell the ship to the recyclers, or they can hold it, waiting for the demolition price to increase, and thus increase their profit margin. As a result, the demolition price is a crucial variable for the stakeholders: Shipyards, cash-buyers, as well as ship owners, are watchful for demolition prices and position themselves accordingly.

This study explores the interdependence between the multiple components of the nature of the demolition industry. So far, the extant literature has identified major determinants of ship scrap prices in the face of steel scrap, exchange rates, cost of demolition, second hand prices and freight rates, but it has also taken into account the distinct socioeconomic conditions in Southeast Asia, where this industry is concentrated. This study incorporates main literature findings (Karlis et al., 2016; Pour et al.,2012; Wang et al.,2014; Papapostolou et al., 2017) and reveals the path of interdependence between the different parts of the shipping sector and the ship breaking industry of the Indian subcontinent. This linkage impinges upon environmental issues which have come to the centre of attention over the last decade by major regulating bodies like IMO. That is the low-cost ship breaking industry of the Indian subcontinent allows higher scrap prices to be paid to ship owners which implies higher earnings and this link is embedded in creating a long-run relationship among shipping and the ship breaking industry. On the other hand, low cost implies lower environmental and safety standards in the ship breaking industry which is a major issue captured by the Hong Kong 2009 convention. First, we find evidence suggesting that demolition prices are determined by commodities important for the emerging economies. Indeed, apart from international steel scrap prices that have been found to influence demolition prices (Kagkarakis et al., 2016), this paper shows that nickel prices, along with seaborne trade and crude oil, are also significant. This is attributed to the economic environment of the major ship-breaking countries: they are all developing economies, heavily relying on the commodities of steel scrap and nickel. Secondly, we show that the scrap or demolition price contributes to the determination of earnings in the shipping sector, given that it is an integral part of the ship valuation process (on the part of revenues). Thirdly, we show that demolition canbalance out supply and demand in the market for vessels by contributing to the adjustment of fleet size. One of the major results of our paper is the finding that the interdependence between scrap prices, earnings and the size of the fleet is strong when the demolition price is determined by the Indian subcontinent, Bangladesh and Pakistan, are economies which consistently escape IMO regulations in dismantling a ship, whereas if the average Chinese  price is used the interdependence breaks – China as well as India recently, have covered substantial ground in applying IMO regulations (IMO, 2019).

The paper proceeds as follows. The next section discusses the literature, Section 3 describes the dataset and methodology while section 4 discusses the empirical results. Section 5 elaborates on policy implications and section 6 concludes.

## 2. **Prior research**

The decision of the ship owner to dismantle the ship has been at the centre of attention of earlier as well as recent economic studies on the ship demolition industry. (Buxton, 1991; Kagkarakis, et al., 2016; Karlis, et al., 2016; Papapostolou et al., 2017; Wang et al. ,2014) are studies which focus on macroeconomic determinants of ship demolition prices. Specifically, Buxton (1991) explores the fundamentals of the market and observes that the main reasons for dismantling a ship are either technological or economic. Technological progress, embodied in the construction rate of new, more efficient vessels, anticipated freight rates and second-hand market prices, are the key determinants of the demolition price. Moreover, the scrap value does not only reflect the value of the materials making up the ship, but also the cost of demolition. This can help explain  the shift of the demolition market, from Western Europe to the Southeast Asia. Kagkarakis et al. (2016) discover a strong correlation and a lead-lag relationship between the ship demolition price and the international steel-crap prices. Specifically, they find that the time lag between them is 4 months, which they attribute to the time it takes to transport the steel-scrap commodity to Southeast Asia, where steel-scrap is in high demand. The authors employ a VAR model and establish that international steel prices have a leading role in the determination of demolition prices. Therefore, the scrap price is determined by factors external to the shipping industry.

Karlis et al. (2016) further show that the currency exchange rate prevailing at the largest ship dismantling countries is a major determinant of ship demolition prices. In general, they found that for all ship sizes, Chinese, Pakistani and Bangladeshi currency exchange rates strongly impact on scrap prices in the following manner: If the local currency depreciates against the U.S. dollar, then the ship-breakers' financial burden rises. As increased costs reduce profit margins, demand for ship dismantling declines, consequently. Thus, the demolition price drops. In addition, Papapostolou et al. (2017) claim that ship owners prefer to hold unnecessary ships and operate at a loss if they expect market conditions to improve in the future. A significant finding of the same study is that when freight markets are down, ship owners display a strong herding behavior in selling their ships for scrap. This herding behavior could lead many ship owners to realize a loss in the future if they do not have enough ships in their fleet. Further, Wang et al. (2014) examine the interconnection between steel and steel scrap industries in China. They show that demand for steel scrap will substantially rise due to pressures for increased environmental protection and for lower carbon emissions which both increase steel production costs. As a result, this will impact on the Chinese ship-breaking market which is expected to expand. According to Mikelis (2013), the contribution of the ship recycling industry located in Turkey, Bangladesh, Pakistan, China and India, to the global steel producing industry is about 1.5%. Merikas et al. (2015) also investigate the ship recycling industry which is booming in the Southeast Asian countries and find that the imported steel scrap is essential in the determination of demolition prices as well as average export prices of steel scrap in the U.S. and Europe. The exchange rate of the Chinese Yuan with respect to the US dollar, the Chinese GDP growth rate, and a profitability index, are also shown to lead demolition prices. Further, Hoffmann (2010) argues that if scrap prices are low, ship owners do not scrap their ships but wait for the prices to increase or for conditions to improve.

On the other hand, Knapp et al. (2008), apart from macroeconomic variables, bring also into the analysis specific ship characteristics as determinants in the ship-owner's decision-making process. The probability of a vessel being scrapped depends on specific characteristics such as the vessel's age, type, size, safety profile, and earnings. They find the vessel's earnings as an independent variable to be negatively associated with the probability of the ship being scrapped. Moreover, the probability of a ship being scrapped is found to be positively related with the demolition price. Further, the safety standards of the vessels seem to be insignificant in the shipowner's decision-making process. These results pertain to all ship-breaking locations. Moreover, the Bangladeshi demolition price was found to be less responsive to changes in earnings and, it was also shown that older and larger vessels are more frequently dismantled there. On the issue of why the ship breaking is primarily located in developing countries, Pour et al. (2012) propose the prevailing low-labor costs. Although mechanized ship breaking methods can be more efficient than manual work, the authors claim that these require large capital investments and thus cannot be employed due to the small profit margins of the industry. The authors note that China's market share was dropping, and with Taiwan and South Korea leaving the industry, Pakistan, Bangladesh and India emerged as global leaders. In addition, the steel scrap derived from ship-breaking, which is considered of high quality, especially the one extracted from tankers, is sold to the construction industry of these countries, in which steel is in high demand.

In the same context, Rahmad and Mayer (2015) find that in countries where most of ship recycling is undertaken, like Bangladesh, the industry has a strong historical, structural and cultural embeddedness in the society, which makes imperative the continuation of this activity but with improved environment and worker protections as vigorously shown by Jun-Ki Choi et.al. (2016).

The environmental, safety, social, and regulatory aspects of ship demolition have been thoroughly examined by scholars and regulatory agencies (European Commission, 2016; Science for Environment Policy, 2016; Rahman, 2017). During the demolition of a ship, a wide number of hazardous contaminants are found which pollute the environment and destroy the local ecosystem while workers might also develop several health problems. For example, it was found that in the Chittagong area of Bangladesh, the levels of phenanthrene in the air were higher than the levels that can be found in Shanghai or in the industrial areas of Taiwan (European Commission, 2016). Furthermore, disasters such as the explosion at the Gadani yard in Pakistan, in November 2016, as a result of workers being forced to start dismantling the ship before the fuel tank could be cleaned of leftover fuel, was added to the list of events that make regulatory intervention mandatory.

There are many organizations that try to regulate the ship demolition market which got together and agreed to the Hong Kong International Convention (HKC 2009). The purpose of the Convention is to minimize environmental and occupational safety and health risks. It requires appropriate safety and environmental management, including the development of a ship recycling plan, specifying the manner in which each ship will be recycled. Ships sent for recycling will be required to carry an inventory of hazardous materials so that they can be properly controlled, to remove risks at the ship recycling facility. The Hong Kong Convention will only enter into force when at least 15 states have ratified it and the merchant fleets of the ratifying states account for 40 per cent of global gross tonnage. The Convention has been ratified by thirteen countries so far, representing 29% of the gross tonnage of the world's merchant shipping. Japan was the last to ratify the convention and the only one from Asia.

## *3. Data and methodology*

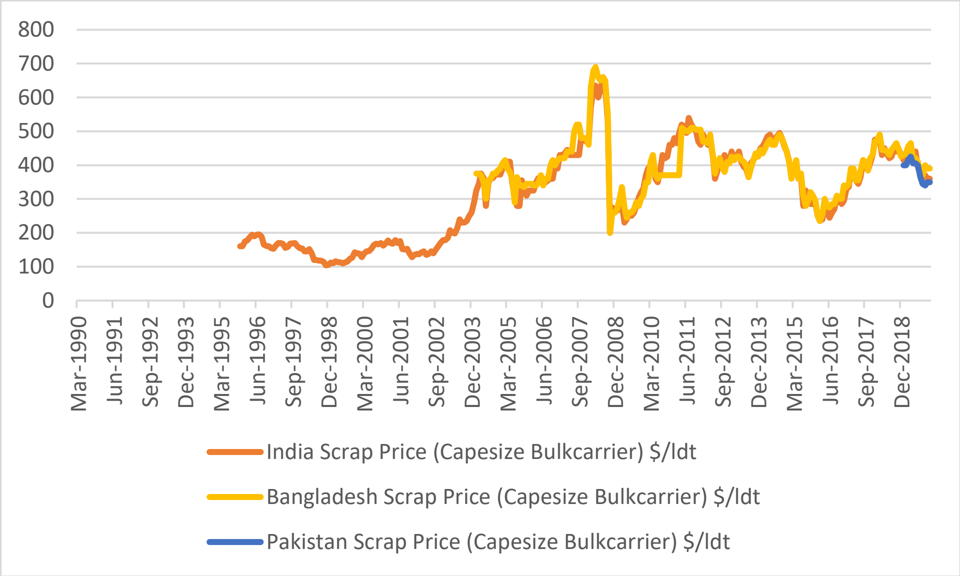
The purpose of this study is to communicate that the mechanism of interdependence between the demolition or scarp price and  shipping sector earnings is strong when the demolition price is determined by Bangladesh. Indian subcontinent countries consistently evade ILO regulations in dismantling a ship. Bangladesh, India and Pakistan account for over 80% of total gross tonnage of demolished ships. On the contrary, the interdependence between ship scrap and earnings in the shipping sector, does not hold in the case of China where the demolition price is considerably lower and compliance with ILO regulation is extensive. We have tested the impact and significance of the Chinese offered scrap price on earnings in each shipping subsector. The Chinese scrap price is cointegrated with earnings and significant in the dry bulk subsector only (but the impulse response function shows a negligible impact). In the tanker and container subsectors it is neither cointegrated nor does it have a significant impact as shown in the Appendix through the VAR Impulse Response functions. These finding are opposed to the case of Bangladesh which is significant in all three markets. Furthermore, Granger causality tests in all three markets show that Bangladesh scrap price leads the Chinese.

Based on the extant literature where a strong relationship between the ship demolition price and the international steel-crap prices has been found, we assert that the scrap price is determined by oil price, nickel price, steel scrap price and seaborne trade. The price of nickel has been selected for two reasons. First, it is strongly correlated with ship scrap price (correlation equals 0.73) and the Granger causality test supports the hypothesis that the price of nickel Granger causes the price of ship scrap. On the other hand, nickel is a metal received during the dismantling of ships. In the Indian subcontinent countries and particularly Bangladesh there is a growing demand for construction materials, and nickel is one of them (Hossain et al.,2010; Rahman, 2017). Further, recognizing the significance of demolition prices in the ship owners' investment decision (Hoffmann 2010) we explore their interdependence with earnings and the fleet size in each market segment.

