THE DRY BULK MARKET AND CAPITAL RETIREMENT:

A VESSEL BASED LOGIT SCRAPPING MODEL

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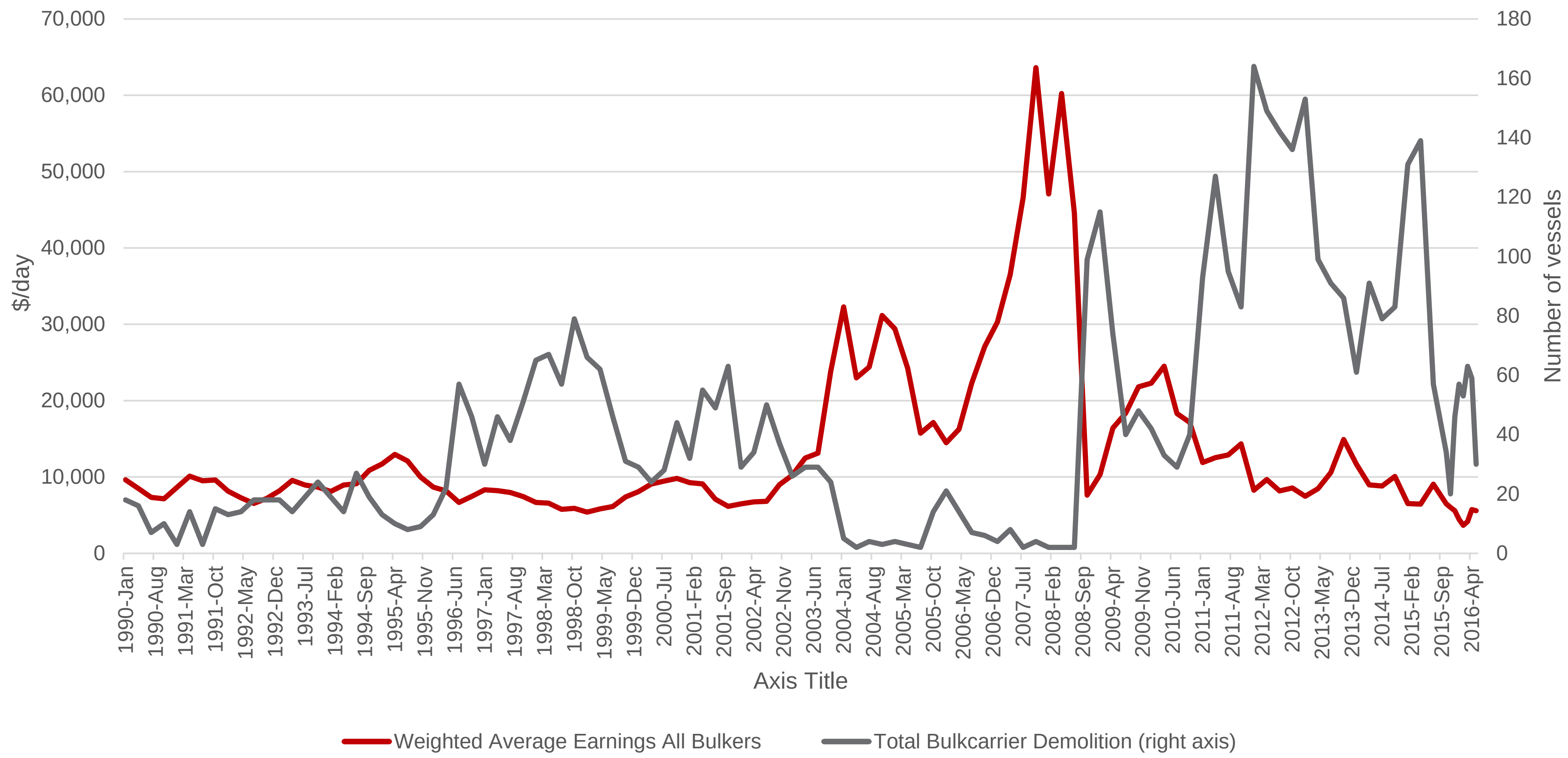
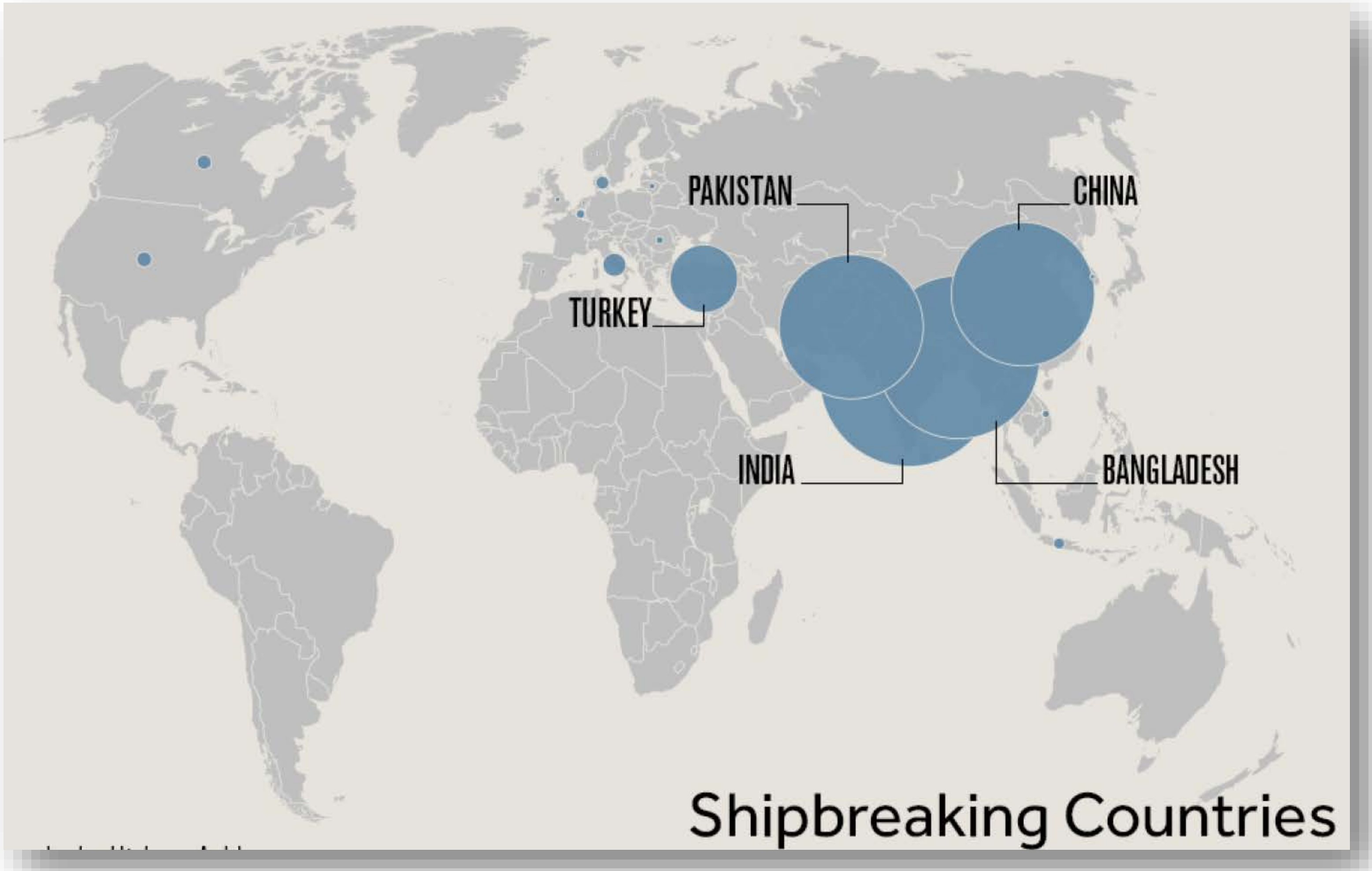
AN UPDATE OF CONTINUING RESEARCH WITH AMIR ALIZADEH AND HELEN THANOPOULOU

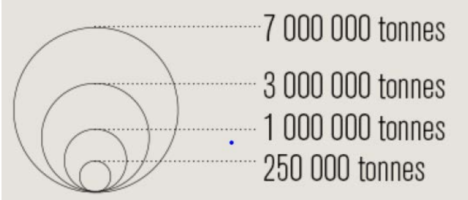
Dry bulk fleet demolition and average earnings



Quarterly data from Clarksons SIN

Shipscrapping countries



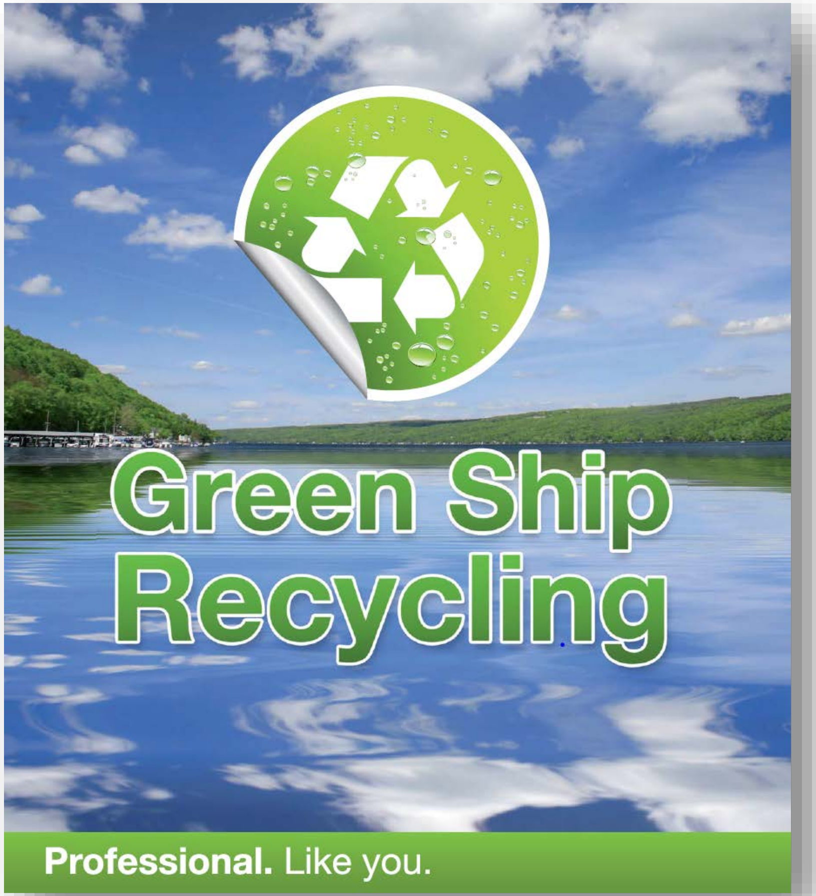


Beaching vessels for scrapping

- Beaching vessels for scrapping in India, Bangladesh and Pakistan
- > 80 % of the scrapped vessels are demolished in this way

"Green" scrapping

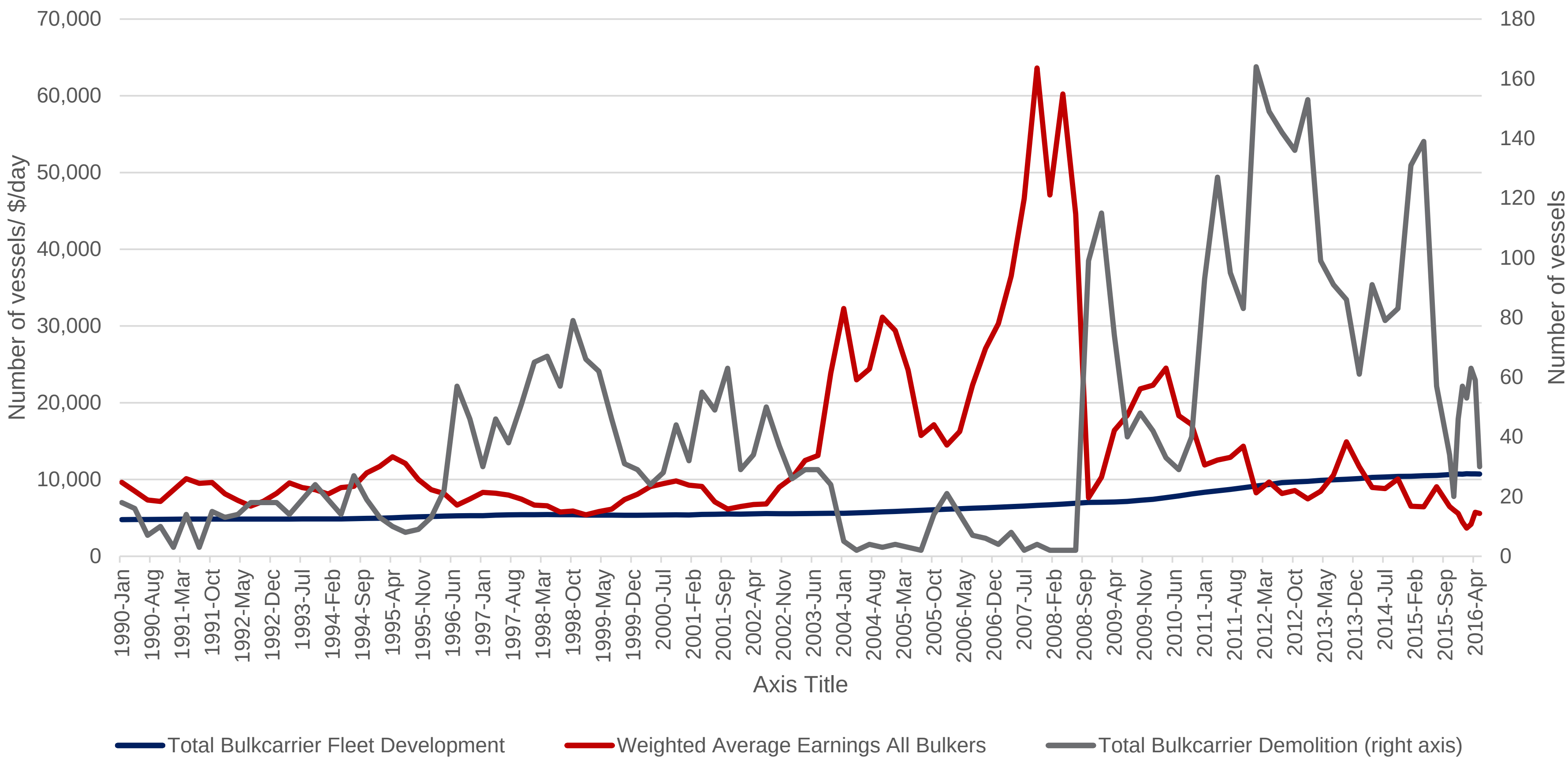
- Demolition process that secures
  - Safe working environment at the yard
  - Safe removal and disposal of hazardous materials
- Minimizing the impact on the environment
- In compliance with IMO requirements even before the ratification of the 2009 convention
- Less than 10% of the approx. 300 demolishing yards are "green". Most of the "green" are located in China.