### *3.1 Data Characteristics*

We collected our data from Clarksons, a web-based shipping database and consulting company and Bloomberg.com. Our sample is of monthly frequency and spans over January 1976 until April 2018. We collected scrap prices ($/ltd) as offered in Bangladesh. The dynamics of the Bangladesh scrap price are representative of the scrap price in the subcontinent as shown in Figure I. The correlation between Bangladesh and India is 0.94 and Bangladesh and Pakistan 0.95. Of the three demolition markets, we focus on Bangladesh as it is also leading in the ship breaking industry, accounting for about 40% of the total number of ships to be dismantled, Rahman (2017). We also collected data on the fleet size in numbers, in the three subsectors, seaborne trade in $million by sector as well as the price of oil, ($/barrel), the price of nickel ($/tonne) and the price of imported steel scrap (in $/metric ton) in the subcontinent. Table 1 provides the description and summary statistics of the full dataset.

**Fig. 1. Comparison of Indian subcontinent scrap prices**




Source: Clarksons Database

**Table 1. Description of Variables Employed**

| Panel A: Definition of variables | |
|---|---|
| $LSCRAPB$ | *Natural logarithm of the Bangladesh Price of Dry Bulk Scrap, $/ltd.* |
| $LSCRAPT$ | *Natural logarithm of the Bangladesh Price of Tanker Scrap, $/ltd.* |
| $LSCRAPC$ | *Natural logarithm of the Bangladesh Price of Container Scrap, $/ltd.* |
| $LOIL$ | *Natural logarithm of the Price of Oil, $/barrel.* |
| $LNIC$ | *Natural logarithm of the Price of Nickel, $/tonne* |
| $LSTEEL$ | *Natural logarithm of the Steel Scrap Price, $/metric ton* |
| $LFLEETB$ | *Natural logarithm of the Dry Bulk Fleet Size in numbers.* |
| $LFLEETT$ | *Natural logarithm of the Tanker Fleet Size in numbers.* |
| $LFLEETC$ | *Natural logarithm of the Container Fleet Size in numbers.* |
| $LEARNB$ | *Natural lobarithm of Dry Bulk Earnings, $/day* |
| $LEARNT$ | *Natural Logarithm of Tanker Earnings, $/day.* |
| $LEARNC$ | *Natural logarithm of Container Earnings, $/day.* |
| $LDEMB$ | *Seaborne trade for Dry Bulk Cargo, $ million.* |
| $LDEMT$ | *Seaborne trade for Tanker Cargo, $ million.* |
| $LDEMC$ | *Seaborne trade for Container Cargo, $million.* |

*Panel B: Descriptive* Statistics *During Jan.1976-April 2018*

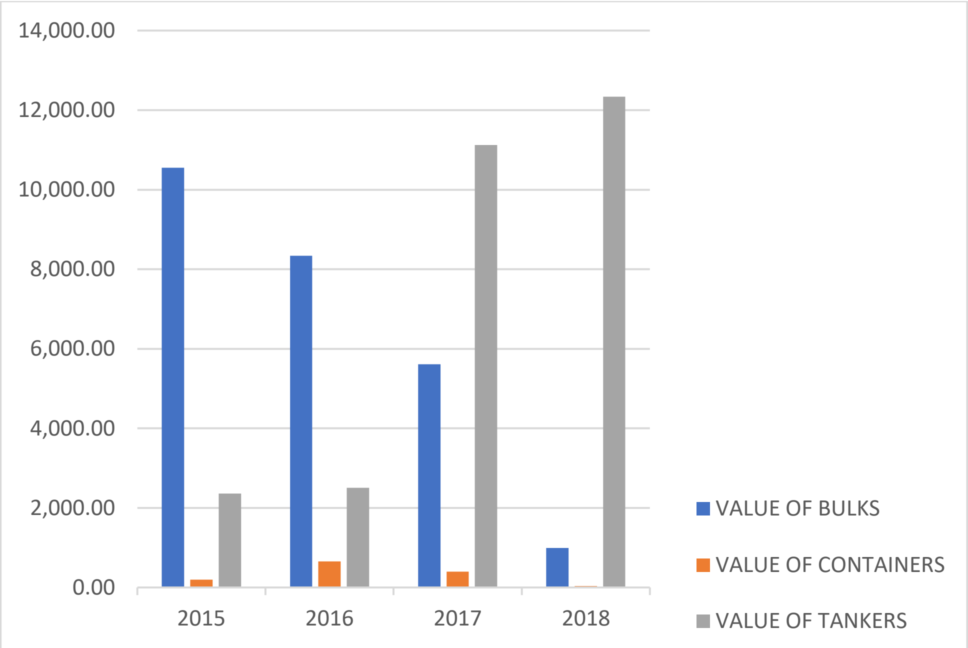
| | $SCRAPB$ | $SCARPT$ | $SCRAPC$ | $OIL$ | $NIC$ | $STEEL$ | $FLEETB$ | $EARNB$ |
|---|---|---|---|---|---|---|---|---|
| Mean | 396.1 | 414.7 | 399.7 | 76.68 | 16273.0 | 483.7 | 6041.9 | 13740.1 |
| Median | 390.0 | 415.0 | 390.0 | 81.54 | 15993.2 | 512.7 | 5319.0 | 9406.3 |
| Max | 690.0 | 750.0 | 690.0 | 133.8 | 31093.0 | 802.8 | 11190.0 | 65172.9 |
| Min | 200.0 | 240.0 | 200.0 | 30.32 | 8298.5 | 231.7 | 3291.0 | 3635.8 |
| Std.Dev. | 101.6 | 107.5 | 101.7 | 24.82 | 5468.0 | 131.4 | 2119.9 | 11022.2 |
| J-B | 14.25 | 29.30 | 11.82 | 5.395 | 6.122 | 1.689 | 135.5 | 1041.4 |
| P-Value | 0.000 | 0.000 | 0.002 | 0.067 | 0.046 | 0.429 | 0.000 | 0.000 |

| | $FLEETT$ | $EARNT$ | $FLEETC$ | $EARNC$ | $DEMB$ | $DEMT$ | $DEMC$ |
|---|---|---|---|---|---|---|---|
| Mean | 5629.1 | 18999.1 | 5043.9 | 12238.9 | 4394.1 | 1875.6 | 1482.5 |
| Median | 5729.0 | 14605.9 | 5088.0 | 12438.2 | 4544.9 | 1864.2 | 1489.4 |
| Max | 6568.0 | 57369.7 | 5232.0 | 28650.8 | 5183.3 | 2022.7 | 1850.5 |
| Min | 4494.0 | 6261.4 | 4641.0 | 4395.6 | 3389.0 | 1784.6 | 1111.6 |
| Std.Dev. | 516.0 | 11193.3 | 150.36 | 5166.2 | 572.6 | 64.67 | 212.9 |
| J-B* | 3.700 | 56.51 | 18.046 | 35.31 | 10.57 | 12.07 | 5.539 |
| P-Value | 0.157 | 0.000 | 0.000 | 0.000 | 0.005 | 0.002 | 0.062 |

*J-B is the Jarque Bera statistic for testing normality

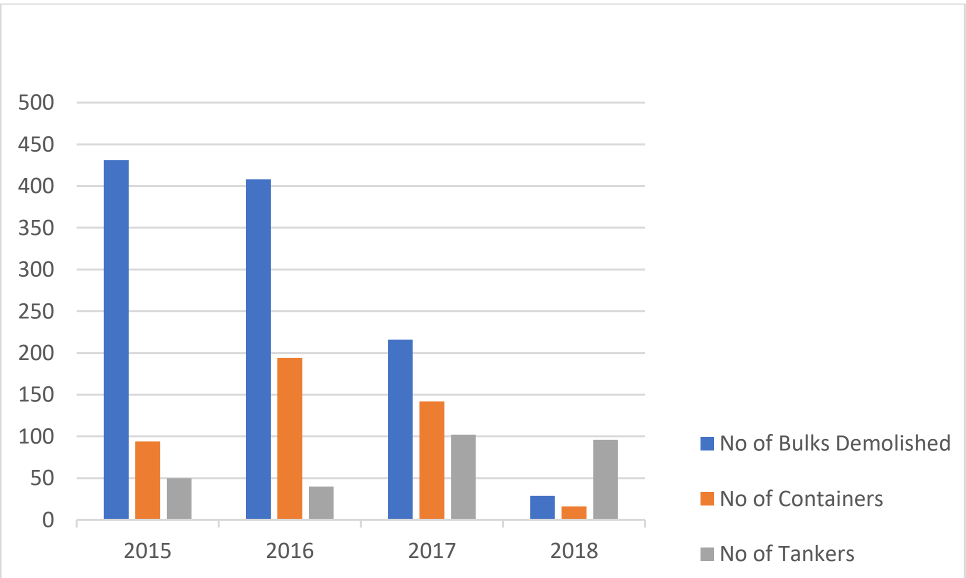
Figures 2 and 3 below show that the tankers demolition value dominated since 2017 while the bulkers demolition numbers dominated until 2017.

**Fig. 2. Demolition value by ship category** (values in billion dollars)




Source: Clarksons Database

**Fig. 3. Number of ships demolished by category**



Source: Clarksons Database

3.2 Methodology

We chose vector autoregressive models (VAR) as it is an effective way to evaluate and compare economic models. They deal with potential endogeneity and can also be used for forecasting purposes through the Impulse Response Functions. A vector error correction (VEC) model is a restricted VAR with nonstationary series which are integrated of the same order and are tested for cointegration. We employed VEC (Vector Error Correction) models in our analysis following Johansen cointegration testing.

In general, the model has the following form

$\Delta x_t = \pi x_{t-1} + \sum_{i=1}^{p-i} \beta_i \, \Delta x_{t-i} + \gamma d_t + \varepsilon_t.$

It is applied first in the ship scrap market, across all shipping subsectors where

$\Delta x_t$ is the first difference of the variables contained in vector

$$x = (LSCRAP_t, LOIL_t, LDEM_t, LNIC_t, LSTEEL_t)$$

and then in the shipping sector, across all markets where

$\Delta x_t$ is the first difference of the variables contained in vector

$x = (LSCRAP_t, LEARN_t, LDEM_t, LFLEET_t),$

where $\pi$ is the coefficient matrix of the cointegrating relationships, $\beta_i$ is a coefficient matrix of the lags of the differenced variables in $x$, $d_t$is a vector of deterministic terms and $\gamma$ its coefficient matrix while $p$ is the lag order of the VAR model, $\varepsilon_t$ is not correlated with $x_{t-1}, x_{t-2}, \dots, x_{t-i}$. It is also assumed that $p$ is large enough so that $\varepsilon_t$ is not correlated over time. The only difference between the VAR and VEC models is the error correction term $\pi x_{t-1}$ which shows how the growth rate in any $x$ variable changes, if one of the variables deviates from its equilibrium value. Estimation of all models is carried out through maximum likelihood. The VEC estimation output consists of two parts. The first part reports the result from the Johansen procedure.

That is the cointegrating relationship is estimated and shown. The second part of the output reports results from the VAR estimation in first differences, including the effect of the error correction term estimated in the first part. Next, we obtain impulse response functions where it is shown how a shock to the $i$-th variable affects not only the $i$-th variable itself but it is also transmitted to all of the other endogenous variables through the dynamic (lag) structure of the VAR. An impulse response function traces the effect of a one-time shock on current and future values of the endogenous variables. A disadvantage of VAR models is their sensitivity to the ordering of variables that enter the VAR.