Wilhelmsen Ship Management

Dry bulk fleet demolition and average earnings plus fleet development

NHH



Quarterly data from Clarksons SIN

Aim of the lecture

- Understand what factors influence bulk carrier scrapping

- Get an overview of
  - Scrapping activity in the crises years 2012-2015
  - Differences in scrapping probabilities for Capesize, Panamax, Handymax/Supramax and Handysize vessels

Content

- Introduction
- Capacity retirement in shipping
- Determinants of the decision to scrap
- Estimating the relative importan of
  - vessel specific factors,
  - company specific factors and
  - market factors on scrapping.
- Estimation results
- Concluding remarks and Highlights

Scrapping= Permanent capacity retirement

Capacity retirement in shipping takes three forms

- In the short term: The economically viable method is speed reduction
- In the medium-term: Firms resort to lay-up in any of the forms present today which include hot and cold lay up (Dunford and Sau, 2009)
- In the long-run: Firms resort to scrapping

In the first two cases, the capacity retirement is temporary while in the latter case it is permanent.

References

Capacity retirement in shipping:

- **Strømme Svendsen's seminal work in 1956 defined the lay-up and scrapping decisions during low freight rate periods**
- **Cockburn and Murray (1992) related capacity retirement to scrapping when modeling the impact of market conditions on tankers**
- **Dixit and Pindyck (1994) introduced a model which provides the economic threshold for lay-up and scrapping of ships based on the real option valuation framework.**
- **Knapp et al (2008) empirically investigate the impact of new regulation about ship recycling and explore determinants on probability for scrapping. They find a negative relation to earnings, a positive relation to scrap prices and no significant relation to flag, ownership or safety factors.**

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Picture courtesy Tsavliris

Determinants of the Decision to Scrap

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At any given time, the decision to scrap a vessel is a function of vessel specific factors, owners' financial condition and market variables

- **<u>Vessel Specific Factors</u> include age, size, condition of vessel, special survey costs, technical obsolescence and efficiency**
- **<u>Company Specific Factors</u> include cash position, strategic plans, cargo commitments**
- **<u>Market Factors</u> include freight market conditions (freight rate level, uncertainty, expected recovery time), bunker prices, scrap steel price, interest rates**

Some of these factors are readily observable while others are not easily accessible or quantifiable

Determinants of the Decision to Scrap

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In general we can define the decision to scrap a vessel as:

$$V_{i,t} = f\left(\overset{+}{Age}_{i,t}, \overset{+}{Dwt}_{i}, \overset{-}{FR}_{i,t}, \overset{+}{BP}_{t}, \overset{+}{SP}_{t}, \overset{+}{IR}^{*}_{t}, \overset{+}{Vol}_{t}, X_{i,t}\right) \quad (1)$$

- $V_{i,t}$ **Binary variable indicating the decision to scrap vessel *i* (*i*=0,1)**
- $Age_{i,t}$ **Age of the vessel *i***
- Dwt_i **Deadweight of vessel *i***
- $FR_{i,t}$ **Freight rate for vessel *i***
- BP_t **Bunker price**
- SP_t **Scrap steel price**
- IR^*_t **Level of interest rate**
- Vol_t **Freight market volatility**
- X_{it} **Reflect the financial situation of the firm owning vessel *i***
- t ***Time period***

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The logit model →

Probability of scrapping the vessel or not

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$$logit(t) = ln(t) - ln(1-t) = -ln(\frac{1-t}{t})$$

- The logistic function of any number *t* gives output between 0 and 1 and is the inverse of the logit function. It may be formulated as

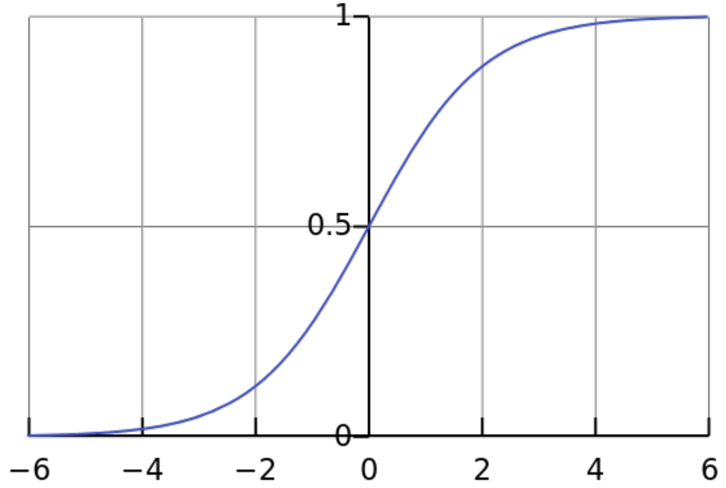
$$\text{Logit}^{-1}(t) = \text{logistic}(t) = \frac{e^t}{e^t+1} = \frac{1}{1+e^{-t}}$$

- *t* may be a function of one or more explanatory variables

$$t = \beta_0 + \beta_1 x$$

- Hence the probability of "success" is *F(x)*

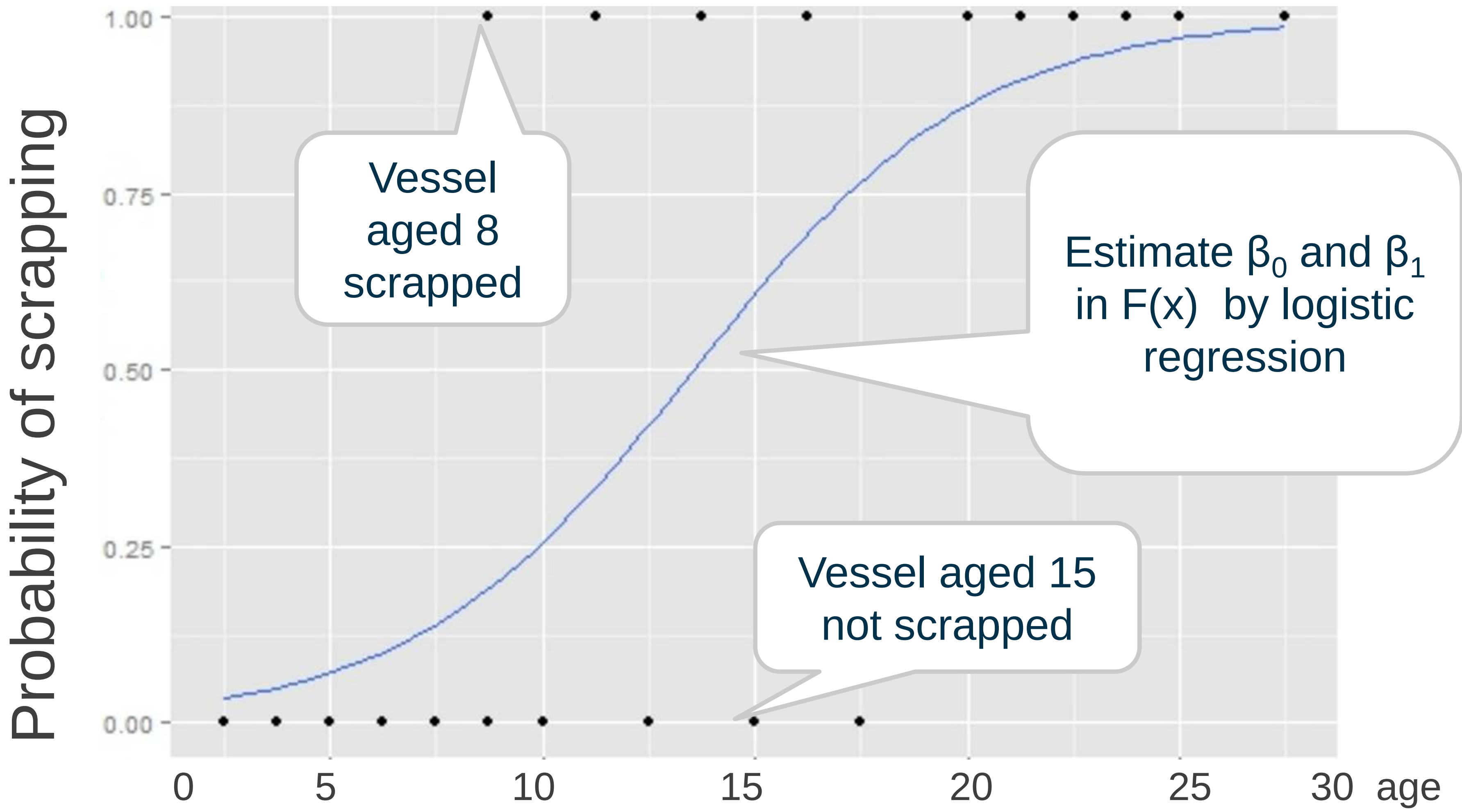
$$F(x) = \frac{1}{1+e^{-(\beta_0+\beta_1 x)}}$$



The standard logistic function of *(t)* ; note that logistic*(t)* ∊ *(0,1)* for all *t*

In our model "success" = scrapping

Probability of being scrapped and vessel age



Methodology I

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Because the dependent variable is a binary one, in order to investigate the impact of vessel specific on the decision to scrap, we specify and estimate a logit model of the following form:

$$\Pr(v_{i,t} = 1 | \Omega_t) = \frac{1}{(1 + e^{-(\beta_0 + \beta_1 Age_i + \beta_2 Dwt_i)})} \quad (2)$$

- **Where $\Pr(v_i = 1 | \Omega \ )$ is the probability of vessel *i* sold for scrapping in a given year in the sample, considering the information Ω set which includes all vessel specific variables.**
- **Parameters of equation (2) can be estimated by naming its log-likelihood function, which is defined as:**

$$\log l(\Pr(v_{i,t} = 1 | \Omega_t)) = \sum v_{i,t} \log(1 - F(-\mathbf{x}_i' \boldsymbol{\beta})) + (1 - v_{i,t}) \log(F(-\mathbf{x}_i' \boldsymbol{\beta}))$$

F(- **x'$_i$β**) = 1- (Pr(v_i=1 | **x$_i$,β**) is the cumulative distribution function of residuals , **x$_i$** is the matrix of explanatory variables, and **β** is the vector of coefficients

Methodology II

Unbalanced since we do not have observations for vessels after they are scrapped

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We extend the analysis by specifying a panel logit model by pooling the four year (2012-2015) data and estimating one unbalanced panel logit regression.

$$\Pr(v_{i,t}=1|\Omega_t)=1/(1+e^{-(\beta_0+\beta_1 Age_i+\beta_2 Dwt_i+\beta_3 DFRi,t+\beta_4 DBPt+\beta_5 DSCt+\beta_6 Vol_{i,t}+\beta_7 DIRt)})$$

- **where subscript *t* represents the year of scrapping (*t*= 2012, 2013, 2014 and 2015)**
- ***$DFR_{t,}$ DBP_t , DSC_t , DIR_t* respectively are deviations of**
  1 year time charter earnings, bunker price, scrap steel price and interest rate in year *t*
  from their long run means.
- ***Vol_t* is the volatility of the freight market**

Description of the Dataset

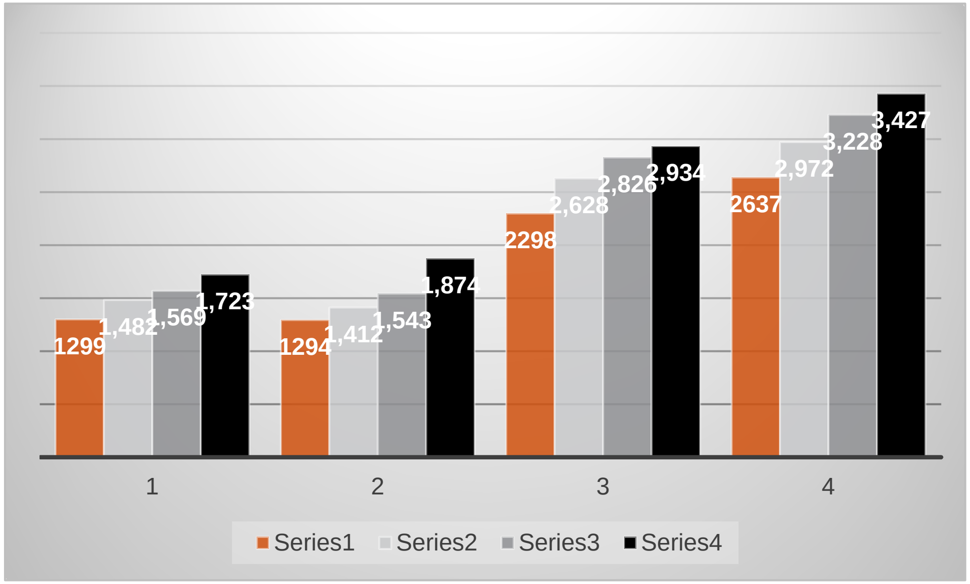
- **The information on scrapped vessels and fleet in different segments of the dry bulk market is obtained from Clarkson Research Ltd and covers the period 2012 to 2015.**
- **The data set includes the size and age of all the vessels, as well as the date on which each vessel is scrapped.**
- **In addition, operational earnings for each type of vessel and bunker prices have been collected Clarksons to be used as operational profitability variables.**
- **The four main sub-segments of the dry bulk market are:**
  - **<u>Capesize</u> vessels with more than 100,000 deadweight tonnes (dwt),**
  - **<u>Panamax</u> of vessels of 60,000dwt to 79,999dwt,**
  - **<u>Handymax/Supramax</u> with vessels between 40,000dwt to 59,999dwt,**
  - **<u>Handysize</u> with vessels ranging from 10,000dwt to 39,999dwt.**