## 4. Empirical findings

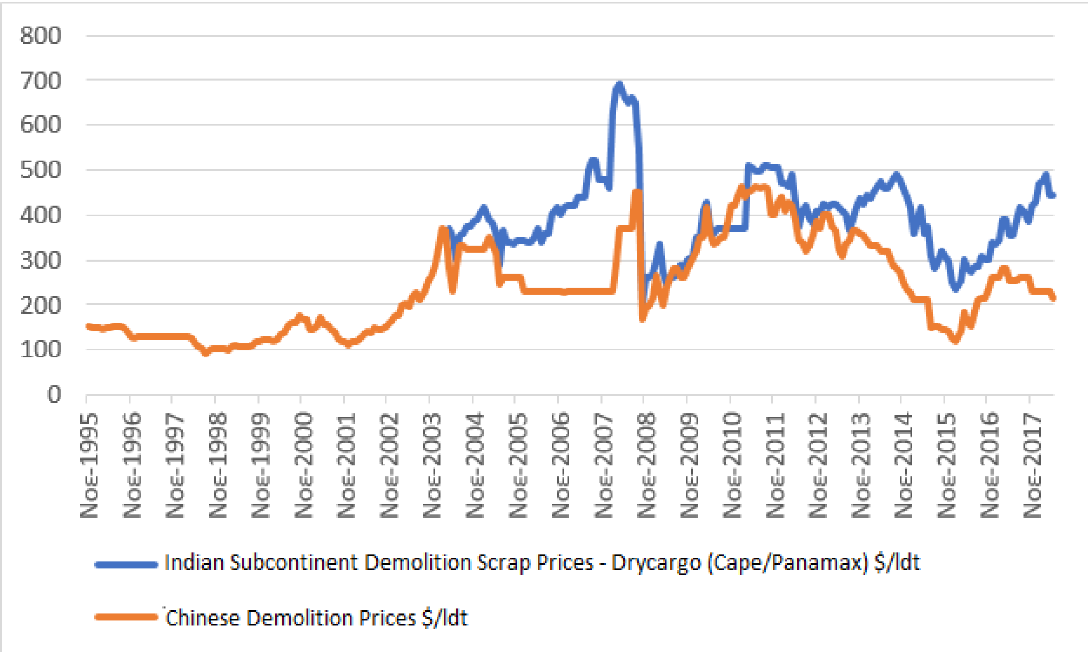
We set up our models in each shipping subsector as follows: First we express the scrap price in terms of steel scrap and oil, following Kagkarakis et al. (2016), with additional variables, nickel (as a substitute to steel scrap) and seaborne trade with respect to the specific subsector. Next, we develop our model for investigating profitability in each shipping subsector following Lyridis et al., (2014) Batrinca and Cozanou (2014), Chowdhury and Dinwoodie (2011) and Vivid Economics (2010) who expressed profitability in terms of fleet size and seaborne trade. An increase in trade is expected to cause an increase in the freight  rates through an increase in the demand for ships, while an increase in the fleet is expected to cause a decrease in the rates. The variable we have added in our specification is the price of scrap which we assert to be negatively related to profitability according to Papapostolou et al. (2017) who find that when freight markets are down, ship owners display a strong unintentional herding behavior when deciding to scrap their ships.

### *4.1 The Dry-Bulk market*

The dry bulk market is the largest part of the shipping industry. Ship sizes within the subsector are distinctly defined and categorized into: Capes, Panamax, Handymax and Handysize. However, this distinction has no influence on the demolition price per light displacement tonnage for dry-bulks, which primarily reflects quality and good maintenance of the metal used. In 2017, 14.5 million DWT or 65% of the total gross tonnage demolished was dry bulk ships. Over 80% of it was demolished in south Asian countries and beached (Vercammen et.al. 2017) [1].

Evidently, the ship owner would love to operate in a booming demolition market since the threshold value for his ship can reach up to 80% of the sale-and-purchase price depending on the age of the vessel. Therefore, the scrap value of a ship is an important determinant in the decision-making process. The consumption of steel scrap contributes significantly to the development process of the Indian subcontinent. Part of this consumption derives from ship scrap, for Bangladesh up to 30% of steel scrap consumption comes from ship dismantling (Sarraf et.al (2010). Fig. 3 shows the difference between the Indian Subcontinent (India, Bangladesh, Pakistan) and China demolition prices which on average is about 40% lower.

**Fig. 4. Demolition price in the Indian subcontinent against China**




**Source:** Clarksons Database

We assert that it is the dry bulk demolition price that the Indian subcontinent offers which achieves a long-run relationship with other commodities (oil, nickel and

[1] Beaching is a lower cost method of dismantling a ship, with negative labor and environmental effects.

imported steel scrap) essential in the development of these economies. And it is the demolition price offered by the Indian subcontinent countries that exhibits a long run relationship with fleet size and earnings and hence exerts a significant influence in the investment decision of the ship-owner. Table 2 below presents unit root tests for the variables of interest.

**Table 2. Unit root tests (ADF and KPSS)**

| Variables | ADF | 95% Crit.Value | KPSS | 95% Crit.Value |
|---|---|---|---|---|
| $LSCRAPB$ | -2.28 | -3.43 | 0.32 | 0.15 |
| $LOIL$ | -3.01 | -3.42 | 0.22 | 0.15 |
| $LNIC$ | -2.99 | -3.42 | 0.15 | 0.14 |
| $LDEMB$ | -2.33 | -3.42 | 0.22 | 0.15 |
| $\Delta(LSCAPB)$ | -16.68 | -2.87 | 0.06 | 0.46 |
| $\Delta(LOIL)$ | -15.27 | -2.87 | 0.05 | 0.46 |
| $\Delta(LNIC)$ | -15.13 | -2.87 | 0.04 | 0.46 |
| $\Delta(LDEMB)$ | -3.49 | -2.87 | 0.15 | 0.46 |

Note: The SIC criterion was used to select the lag order of the ADF regressions.

Table 3 below presents the results of the Johansen cointegration test in the dry-bulk market.

**Table 3. Results of Johansen cointegration test in the dry-bulk market**

| $H_0$ | Max-eigenvalue Statistic | 95% Critical Value | Trace test Statistic | 95% Crit. Value |
|---|---|---|---|---|
| r=0 | 27.58 | 20.34 | 48.43 | 47.85 |
| r≤1 | 15.36 | 18.13 | 28.08 | 29.80 |
| r≤2 | 9.51 | 14.26 | 12.73 | 15.49 |
| r≤3 | 3.22 | 3.84 | 3.22 | 3.84 |

Note: r denotes the number of cointegrating vectors

With respect to the determination of the demolition price for dry bulk ships, Tables 2 and 3 help us to derive the long run cointegrating relationship (1). The maximum eigenvalue and the trace tests suggest that there is one single cointegrating vector between the scrap price of dry bulks and the price of oil, the price of nickel and the seaborne trade for dry bulks. This implies that the prices of oil, nickel and seaborne trade determine the demolition price as expected. An increase in the price of oil signals lower future rates of global economic growth and higher price for nickel means rising demand for scrap, hence a positive impact is expected. Estimating the error correction model yields the following long- term relationship for the bulkers scrap price.

$$LSCRAPB_t = -13.69 - \underset{(0.23)}{0.90}LOIL_t + \underset{(0.19)}{0{,}92}LNIC_t + \underset{(0.29)}{1.73}LDEMB_t \quad (1)$$

The asymptotic standard errors of the coefficients can be found in the parentheses. As we can see in equation (1) if the price of nickel increases by 1%, the scrap price of bulkers increases by 0.92% and if the oil price increases by 1% then the demolition price falls by 0.90% on average. There is also a strong effect of seaborne trade on the price of scrap. This is because in an expansionary phase of the market, ship owners do not offer their ships for scrapping, they prefer to operate them. So, a higher scrap price needs to be offered to tempt them.

**Table 4. Dynamics of Adjustment in the Dry-Bulk Scrap Market**

| | $\Delta(LSCRAPB)$ | $\Delta(LOIL)$ | $\Delta(LNIC)$ | $\Delta(LDEMB)$ |
|---|---|---|---|---|
| $ECT_{t-1}$ | -0.070*** | -0.046*** | -0.010 | -0.00002*** |
| | (0.019) | (0.017) | (0.016) | (0.00008) |
| $Constant$ | -0.094 | -0.058 | -0.007 | 0.0001*** |
| | (0.067) | (0.058) | (0.056) | (0.00004) |
| $\Delta(LSCAPB)_{t-1}$ | -0.085 | 0.128*** | 0.040 | -0.00002 |
| | (0.063) | (0.055) | (0.053) | (0.00002) |
| $\Delta(LSCPAB)_{t-2}$ | -0.091 | 0.122*** | 0.061 | -0.00002 |
| | (0.063) | (0.055) | (0.053) | (0.00002) |
| $\Delta(LOIL)_{t-1}$ | 0.138*** | 0.183*** | -0.041 | 0.0002*** |
| | (0.073) | (0.064) | (0.061) | (0.00002) |
| $\Delta(LOIL)_{t-2}$ | -0.000 | 0.004 | 0.024 | 0.0002*** |
| | (0.076) | (0.064) | (0.061) | (0.00002) |
| $\Delta(LNIC)_{t-1}$ | -0.020 | -0.048 | 0.201*** | 0.00008 |
| | (0.079) | (0.069) | (0.066) | (0.00005) |
| $\Delta(LNIC)_{t-2}$ | 0.027 | 0.097 | -0.078 | -0.00007 |
| | (0.080) | (0.070) | (0.067) | (0.000005) |
| $\Delta(LDEMB)_{t-1}$ | -22.053 | 4.602 | 5.317 | 1.951*** |
| | (12.893) | (11.296) | (0.492) | (0.009) |
| $\Delta(LDEMB)_{t-2}$ | 25.906*** | -1.249 | 2.832 | - |
| | (13.091) | (11.470) | (10.953) | 0.974*** |
| | | | | (0.009) |
| $LSTEEL$ | 0.014 | 0.008 | -0.000 | 0.863*** |
| | (0.011) | (0.010) | (0.000) | (0.029) |

**Note:** Numbers in brackets are standard errors. *** Indicates significance at 1% level. ** Indicates significance at 5% level. * Indicates significance at 10% level.

The dynamic specification shown in Table 4, exhibits a significant error correction coefficient for the demolition price of dry bulk ships, with the expected negative sign. The value of this coefficient, i.e. the speed of return to the equilibrium demolition price level appears to be relatively slow. The oil, nickel, and seaborne trade equations from Table 4 above, do not seem to contribute to the error correction of a shock, because the coefficients have the same sign as in the equilibrium relationship. This confirms the unique cointegrating relationship between the demolition price and its determinants. Below we present the impulse response functions (IRFs) as essential graphs of market dynamics. Fig. 5 shows that one standard deviation (shock) increase in the price of oil will result in about 2% fall in the dry bulk demolition price offered by Bangladesh. Fig. 6 shows that one standard deviation (shock) increase in the price of nickel will result in about 3.5% increase in the dry bulk demolition price offered by Bangladesh. This implies an increase in the demand for scrap as nickel is a substitute.

**Fig. 5. The IRF of a shock in the price of oil onto the Price of Scrap**

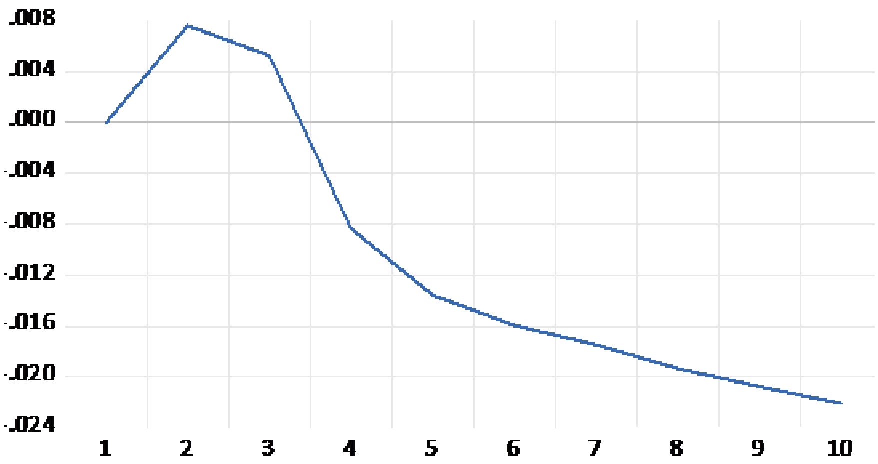
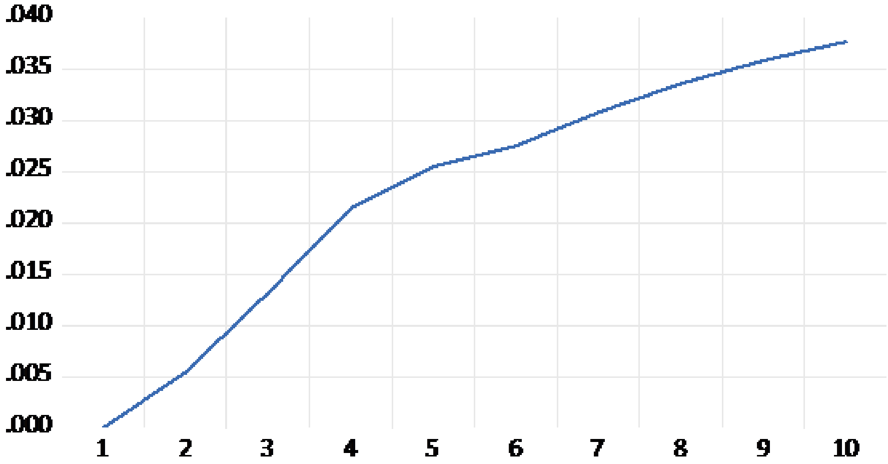


**Fig. 6. The IRF of a shock in the price of Nickel and Seaborne trade on Scrap**




Tables 5 and 6 below pave the way to the derivation of a long run relationship, between the decision variables of fleet size, earnings, scrap value and investment in the dry bulk subsector. Table 5 shows the results of the unit root tests and Table 6 the results of the Johansen cointegration test.