Descriptive statistics of the dataset 2012

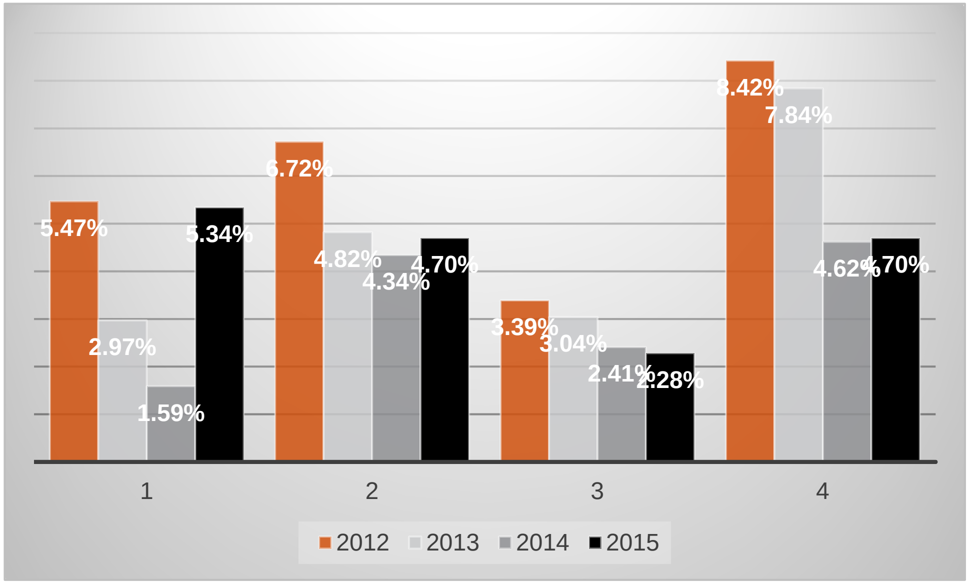
2012	Capesize	Panamax	Handymax	Handysize
Total fleet	1299	1,294	2,298	2,637
Scrapped	71	87	78	222
Proportion scrapped	5.47%	6.72%	3.39%	8.42%
Ave age of fleet (years)	8	11.8	8.6	12.6
Max age fleet	31	35	37	54
Min age of fleet	1	1	1	1
Ave age scrap (years)	22.9	28.6	26.5	30.1
Max scrap age	31	35	35	50
Min scrap age	15	22	18	18
Average size (dwt)	182,982	73,047	51,832	27,223
Max size fleet	404,389	79,964	59,888	39,991
Min size fleet	100,314	60,050	40,009	10,083

Similar statistics for 2013, 2014 and 2015

The fleets continue to rise



Proportion scrapped falls



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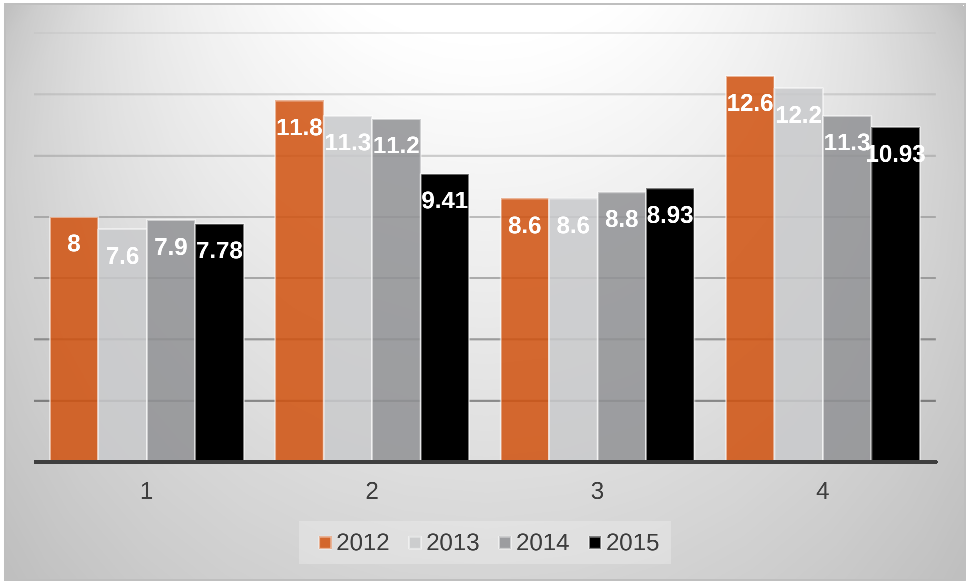
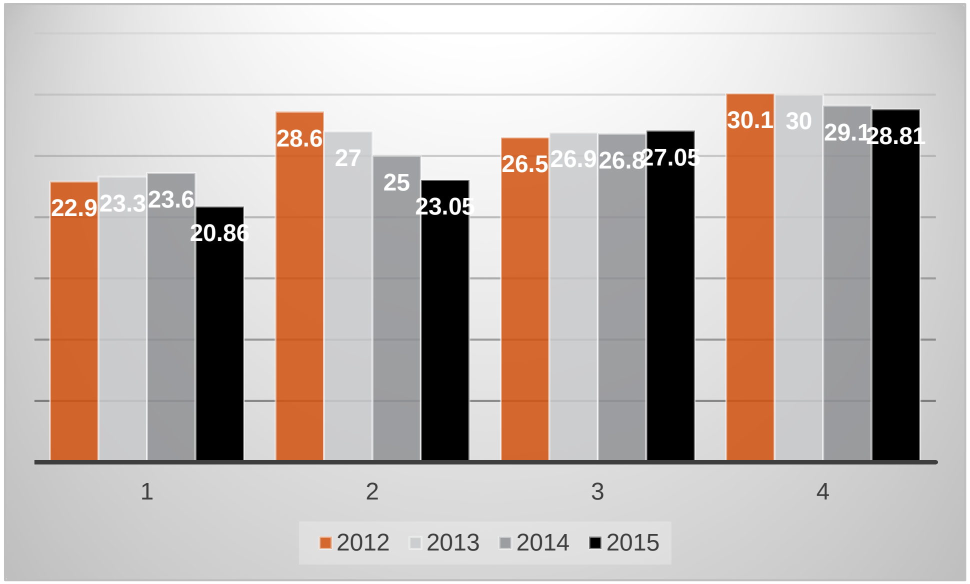
Similar statistics for 2013, 2014 and 2015