**Table 5: Unit root tests (ADF and KPSS)**

| Variables | ADF | 95% Crit.Value | KPSS | 95% Crit.Value |
|---|---|---|---|---|
| $LFLEETB$ | -2.13 | -3.43 | 0.54 | 0.15 |
| $LEARNB$ | -3.28 | -3.42 | 0.29 | 0.15 |
| $LDEMB$ | -2.33 | -3.42 | 0.22 | 0.15 |
| $LSCRAPB$ | -2.28 | -3.43 | 0.32 | 0.15 |
| $\Delta(LFLEETB)$ | -2.93 | -2.87 | 0.33 | 0.46 |
| $\Delta(LEARNB)$ | -12.85 | -2.87 | 0.04 | 0.46 |
| $\Delta(LDEMB)$ | -3.49 | -2.87 | 0.15 | 0.46 |

Note: The SIC criterion was used to select the lag order of the ADF regressions.

**Table 6. Results of Johansen Cointegration test in the dry-bulk Market**

| $H_0$ | Max-eigenvalue Statistic | 95% Crit. Value | Trace test Statistic | 95% Crit. Value |
|---|---|---|---|---|
| r=0 | 43.57 | 27.58 | 68.88 | 47.86 |
| r≤1 | 20.03 | 21.13 | 25.31 | 29.79 |
| r≤2 | 5.26 | 14.26 | 5.27 | 15.49 |
| r≤3 | 0.01 | 3.84 | 0.01 | 3.84 |

Note: r denotes the number of cointegrating vectors

The maximum eigenvalue and the trace tests suggest that there is one single cointegrating relation between the scrap price of dry bulks, the fleet, the earnings, and the seaborne trade in the dry bulk subsector. Estimating the error correction model yields the following long-term relationship for our variables of interest there will be a long run equilibrium relationship between our variables, i.e. they move together in the long run.

$$\boldsymbol{LEARNB = -7.18 + 5.32LDEMB + 0.52LSCRAP - 5.19LFLEET} \quad \textbf{(2)}$$

$$\qquad\qquad (\mathbf{1.69}) \qquad\qquad (\mathbf{0.26}) \qquad\qquad (\mathbf{0.97})$$

The asymptotic standard errors of the coefficients are shown in the parentheses. As we can see in equation (2) the scrap price has a significant positive effect on the earnings of bulkers. If the price of scrap increases by 1%, earnings rise by 0.52% and if the fleet increases by 1% then earnings fall by 5.19% on average. The effect of seaborne trade is also found to be positive and strongly significant.

**Table 7. Dynamics of adjustment in the dry-bulk earnings**

| | $\Delta(LEARNB)$ | $\Delta(LDEMB)$ | $\Delta(LSCRAPB)$ | $\Delta(LFLEETB)$ |
|---|---|---|---|---|
| $ECT_{t-1}$ | -0.14*** | -0.00007*** | -0.014 | 0.001** |
| | (0.041) | (0.00001) | (0.023) | (0.0006) |
| $Constant$ | 0.008 | 0.00007*** | 0.005 | 0.0005** |
| | (0.023) | (0.000008) | (0.013) | (0.0003) |
| $\Delta(LFLEETB)_{t-1}$ | 5.654 | 0.003*** | -3.019 | 0.218*** |
| | (4.027) | (0.001) | (2.299) | (0.058) |
| $\Delta(LFLEETB)_{t-2}$ | -12.95*** | 0.004*** | 0.029 | 0.550*** |
| | (3.962) | (0.001) | (2.263) | (0.057) |
| $\Delta(LEARNB)_{t-1}$ | 0.309*** | -0.000007 | 0.068** | -0.002** |
| | (0.072) | (0.00002) | (0.042) | (0.001) |
| $\Delta(LEARNB)_{t-2}$ | -0.165*** | -0.00003 | -0.041 | 0.002*** |
| | (0.074) | (0.00002) | (0.042) | (0.001) |
| $\Delta(LSCRAPB)_{t-1}$ | 0.240*** | -0.000008 | -0.148*** | 0.0003 |
| | (0.129) | (0.00004) | (0.073) | (0.002) |
| $\Delta(LSCRAPB)_{t-2}$ | 0.125 | 0.00003 | -0.115 | -0.001 |
| | (0.1299) | (0.00004) | (0.074) | (0.001) |
| $\Delta(LDEMB)_{t-1}$ | -33.686 | 1.940*** | -44.33*** | 0.075 |
| | (29.301) | (0.010) | (16.732) | (0.427) |
| $\Delta(LDEMB)_{t-2}$ | 40.539 | -0.968 | 51.547*** | 0.104 |
| | (28.898) | (0.010) | (16.502) | (0.422) |

The dynamic specification, shown in Table 7, exhibits a significant error correction coefficient for the demolition price of dry bulk ships, with the expected negative sign. The value of this coefficient, i.e. the speed of return to the equilibrium demolition price level appears to be relatively slow: every month there is an adjustment towards the equilibrium earnings level by 14%.

## 4.2 The Tanker Market

The tanker subsector is the second largest in the shipping industry accounting for 6,634 vessels- 37% of the total number of ships carrying commodities- and 538 million DWT in capacity (Clarksons 2017). The demolition price of tankers is higher compared to dry bulk and containers as the metal quality is better Kagkarakis et al. (2016). Fig. 7 below shows that the demolition price differential between the Indian Subcontinent and China is substantial, on average 35%.

**Fig. 7. Demolition price in the Indian Subcontinent Compared to the Chinese**


Source: Clarksons Database

The existence of a long run relationship between commodities signifies the fact that the ship demolition market goes hand to hand with economic growth in the emerging economies where demolition is primarily based. We initially run the unit root test and the Johansen cointegration test.

Tables 8 and 9 below present the results.

**Table 8. Unit root tests (ADF and KPSS)**

| Variables | ADF | 95% Critical Value | KPSS | 95% Crit.Value |
|---|---|---|---|---|
| $LSCRAPT$ | -2.07 | -3.43 | 0.31 | 0.15 |
| $LDEMT$ | -1.95 | -3.42 | 0.46 | 0.15 |
| $LNIC$ | -2.99 | -3.42 | 0.15 | 0.14 |
| $LOIL$ | -3.00 | -3.42 | 0.24 | 0.14 |
| $\Delta(LSCRAPT)$ | -16.44 | -2.87 | 0.06 | 0.46 |
| $\Delta(LDEMT)$ | -3.56 | -2.87 | 0.35 | 0.46 |
| $\Delta(LNIC)$ | -15.13 | -2.87 | 0.04 | 0.46 |
| $\Delta(LOIL)$ | -11.90 | -2.87 | 0.03 | 0.46 |

Note: The SIC criterion was used to select the lag order of the ADF regressions.

**Table 9. Results of Johansen cointegration test in the tanker market**

| $H_0$ | Max-eigenvalue Statistic | 95% Critical Value | Trace test Statistic | 95% Crit. Value |
|---|---|---|---|---|
| r=0 | 25.99 | 27.58 | 54.70 | 47.86 |
| r≤1 | 16.67 | 21.13 | 28.70 | 29.79 |
| r≤2 | 8.56 | 14.26 | 12.03 | 15.49 |
| r≤3 | 3.48 | 3.84 | 3.476 | 3.84 |

Note: r denotes the number of cointegrating vectors

The trace test suggests that there is one single cointegrating relation between the scrap price of tankers and the price of oil, the price of nickel and the steel scrap price. Estimating the error correction model yields the following long- term relationship for the tankers scrap price.

$$LSCRAPT_t = -12.68 - 0.22LOIL_t + 0.45LNIC_t + 1.99LDEMB_t \quad (3)$$

$$(0.104) \qquad (0.08) \qquad (0.45)$$

The asymptotic standard errors of the coefficients can be found in the parentheses. As we can see in equation (3) the price of nickel has a significant 0.45% positive effect on the demolition price of tankers, that is if the price of nickel increases by 1%, the scrap price of tankers increases by 0.454% and if the price of oil increases by 1% then the demolition price falls by 0.21% on average. The effect of the seaborne trade is also found to be positive and strongly significant.

**Table 10. Dynamics of Adjustment in the Tanker Scrap Market**

| | $\Delta(LSCRAPT)$ | $\Delta(LDEMT)$ | $\Delta(LNIC)$ | $\Delta(LOIL)$ |
|---|---|---|---|---|
| $ECT_{t-1}$ | -0.228*** | 0.00002 | - 0.057 | -0.124*** |
| | (0.037) | (0.00002) | (0.035) | (0.036) |
| $Constant$ | - 0.567*** | 0.000007 | - 0.122 | -0.259** |
| | (0.104) | (0.000005) | (0.099) | (0.101) |
| $\Delta(LSCRAPT)_{t-1}$ | -0.032 | - 0.00005 | 0.045 | 0.174*** |
| | (0.063) | (0.00003) | (0.060) | (0.062) |
| $\Delta(LSCRAPT)_{t-2}$ | -0.074** | -0.00004** | 0.036 | 0.175*** |
| | (0.063) | (0.00002) | (0.060) | (0.061) |
| $\Delta(LSCRAPT)_{t-3}$ | 0.052 | - 0.0005** | -0.116*** | 0.075 |
| | (0.063) | (0.0002) | (0.060) | (0.061) |
| $\Delta(LDEMT)_{t-1}$ | -118.5 | 2.800*** | -39.007 | -126.43* |
| | (74.46) | (0.030) | (71.46) | (72.81) |
| $\Delta(LDEMT)_{t-2}$ | 228.36 | 257.03*** | 86.16 | 257.03 |
| | (145.51) | (142.28) | (139.65) | (142.28) |
| $\Delta(LDEMT)_{t-3}$ | -113.30 | -134.37** | -45.29 | -134.37 |
| | (73.65) | (72.017) | (70.68) | (72.017) |
| $\Delta(LNIC)_{t-1}$ | 0.023 | -0.00007*** | 0.237*** | - 0.050 |
| | (0.071) | (0.00003) | (0.068) | (0.070) |
| $\Delta(LNIC)_{t-2}$ | -0.032 | 0.00001 | -0.031 | 0.117** |
| | (0.072) | (0.00003) | (0.069) | (0.071) |
| $\Delta(LNIC)_{t-3}$ | -0.007 | 0.000002 | -0.010 | -0.091 |
| | (0.072) | (0.00003) | (0.069) | (0.070) |
| $\Delta(LOIL)_{t-1}$ | 0.086 | -0.000005 | -0.007 | 0.154*** |
| | (0.068) | (0.00003) | (0.065) | (0.066) |
| $\Delta(LOIL)_{t-2}$ | -0.038 | 0.00002 | 0.056 | -0.026 |

| | | | | |
|---|---|---|---|---|
| | (0.067) | (0.00003) | (0.064) | (0.066) |
| $\Delta(LOIL)_{t-3}$ | -0.063 | 0.00001 | -0.017 | -0.091 |
| | (0.065) | (0.00003) | (0.063) | (0.064) |
| $LSTEEL$ | 0.100*** | 0.0000** | 0.021 | 0.047*** |
| | (0.018) | (0.0000) | (0.017) | (0.017) |

The dynamic specification exhibits a significant error correction coefficient for the demolition price of tankers, with the expected negative sign. The value of this coefficient, i.e. the speed of return to the equilibrium demolition price level appears to be moderate. The seaborne trade equation does not seem to account for the error correction of a shock, because the coefficient has the same sign as in the equilibrium relationship. The nickel and the steel scrap equations have the correct sign in their error correction term, but their effect is insignificant. Fig. 8 below shows that one standard deviation (shock) increase in the price of steel scrap will result in about 2.8% increase in the tanker demolition price offered by Bangladesh. Tankers offer a better quality scrap and therefore it is valued more comparatively by recyclers.