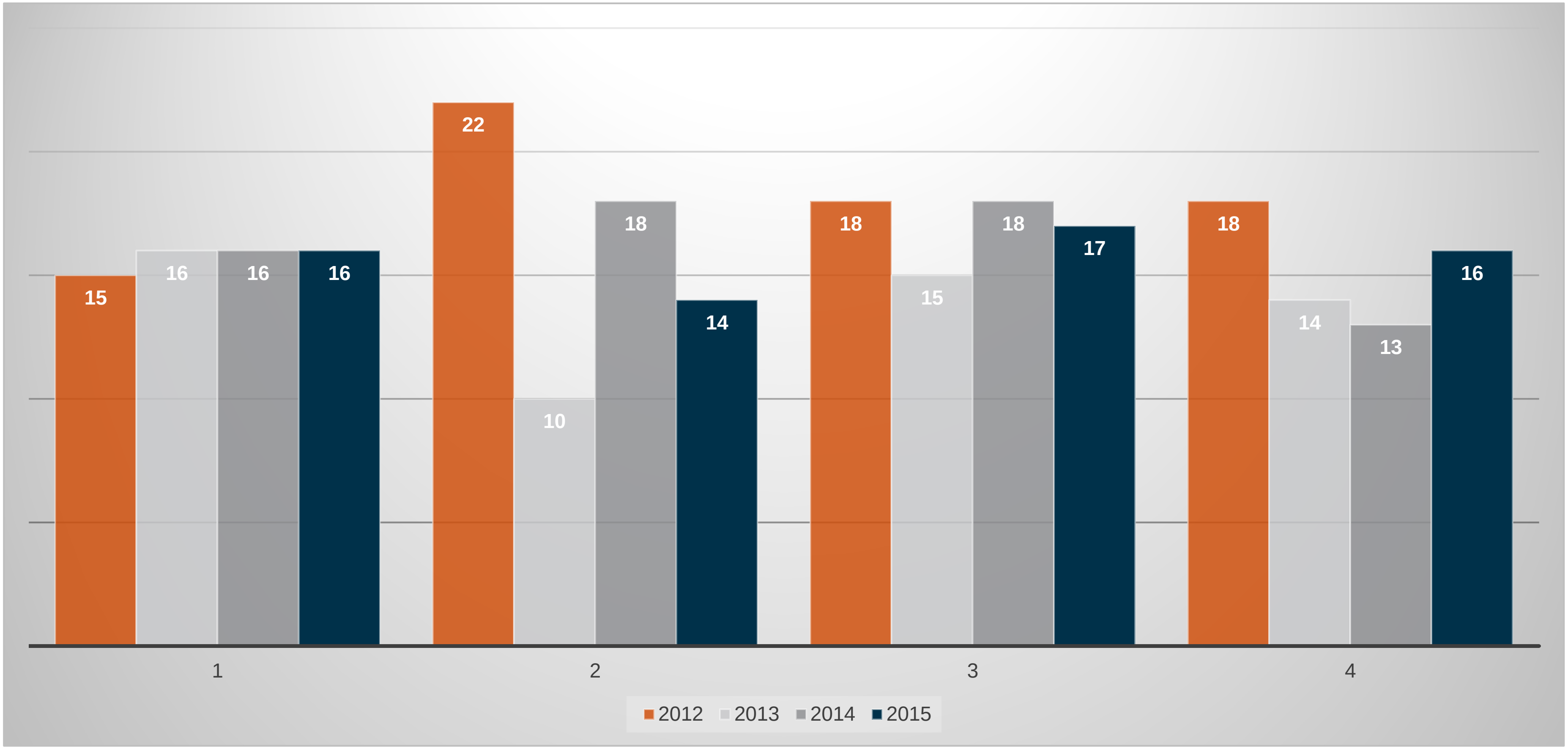
Average age of fleet



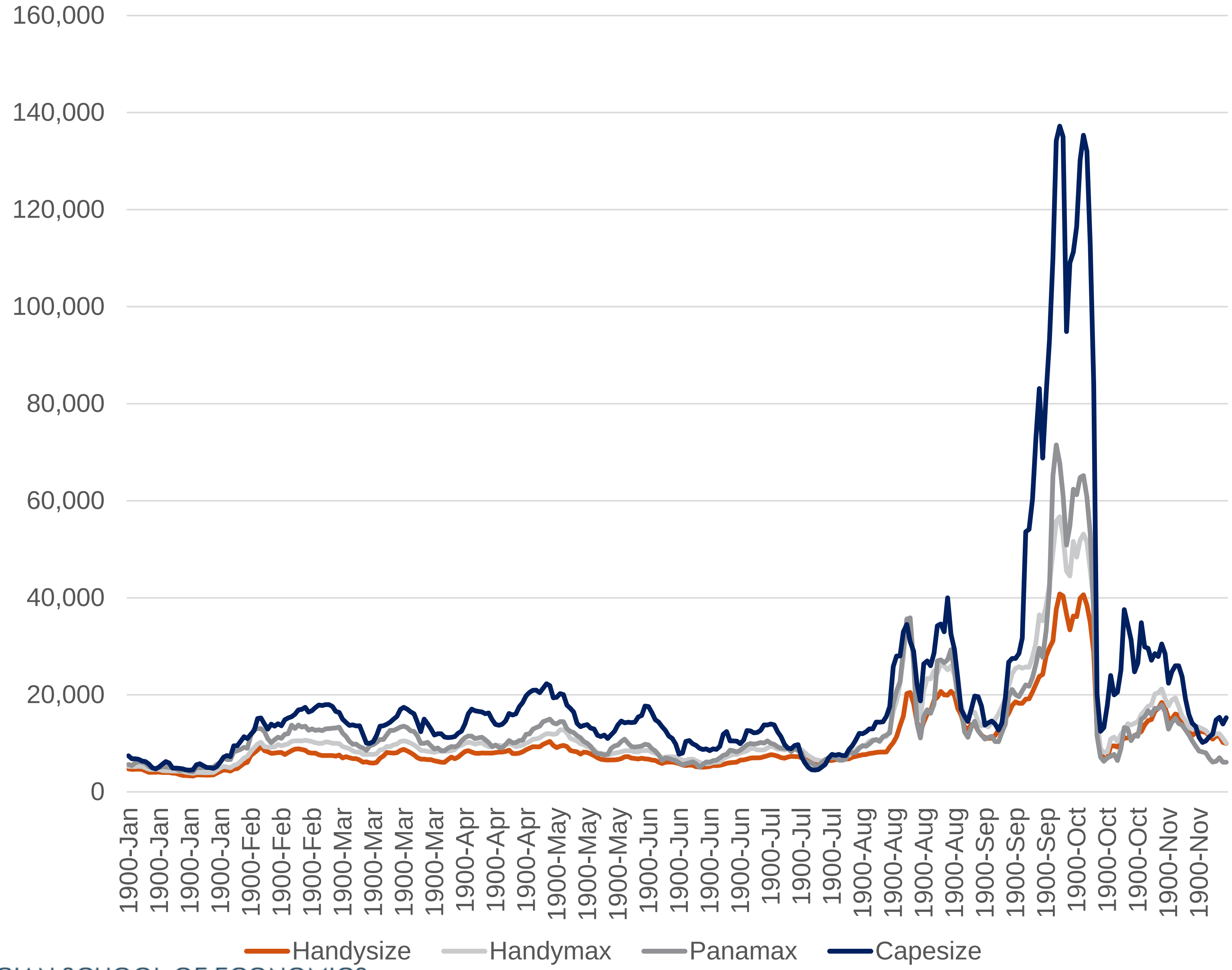
Average age of scrapped vessels



Minimum scrapping age 2012-2015



Assessing freight market volatility Earnings – 1 year TC 1985-2011



Average 1 Year Time-charter rates and bunker price

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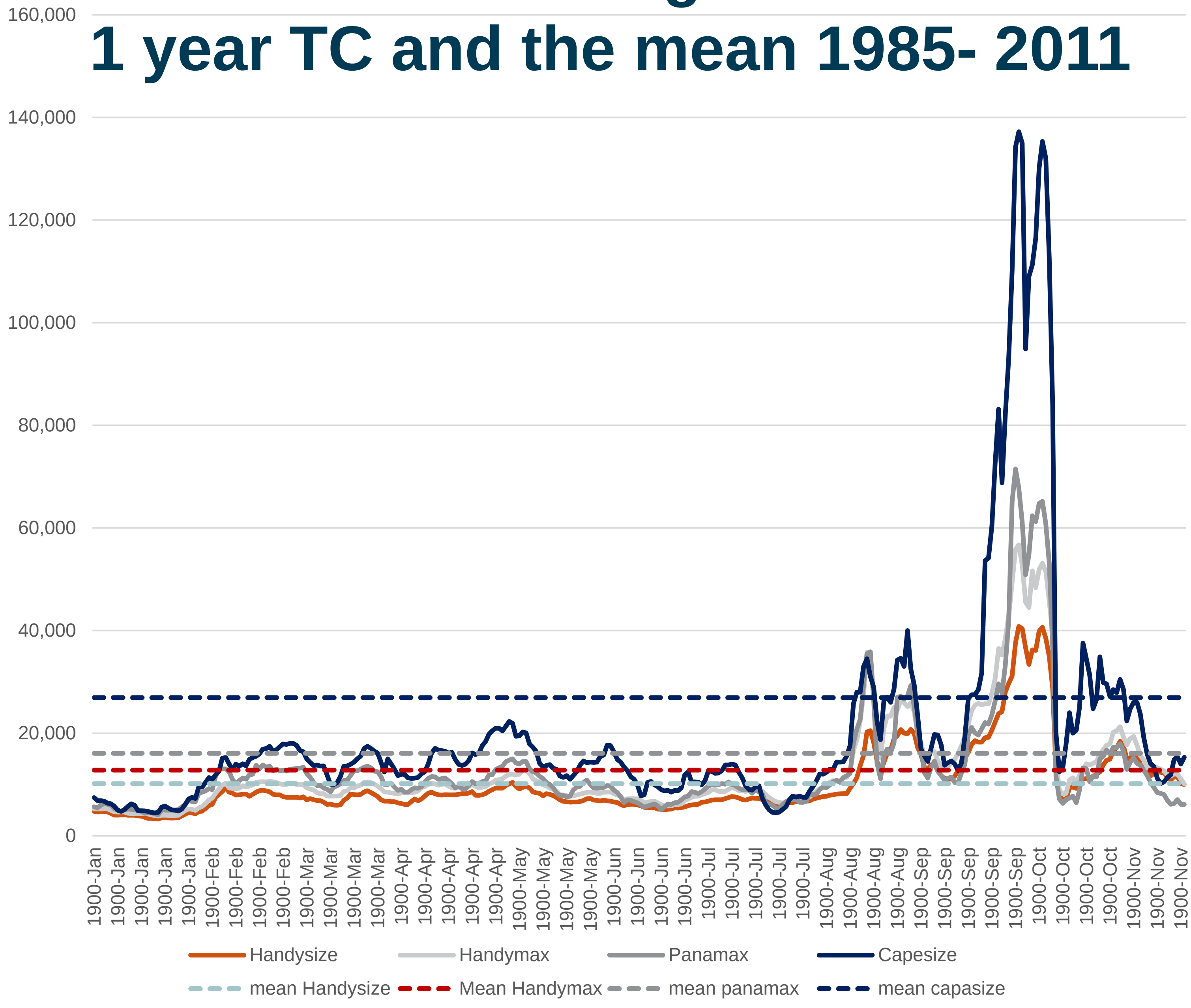
Rates for different size dry bulk carriers and bunker prices over the sample period