**Fig. 8. The IRF of a Shock in the Price of Steel Scrap on the Tanker scrap price.**

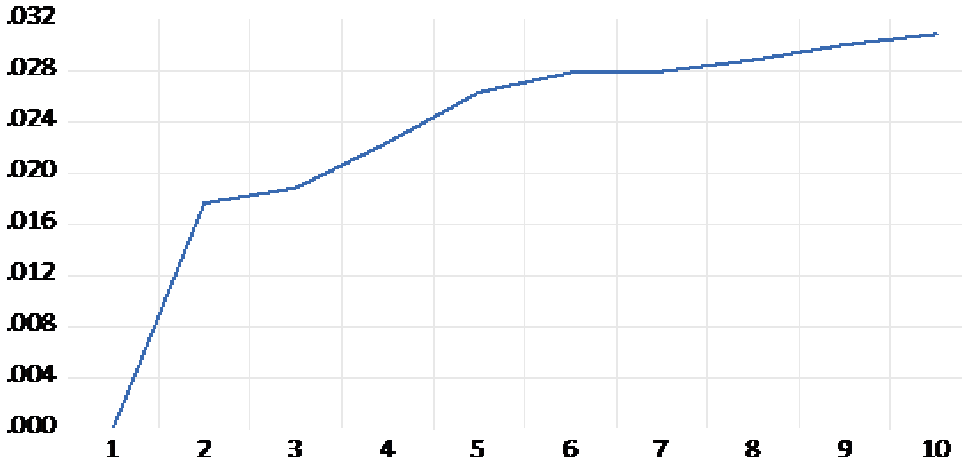
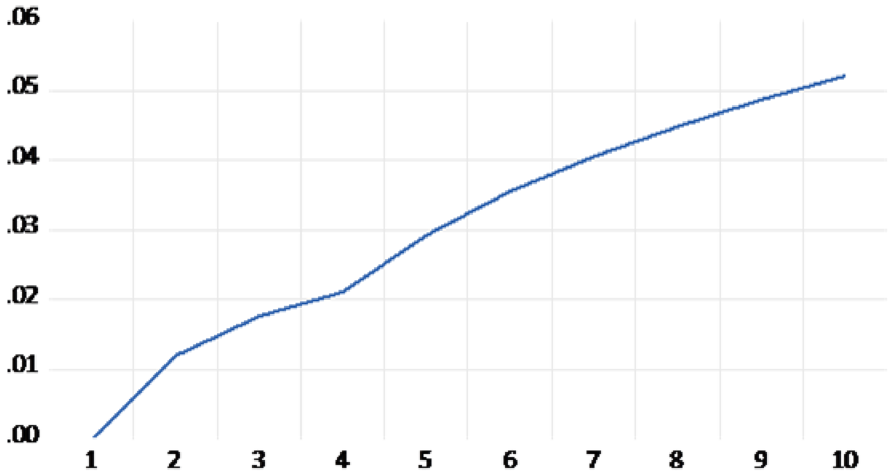



Fig. 9 shows that one standard deviation (shock) increase in the price of nickel will result in about 5% increase in the ship demolition price offered by Bangladesh.

**Fig. 9. The IRF of a Shock in the Price of Nickel on Tanker Scrap Price.**




Having established a long run relationship among commodities and the tanker demolition price we turn into how the scrap price feeds into the shipping sector and impacts on shipping sector fundamentals. Tables 11 and 12 provide the underpinnings of the long run relationship (4) between the fleet size, earnings, tanker scrap price and seaborne trade in the tanker subsector.

**Table 11: Unit root tests (ADF and KPSS)**

| Variables | ADF | 95% Crit.Value | KPSS | 95% Crit.Value |
|---|---|---|---|---|
| $LFLEETT$ | -2.10 | -3.43 | 0.69 | 0.15 |
| $LEARNT$ | -3.36 | -3.42 | 0.31 | 0.14 |
| $LSCRAPT$ | -2.07 | -3.43 | 0.31 | 0.15 |
| $LDEMT$ | -1.95 | -3.42 | 0.46 | 0.15 |
| $\Delta(LFLEETT)$ | -3.14 | -2.87 | 0.14 | 0.46 |
| $\Delta(LEARNT)$ | -14.14 | -2.87 | 0.07 | 0.46 |
| $\Delta(LSCRAPT)$ | -16.44 | -2.87 | 0.06 | 0.46 |
| $\Delta(LDEMT)$ | -3.56 | -2.87 | 0.35 | 0.46 |

Note: The SIC criterion was used to select the lag order of the ADF regressions

**Table 12: Results of Johansen cointegration test in the tanker market**

| $H_0$ | Max-eigenvalue Statistic | 95% Critical Value | Trace test Statistic | 95% Critical Value |
|---|---|---|---|---|
| r=0 | 34.92 | 33.87 | 75.85 | 69.82 |
| r≤1 | 20.64 | 27.58 | 40.93 | 47.85 |
| r≤2 | 13.15 | 21.13 | 20.29 | 29.79 |
| r≤3 | 6.89 | 14.26 | 7.14 | 15.49 |

Note: r denotes the number of cointegrating vectors

The maximum eigenvalue and the trace tests suggest that there is one single cointegrating relation between the scrap price of tankers, the fleet size, the earnings, and seaborne trade in the tanker subsector. Estimating the error correction model yields the following long-term relationship for our decision variables. This combination of variables achieves a long run equilibrium in jointly determining earnings.

$$LEARNT_t = -72.65 - 10.54LFLEETT_t + 0.46LSCRAPT_t + 21.46LDEMT_t \quad (4)$$

$$(1.059) \qquad (0.389) \qquad (2.603)$$

The asymptotic standard errors of the coefficients can be found in the brackets. As we can see in equation (4) the scrap price has a significant 0.46% positive effect on the earnings of tankers. If the price of scrap increases by 1%, the earnings rise by 0.46% and if the fleet increases by 1% then the earnings fall by 10.54% on average. The effect of the seaborne trade is also found to be positive and strongly significant, which implies that it also contributes decisively to the determination of earnings as expected. The dynamic specification, shown in Table 13 below, exhibits a significant error correction coefficient for the earnings of tankers, with the expected negative sign. The value of this coefficient, i.e. the speed of return to the equilibrium fleet size level appears to be pretty slow. The scrap price, fleet and seaborne trade equations do not seem to significantly account for the error correction of a shock.

**Table 13. Dynamics of Adjustment in the Tanker Earnings**

| | $\Delta(LEARNT)$ | $\Delta(DEMT)$ | $\Delta(LSCRAPT)$ | $\Delta(LFLEETT)$ |
|---|---|---|---|---|
| $ECT_{t-1}$ | -0.036*** | 0.0002*** | -0.009 | -0.0007 |
| | (0.014) | (0.00003) | (0.006) | (0.0002) |
| $Constant$ | 0.013 | -0.00007** | -0.002 | 0.002*** |
| | (0.021) | (0.00004) | (0.009) | (0.0002) |
| $\Delta(LFLEETT)_{t-1}$ | -6.114 | 0.020*** | 0.066 | 0.371*** |
| | (5.129) | (0.009) | (2.218) | (0.059) |
| $\Delta(LEARNT)_{t-1}$ | 0.176*** | -0.0003*** | -0.012 | -0.00004 |
| | (0.061) | (0.0001) | (0.026) | (0.0007) |
| $\Delta(\text{LSCRAPT})_{t-1}$ | -0.087 | -0.0002 | -0.035 | -0.0002 |
| | (0.144) | (0.0003) | (0.063) | (0.002) |
| $\Delta(\text{DEMT})_{t-1}$ | 2.318 | 0.999*** | 3.297** | -0.039 |
| | (4.638) | (0.008) | (2.006) | (0.053) |

## 4.3 The Container Market

In 2017 container demolition was about 399 thousand TEUs, according to Clarksons, it had the smallest value among all shipping subsectors, but it was the second largest in numbers of ships. The compound average growth rate (CAGR) of world container traffic from 2005 to 2016 is estimated at 6% compared with a global real GDP CAGR of 2.5% for the same period, according to the World Bank. Determining factors in this growth were the growth in global trade, increased global sourcing and manufacturing, a shift from transporting cargo in bulk to transporting cargo in containers. In 2017 world container traffic growth was 2% (UNCTAD,2018).

Tables 14 and 15 below present the unit root tests and the results of the Johansen cointegration test in the Container market.

**Table 14. Unit Root Tests (ADF and KPSS)**

| Variables | ADF | 95% Crit.Value | KPSS | 95% Crit.Value |
|---|---|---|---|---|
| $LSCRAPC$ | -2.22 | -3.43 | 0.31 | 0.16 |
| $LOIL$ | -3.01 | -3.42 | 0.22 | 0.15 |
| $LNIC$ | -2.99 | -3.42 | 0.15 | 0.14 |
| $LDEMC$ | -0.47 | -3.42 | 0.47 | 0.15 |
| $\Delta(LSCRAPC)$ | -16.59 | -2.87 | 0.05 | 0.46 |
| $\Delta(LOIL)$ | -15.27 | -2.87 | 0.05 | 0.46 |
| $\Delta(LNIC)$ | -15.13 | -2.87 | 0.04 | 0.46 |
| $\Delta(LDEMC)$ | -3.27 | -2.87 | 0.43 | 0.46 |

Note: The SIC criterion was used to select the lag order of the ADF regressions

**Table 15.: Results of Johansen Cointegration test in the Container Market**

| $H_0$ | Max-eigenvalue Statistic | 95% Crit. Value | Trace test Statistic | 95% Crit. Value |
|---|---|---|---|---|
| r=0 | 19.79 | 27.58 | 47.92 | 47.86 |
| r≤1 | 15.52 | 21.13 | 28.13 | 29.79 |
| r≤2 | 9.48 | 14.26 | 12.60 | 15.49 |
| r≤3 | 3.12 | 3.84 | 3.12 | 3.84 |

Note: r denotes the number of cointegrating vectors

The trace test (Table 15) marginally suggests that there is one single cointegrating relation between the scrap price of containers and the price of oil, the price of nickel and the steel scrap price. Estimating the error correction model yields the following long-term relationship for the containers scrap price.

$$\boldsymbol{LSCRAPC_t = 6.10 - \underset{(0.212)}{0.77}LOIL_t + \underset{(0.165)}{1.99}LNIC_t + \underset{(0.177)}{0.76}LDEMC_t \ (5)}$$

The asymptotic standard errors of the coefficients can be found in the brackets. As we can see in equation (5) the price of nickel has a significant 1.99% positive effect on the demolition price of containers. If the price of nickel increases by 1%, the scrap price of containers increases by 1.99% and if the oil price increases by 1% then the demolition price falls by 0.77% on average. The effect of the price of seaborne trade is found to be positive and strongly significant. The dynamic specification as shown in Table 16, exhibits a significant error correction coefficient for the demolition price of container ships, with the expected negative sign. The value of this coefficient, i.e. the speed of return to the equilibrium demolition price level appears to be relatively slow. This coefficient can be interpreted as the coefficient of speed of adjustment between short run dynamics and long run equilibrium values. In other words, it measures the speed of movement towards a new equilibrium because of the introduction of the error correction term of the previous period as explanatory variable which allows to move towards a new equilibrium.

**Table 16. Dynamics of Adjustment in the Container Scrap Market**

| | $\Delta(LSCRAPC)$ | $\Delta(LOIL)$ | $\Delta(LNIC)$ | $\Delta(LDEMC)$ |
|---|---|---|---|---|
| $ECT_{t-1}$ | -0.077*** | - 0.054** | 0.030 | 0.00005*** |
| | (0.026) | (0.023) | (0.022) | (0.00001) |
| $Constant$ | - 0.219*** | - 0.053 | -0.027 | 0.0002*** |
| | (0.091) | (0.081) | (0.077) | (0.00004) |
| $\Delta(LSCRAPC)_{t-1}$ | -0.107** | 0.141*** | 0.017 | - 0.00005** |
| | (0.065) | (0.058) | (0.055) | (0.00003) |
| $\Delta(LSCRAPC)_{t-2}$ | -0.105* | 0.142*** | 0.013 | - 0.00007*** |
| | (0.065) | (0.058) | (0.055) | (0.00003) |
| $\Delta(LSCRAPC)_{t-3}$ | -0.063 | 0.054 | -0.144*** | - 0.0001*** |
| | (0.065) | (0.058) | (0.055) | (0.00003) |
| $\Delta(LOIL)_{t-1}$ | 0.128** | 0.162*** | -0.037 | 0.00008*** |
| | (0.075) | (0.067) | (0.064) | (0.00003) |
| $\Delta(LOIL)_{t-2}$ | 0.007 | -0.020 | 0.013 | -0.00004 |
| | (0.076) | (0.067) | (0.064) | (0.00003) |
| $\Delta(LOIL)_{t-3}$ | -0.104 | -0.096 | -0.055 | 0.00003 |
| | (0.076) | (0.067) | (0.064) | (0.00003) |
| $\Delta(LNIC)_{t-1}$ | - 0.013 | - 0.053 | 0.231*** | 0.0001*** |
| | (0.080) | (0.071) | (0.068) | (0.00004) |
| $\Delta(LNIC)_{t-2}$ | 0.020 | 0.124** | - 0.010 | 0.000009 |
| | (0.082) | (0.073) | (0.069) | (0.00004) |
| $\Delta(LNIC)_{t-3}$ | 0.022 | -0.082 | 0.004 | 0.000002 |
| | (0.081) | (0.072) | (0.068) | (0.00004) |
| $\Delta(LDEMC)_{t-1}$ | -5.628 | - 119.33*** | -82.7** | 2.800*** |
| | (62.28) | (55.36) | (52.59) | (0.031) |
| $\Delta(LDEMC)_{t-2}$ | -2.659 | 236.50*** | 174.29** | -2.65*** |
| | (120.88) | (107.45) | (102.066) | (0.060) |
| $\Delta(LDEMC)_{t-3}$ | 11.473 | - 118.46*** | -87.2** | 0.855*** |
| | (60.30) | (53.60) | (50.92) | (0.030) |

Below we present the impulse response functions as essential graphs of market dynamics. Fig. 10 shows that one standard deviation (shock) increase in the price of oil will result in about 2% fall in the dry bulk demolition price offered by Bangladesh. Fig. 11 shows that one standard deviation (shock) increase in the price of nickel will result in about 3.2% increase in the dry bulk demolition price offered by Bangladesh.

**Fig. 10. The IRF of a Shock in the Price of Oil onto Scrap Price.**

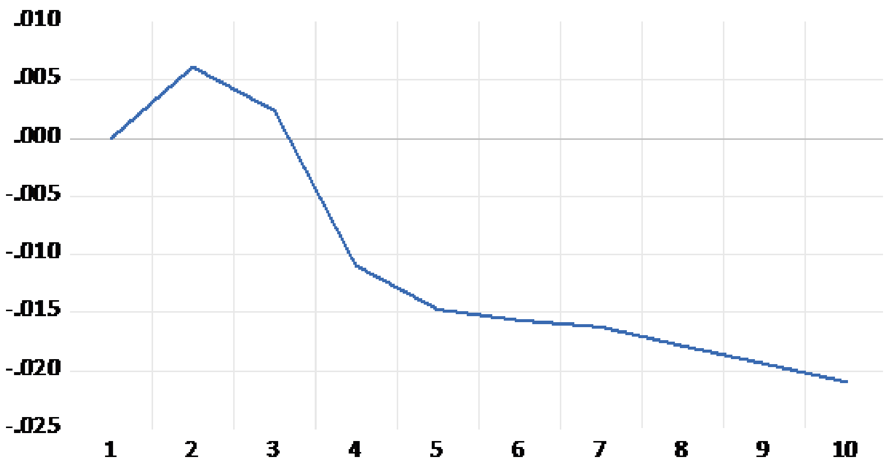
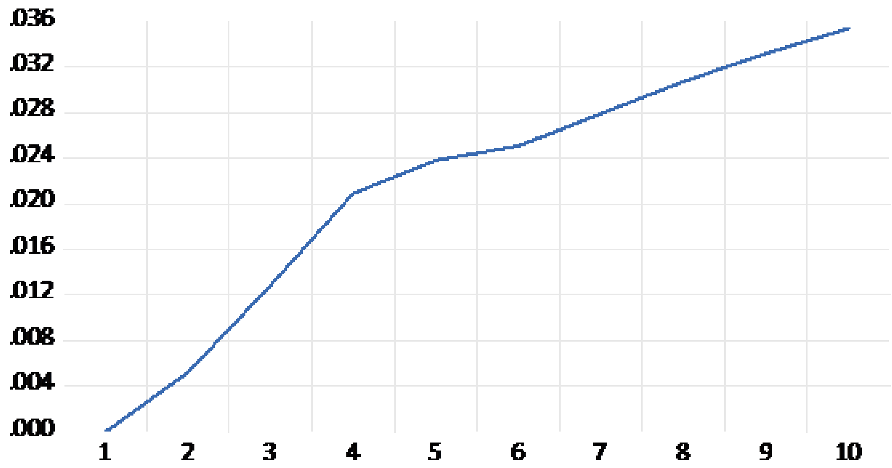



**Fig. 11. The IRF of a Shock in the Price of Nickel on Scrap Price.**




We then proceeded to investigate the interdependence of the demolition price of container ships with the other market fundamentals. Tables 17 and 18 and 19 demonstrate the background and the estimates for the long run equilibrium relationship (6) below.

**Table 17. Unit Root Tests (ADF and KPSS)**

| Variables | ADF | 95% Crit.Value | KPSS | 95% Crit.Value |
|---|---|---|---|---|
| $LFLEETC$ | -1.05 | -3.43 | 0.43 | 0.16 |
| $LEARNC$ | -3.25 | -3.42 | 0.15 | 0.14 |
| $LSCRAPC$ | -2.22 | -3.43 | 0.31 | 0.16 |
| $LDEMC$ | -0.47 | -3.42 | 0.47 | 0.15 |
| $\Delta(LFLEETC)$ | -3.53 | -2.87 | 0.14 | 0.46 |
| $\Delta(LEARNC)$ | -6.20 | -2.87 | 0.04 | 0.46 |
| $\Delta(LSCRAPC)$ | -16.59 | -2.87 | 0.05 | 0.46 |
| $\Delta(LDEMC)$ | -3.27 | -2.87 | 0.43 | 0.46 |

Note: The SIC criterion was used to select the lag order of the ADF regressions.

**Table 18. Results of Johansen Cointegration Test in the Container Market**

| $H_0$ | Max-eigenvalue Statistic | 95% Critical Value | Trace test Statistic | 95% Critical Value |
|---|---|---|---|---|
| r=0 | 28.76 | 27.58 | 62.46 | 47.85 |
| r≤1 | 19.91 | 21.13 | 33.70 | 29.79 |
| r≤2 | 10.36 | 14.26 | 13.78 | 15.49 |
| r≤3 | 3.42 | 3.84 | 3.42 | 3.84 |

Note: r denotes the number of cointegrating vectors

The trace test suggests that there is one single cointegrating relation between the scrap price of container ships and the size of the fleet, the earnings and the seaborne trade. Estimating the error correction model yields the following long-term relationship for containers' earnings.

$$\boldsymbol{LEARNC_t = 7.57 - 2.39LFLEETC_t + 0.49LSCRAPC_t + 2.30LDEMC_t} \quad (\mathbf{6})$$

$$(\mathbf{0.282}) \qquad (\mathbf{0.101}) \qquad (\mathbf{0.282})$$

The asymptotic standard errors of the coefficients can be found in the brackets. As we can see in equation (6) the seaborne trade has a significant 2.3% positive effect on the earnings of containers. If the scrap price increases by 1% container earnings will increase by 0.49% on average and if the fleet falls by 1% earnings will rise by 2.4% approximately.Our estimates support the findings by Chowdhury & Dinwoodie, (2011).

**Table 19. Dynamics of Adjustment in the Container Earnings**

| | $\Delta(LEARNC)$ | $\Delta(LFLEETC)$ | $\Delta(LDEMC)$ | $\Delta(LSCRAPC)$ |
|---|---|---|---|---|
| $ECT_{t-1}$ | -0.093*** | - 0.00008 | -0.00007*** | 0.102*** |
| | (0.018) | (0.0016) | (0.00002) | (0.047) |
| $Constant$ | -0.015*** | 0.001*** | -0.000008 | 0.007 |
| | (0.007) | (0.0006) | (0.000009) | (0.018) |
| $\Delta(LEARNC)_{t-1}$ | 0.434*** | 0.003 | 0.00004 | -0.112 |
| | (0.060) | (0.005) | (0.00007) | (0.153) |
| $\Delta(LEARNC)_{t-2}$ | 0.219*** | 0.006 | 0.000002 | 0.150 |
| | (0.065) | (0.005) | (0.00008) | (0.165) |
| $\Delta(LEARNC)_{t-3}$ | -0.073 | 0.001 | 0.00005 | -0.078 |
| | (0.062) | (0.005) | (0.00008) | (0.157) |
| $\Delta(FLEETC)_{t-1}$ | -0.336 | 0.149*** | -0.0007 | -0.618 |
| | (0.719) | (0.060) | (0.0009) | (1.813) |
| $\Delta(FLEETC)_{t-2}$ | -1.489*** | 0.295*** | 0.002*** | -1.324 |
| | (0.698) | (0.058) | (0.0009) | (1.758) |
| $\Delta(FLEETC)_{t-3}$ | -0.442 | 0.380*** | 0.0002 | 0.414 |
| | (0.738) | (0.062) | (0.0009) | (1.861) |
| $\Delta(LDEMC)_{t-1}$ | 44.712*** | -1.263 | 2.848*** | -56.921 |
| | (21.804) | (1.827) | (0.027) | (54.928) |
| $\Delta(LDEMC)_{t-2}$ | -83.798*** | 2.351 | -2.750*** | 101.900 |
| | (43.182) | (3.619) | (0.054) | (108.782) |
| $\Delta(LDEMC)_{t-3}$ | 44.500*** | -1.090 | 0.902*** | -43.393 |
| | (22.059) | (1.849) | (0.028) | (55.568) |
| $\Delta(LSCRAPC)_{t-1}$ | -0.067*** | -0.0002 | -0.00006*** | -0.069 |
| | (0.026) | (0.002) | (0.00003) | (0.065) |
| $\Delta(LSCRAPC)_{t-2}$ | -0.005 | 0.001 | -0.00009*** | -0.069 |

| | | | | |
|---|---|---|---|---|
| | (0.026) | (0.002) | (0.00003) | (0.065) |
| $\Delta(LSCRAPC)_{t-3}$ | -0.021 | 0.0001 | -0.0001*** | -0.035 |
| | (0.025) | (0.002) | (0.00003) | (0.065) |

The dynamic specification, shown in Table 19, exhibits a significant error correction coefficient for the fleet size of containers, with the expected negative sign. The value of this coefficient, i.e. the speed of return to the equilibrium fleet size level appears to be very slow. The scrap price, fleet, and the seaborne trade equations do not seem to significantly explain the error correction of a shock.