		Handysize $/day	Handymax $/day	Panamax $/day	Capesize $/day	Bunker Price $/mt
1985-2011	Mean	10,167	12,811	16,077	26,924	193.81
	SD %	0.280	0.320	0.367	0.460	
	SD $	2850	4104	5906	12381	
2012	Mean	8,233	8,655	9,708	13,749	639.64
2013	Mean	8,104	8,642	10,115	15,811	594.80
2014	Mean	9,015	10,764	12,028	21,778	532.14
2015	Mean	6,709	8,116	7,505	9,962	267,.80
Deviation from the long run mean						
2012		-1,934	-4,156	-6,369	-13,175	445.82
2013		-2,063	-4,169	-5,962	-11,113	400.98
2014		-1,152	-2,048	-4,049	-5,146	338.33
2015		-3,458	-4,695	-8,572	-16,962	73.99

Earnings

1 year TC and the mean 1985- 2011



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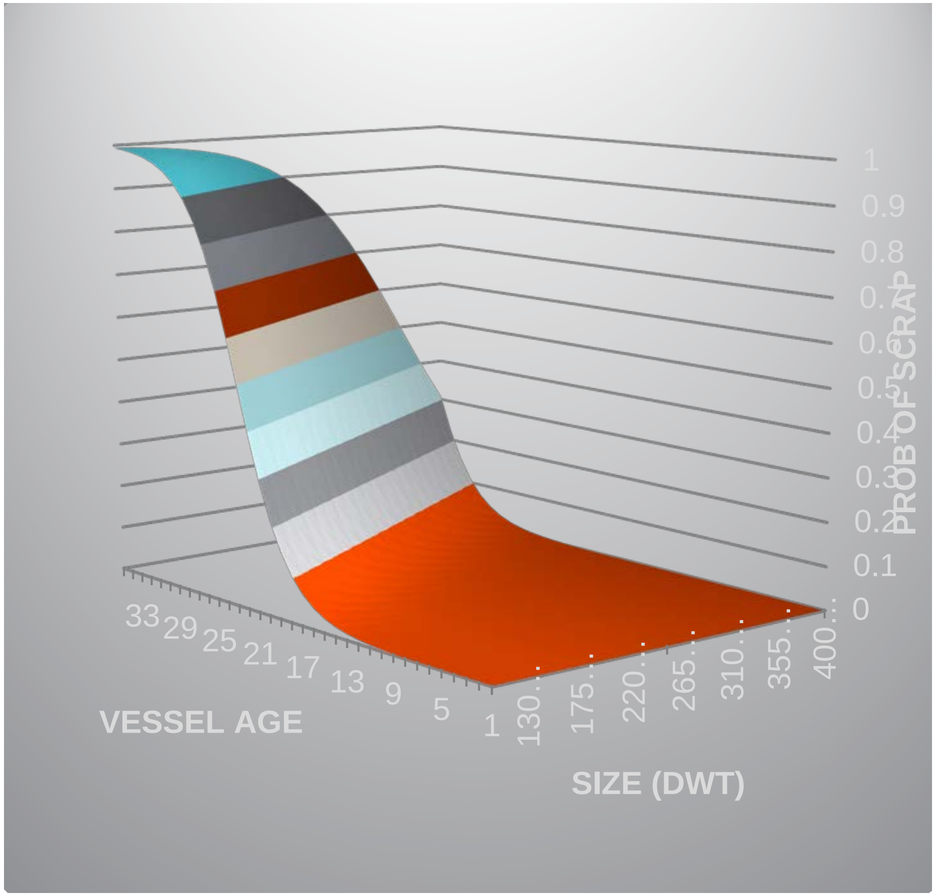


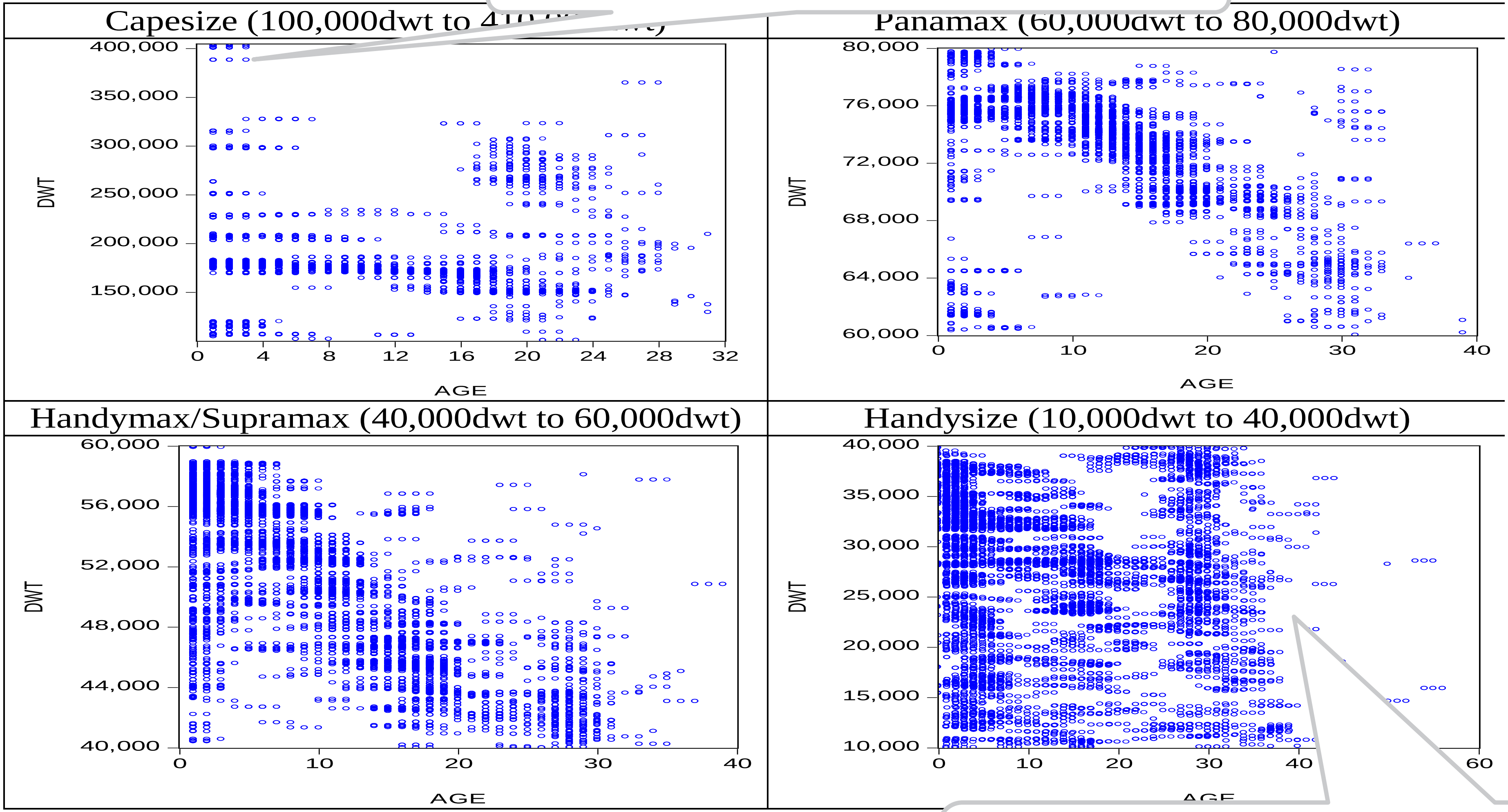
Estimation results of the logit model for Capesize scrapping