### 4.4 Robustness Checks

To test our assertion, that the scrap price is determined by oil price, nickel price , imported steel-scrap price and seaborne trade, or our assertion, that the demolition or scrap price, earnings, the fleet size and seaborne trade are interdependent in each market, we can estimate the VECMs jointly for all sectors and separately for each sector. The joint model delivers a forecast of the scrap price, say $\hat{p}_t$. From the individual models we have the corresponding forecast $\hat{p}_t^{(m)}$ ($m = 1,2,3$ for the different sectors). If our first assertion is correct we would expect the forecasts to be similar. The Diebold and Mariano (1995) test can be used in this instance to test it. Define the forecast errors $e_t = \hat{p}_t - p_t$ and $e_t^{(m)} = \hat{p}_t^{(m)} - p_t$. If we define $d_t^{(m)} = |\hat{p}_t - p_t| - |p_t^{(m)} - p_t|$ then the null hypothesis is $H_1: E\left(d_t^{(m)}\right) = 0$. The Diebold-Mariano ($DM$) statistic is:

$$DM = \frac{\bar{d}}{\sqrt{\frac{2\pi f_d(0)}{T}}}$$

where $f_d(0) = \frac{1}{2\pi}\sum_{k=-\infty}^{\infty}\gamma_d(k)$ , $\gamma_d(k)$ is the autocovariance of $d_t^{(m)}$ at lag k. The $DM$ statistic converges asymptotically to a standard normal distribution. We apply the $DM$ test using $h$-step ahead forecasts. From Table 20 below it seems that both of our assertions can be accepted.

**Table 20. p-values of DM statistic**

| | *h=1* | *h=5* | *h=10* |
|---|---|---|---|
| | | *Assertion 1* | |
| *m=1* | *0.157* | *0.095* | *0.077* |
| *m=2* | *0.145* | *0.092* | *0.081* |
| *m=3* | *0.095* | *0.073* | *0.064* |
| | | *Assertion 2* | |
| *m=1* | *0.233* | *0.133* | *0.093* |
| *m=2* | *0.143* | *0.128* | *0.102* |
| *m=3* | *0.125* | *0.114* | *0.073* |

As a second robustness check for both of our assertions we consider the Clark and West(2007) test. Again we estimate the VECMs jointly for all subsectors and for each one separately. We consider 5-step ahead forecasts. The 5 period ahead forecast of the jointly estimated model is $\hat{p}_{t+5}$ and from the other three, one for each subsector, is $\hat{p}_{t+5}^{(m)}$ where $m = 1,2,3$. The 5 period forecast error of the joint model is $e_t = p_t - \hat{p}_{t+5}$ and or each of the subsectors $e_t^{(m)} = p_t^m - \hat{p}_{t+5}^{(m)}$ . The sample MSPEs (mean square prediction errors) are $\hat{\sigma}^2$ $and$ $\hat{\sigma}_m^2$ (where $\mathrm{m} = 1,2,3$) and computed as sample averages of $(p_t - \hat{p}_{t+5})^2$ and for each subsector $(p_t^m - \hat{p}_{t+5}^{(m)})^2$.The Clark and West (2007) test defines an adjustment term as the sample average of $(\hat{p}_{t+5}^m - \hat{p}_{t+5})^2$.Then the null hypothesis is

$\mathrm{H_0}$: $\hat{\sigma}^2 - (\hat{\sigma}_m^2 - adjustment) = 0$ against the alternative that

$\mathrm{H_A}$: $(\hat{\sigma}_m^2 - adjustment) < \hat{\sigma}^2$

The adjustment term adjusts for the upward bias in MSPE produced by the estimates of parameters that are zero under $\mathrm{H_0}$.

We construct the sample average of the $\mathrm{H_0}$

$$\hat{f}_{t+5} = (p_t - \hat{p}_{t+5})^2 - [(p_t^m - \hat{p}_{t+5}^{(m)})^2 - (\hat{p}_{t+5}^m - \hat{p}_{t+5})^2]$$

and regress it on a constant. The resulting t-statistic is compared with the critical value of 1.64 for a one-sided test at the 5% level of significance. We reject the null hypothesis if this statistic is greater than 1.64. The $\mathrm{H_0}$ is not rejected for all three subsectors, both in the case of the scrap VECMs and in the case of the earnings VECMs.

## 5. Policy Implications

We discovered that the scrap price in Bangladesh is a key determinant of the charter rate in each segment of the shipping sector. The policy implications for ship owners are clear: They should increase their capital investment when they see higher prices for scrap in Bangladesh, since such higher prices indicate increased profitability. Ship owners are expected to be more willing to invest in ships when they know that they can sell them for higher prices as scrap at the end of their lives. Ship dismantling companies can offer higher prices for ships to the extent that have lower costs. In the case of the Indian subcontinent, lower costs can be the result of loose environmental and safety regulations (Mikelis, 2018).

However, policy implications for regulators are less evident. Regulators can take measures to discourage or to encourage such investment practices, depending on their beliefs about the growth and the sustainability of the shipping industry. On the one hand, the growth of the shipping industry could be boosted if ship owners are encouraged to take advantage of favourable scrapping prices. On the other hand, shipping profits need to accommodate the objectives of major stakeholders such as the environment and the society. Shipping profits need to rely on the principles of sustainable economic development, incorporate corporate social responsibility practices and respect regulations on labor relations and environmental protection. In fact, this is the direction that is largely advocated by regulators and policy makers. According to the HKC, the countries where the ship departs from in order to be dismantled  should approve only certified shipyards (Choi et.al. 2016). Moreover, according to IMO regulations, any voyage for dismantling should be properly documented and the port authorities are called to evaluate the destination shipyards' official documentation to provide port clearance.

Despite the policy objectives of IMO and HKC, the dismantling market largely evades strict safety and environmental regulations; in terms of tonnage, more than 96% of ship dismantling takes place in countries that have not yet ratified the

HMC. Policy makers, therefore, need to enforce the same rules of sustainable shipping to all players in the ship dismantling market, thereby ensuring that sustainability is pursued as a prerequisite for profits instead of being treated as an avoidable expense.

**6. Conclusions**

In this study we assert that the market signal transmitted through the higher ship demolition price offered by the Indian subcontinent (up to 40% higher in recent years) is the scrap price at which the global shipping industry achieves a long run equilibrium relationship when it comes to its earnings determination. It price level though also reflects misallocation of resources (over-allocation) to an activity (ship recycling) which inflicts a severe external cost both in terms of human lives as well as the environment.

The ship demolition industry enables the stakeholders, ship owners, cash buyers and ship recyclers to bridge the gap between demand and supply in the shipping market. It is a dynamic land-based industry where stakeholders form expectations about the direction of change in the ship demolition price. As a result, the demolition price is used as a decision variable to balance out market conditions in the shipping industry. It is exactly this dual character of the demolition industry that makes it distinct and gathers the focus of attention by both scholars and practitioners. Through our empirical investigation we delve into both sides of the demolition industry and show a strong interdependence between the two parts. Overall, this research has been conducted in order to discover the factors that shape the ship demolition markets and how these factors filter through to decision making in the shipping market. Compliance with the Hong Kong Convention, even though it appears to be a very difficult task and seemingly involves high costs for the subcontinent countries, needs to be adopted. Eventually the scrap price will be adjusted to reflect the required investment cost by the recycler and in the longer run part of this cost will be borne by the end users of the shipping services, the consumers. Further research could be undertaken into the developments in the cash-buyers transactions in order to uncover changes in the conditions in which the industry operates and connects its two parts under IMO regulations.

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APPENDIX

**Fig. I. Response of Dry-Bulk Earnings to Chinese scrap price**

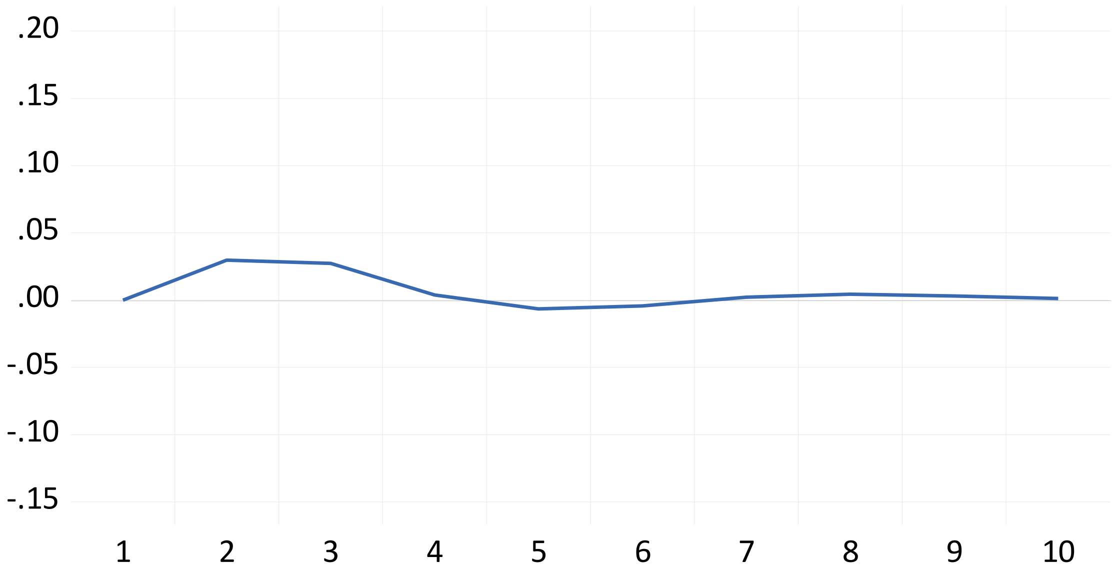


**Figure II**. **Response of tanker earnings to Chinese scrap price**

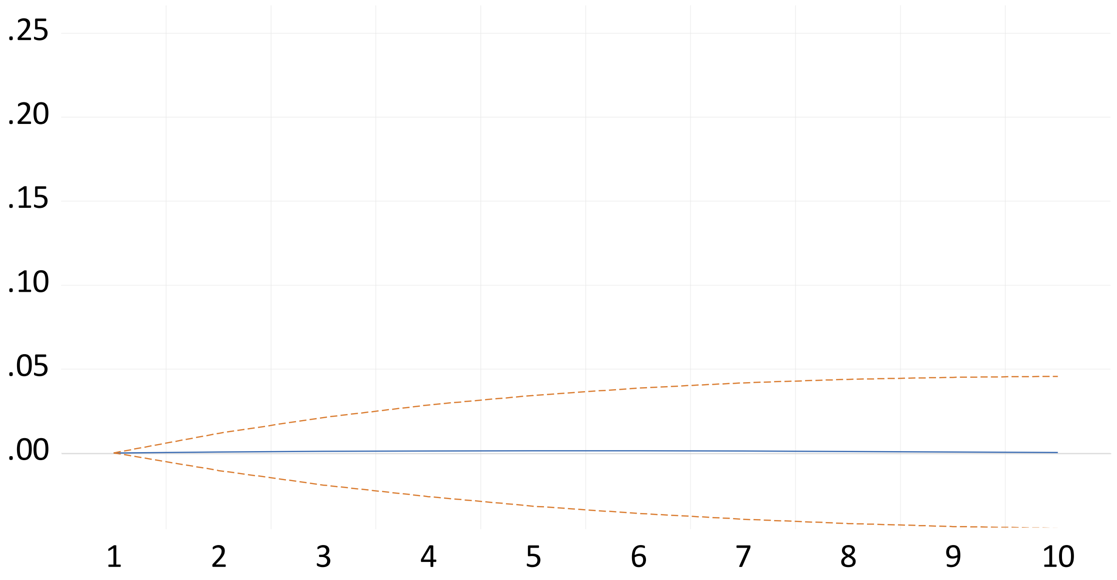


**Fig. III. Response of container earnings to Chinese scrap price**

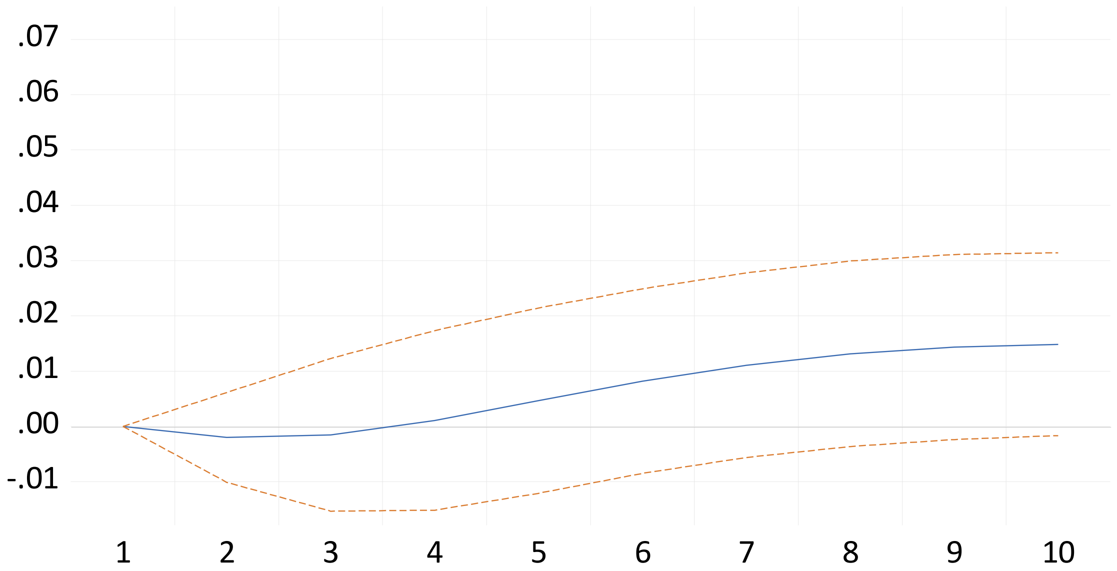


**Fig. IV. Graph of Dry-Bulk Scrap Cointegrating Relation.Eq.(1)**

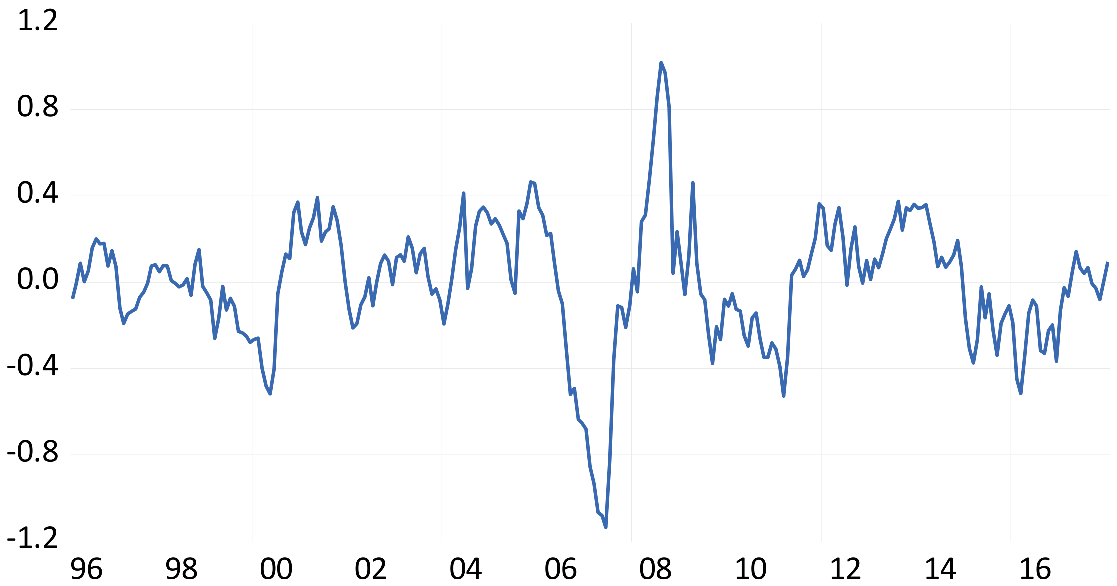


**Fig. V. Graph of Dry-Bulk Earnings Cointegrating Relation.Eq.(2)**

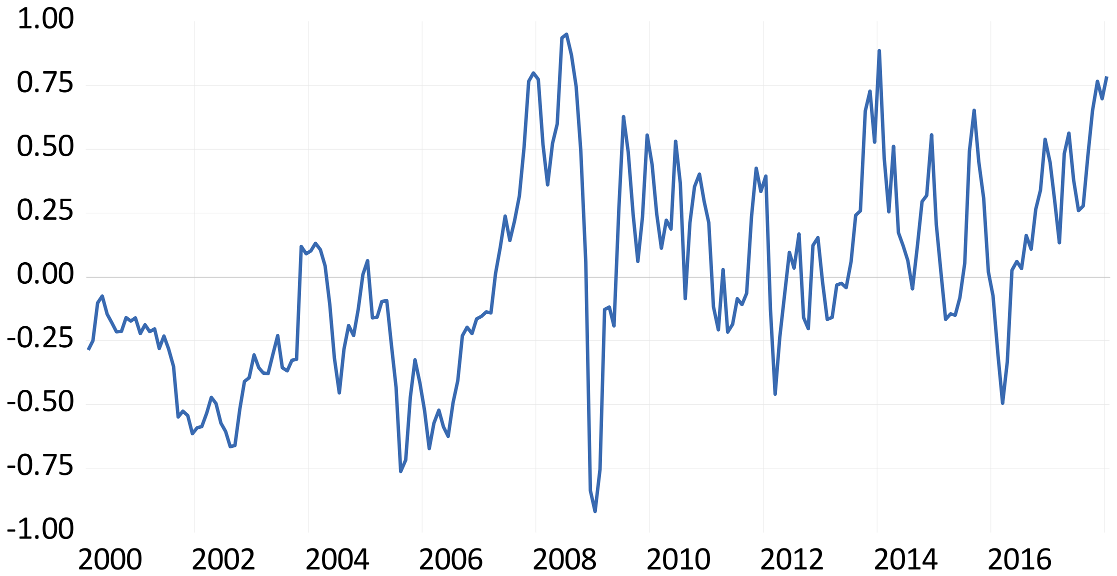


**Fig. VI. Graph of Tankers Scrap Cointegrating Relation.Eq.(3)**

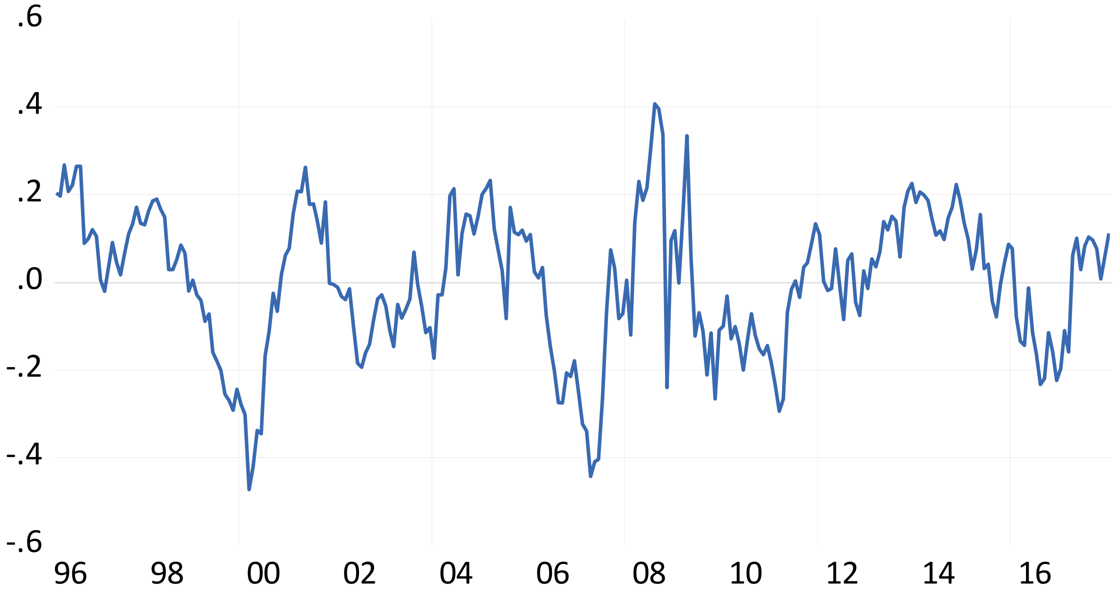


**Fig. VII. Graph of Tankers Earnings Cointegrating Relation.Eq.(4)**

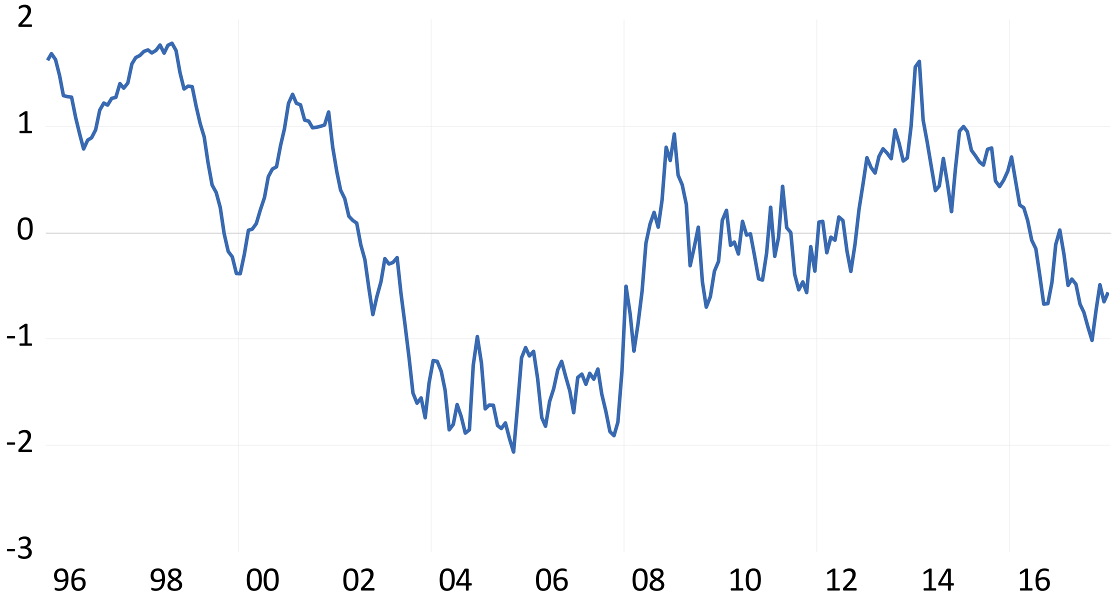


**Fig.VIII. Graph of Containers Scrap Cointegrating Relation.Eq.(5)**

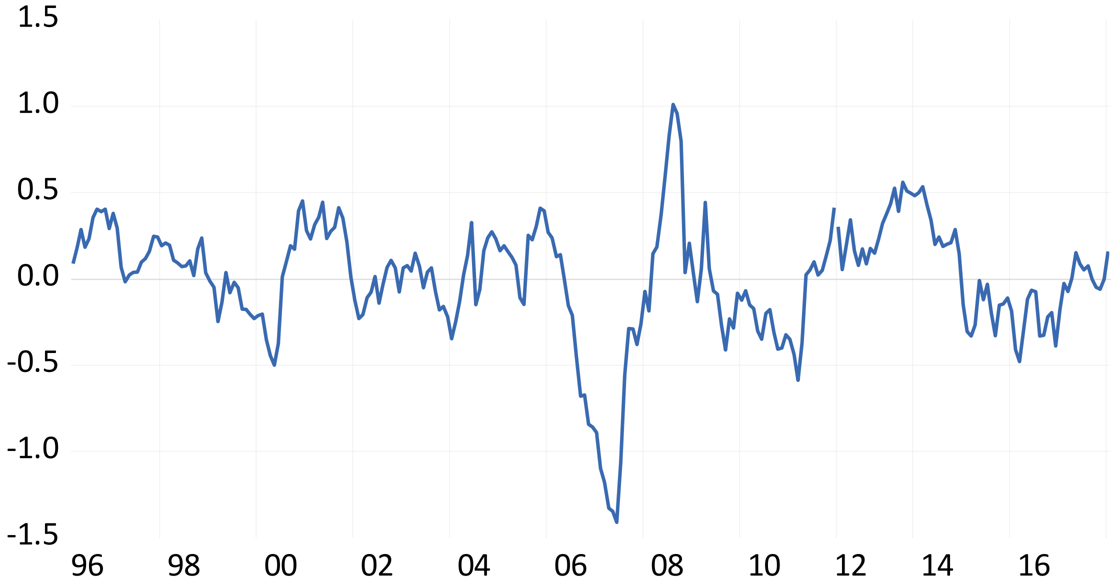


**Fig. IX. Graph of Containers Earnings Cointegrating Relation Eq.(6)**