$$\Pr(v_i = 1 \mid \Omega) = \frac{1}{(1 + e^{-(\beta_0 + \beta_1 Age_i + \beta_2 Dwt_i)})}$$

	2012	2013	2014	2015
B_0	-8.510***	-10.985***	-9.574***	-4.053***
	(-7.018)	(-7.918)	(-5.730)	(-5.216)
B_1 (age)	0.538***	0.563***	0.450***	0.350***
	(9.725)	(8.194)	(6.183)	(11.122)
B_2 (DWT)	-2.077***	-1.424***	-1.425***	-2.302***
	(-4.729)	(-3.421)	(-2.972)	(-6.167)
McFadden-R-Squared	0.618	0.567	0.484	0.500
Log-Likelihood	-105.165	-85.712	-66.150	-179.416
SBIC	0.178473	0.13045	0.09839	0.221
Hosmer-Lemeshow stat	0.806	2.428	1.879	4.934
	[0.999]	[0.965]	[0.985]	[0.765]

Age and size distribution of different segment of dry bulk fleet

Larger new Capesize vessels



Handysize vessel sizes evenly distributed across age

Main results for Panamax, Handymax and Handysize

- The parameter for age is positive and significant for all vessel types and with similar values as for Capesize.
- The parameter for size (dwt) is
  - Negative also for Panamax and Handymax/supramax.
    For Panamax and Handymax the parameters are significant at lower levels (5 -10%) or insignificant, however.
  - Positive and significant for Handysize
- This is as should be expected with the differences in age size profile for these fleet segments.

Panel logit regression results for different size dry bulk carriers

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$$\Pr(v_{i,t}=1\,|\,\Omega_t)=\frac{1}{(1+e^{-(\beta_0+\beta_1 Age_i,t+\beta_2 Dwt_{i,t}+\beta_3 DFR_{i,t}+\beta_4 DBP_{i,t})})}$$

	Capeszie	Panamax	Handymax	Handysize
B_0	-8.183***	-2.018	-8.419***	-10.906**
	(-12.136)	(-0.1043)	(-5.528)	(-23.276)
B_1 Age	0.429***	0.262***	0.282***	0.193***
	(19.195)	(19.571)	(19.873)	(34.174)
B_2 DWT	-1.986***	-8.902***	-2.991	7.670***
	(-7.883)	(-3.867)	(1.126)	(13.308)
B_3 DFR	-0.112***	-0.107*	-0.0167**	-0.441***
	(-5.786)	(-1.795)	(-2.158)	(-4.519)
B_4 DBP	0.0006	0.00001	0.0015***	0.0032***
	(0.781)	(0.017)	(2.632)	(6.123)
Adj-R-Squared	0.549	0.471	0.483	0.400
Log-Likelihood	-416.319	-648.595	-694.503	-1716.802

Estimation results

$$\Pr(v_{i,t}=1|\Omega_t)=1/(1+e^{-(\beta_0+\beta_1 Age_i+\beta_2 Dwt_i+\beta_3 DFRi,t+\beta_4 DBPt+\beta_5 DSCt+\beta_6 Vol_{i,t}+\beta_7 DIRt)})$$

- **Panel logit regressions all vessels**
- **Ship and market specific explanatory variables**
- **Significant parameters indicate that**
  - **Scrapping increases with vessel age, scrap price, freight volatility and the interest rate**

		All vessels
B_0		-7.747***
		(-24.700)
B_1 Age		0.228***
		-52.418
B_2 Dwt		-0.016
		(-0.101)
B_3 DFR		-0.093***
		(-5.866)
B_4 DBP		-0.0003
		(-0.173)
B_5 DSC		0.006**
		-2.178
B_6 Vol		1.007***
		(3.198)
B_7 DIR		0.212*
		(1.879)
Adj-R-Squared		0.419
Log-Likelihood		-3746.381

Estimation results

$$\Pr(v_{i,t}=1|\Omega_t)=1/(1+e^{-(\beta_0+\beta_1 Age_i+\beta_2 Dwt_i+\beta_3 DFRi,t+\beta_4 DBPt+\beta_5 DSCt+\beta_6 Vol_{i,t}+\beta_7 DIRt)})$$

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- **Panel logit regressions all vessels**
- **Ship and market specific explanatory variables**
- **Significant parameters indicate that**
  - **Scrapping increases with vessel age, scrapping price, freight volatility and the interest rate**
  - **Scrapping falls with freight rates above the long term mean**
- **Vessel size has no significant The effects found for different segments seem to cancel out**
- **Bunker price has no significant effect**

		All vessels
B_0		-7.747***
		(-24.700)
B_1 Age		0.228***
		-52.418
B_2 Dwt		-0.016
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Adj-R-Squared		0.419
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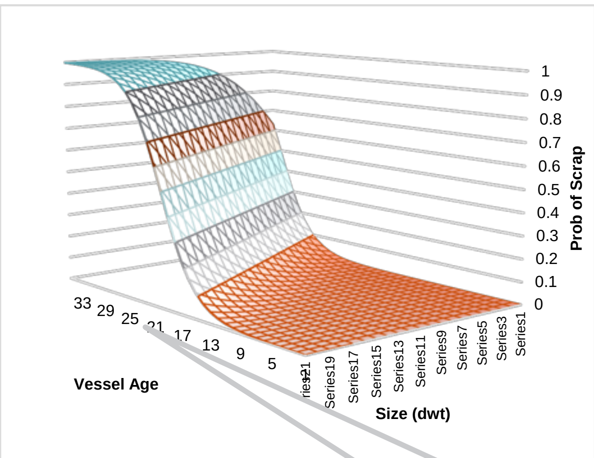
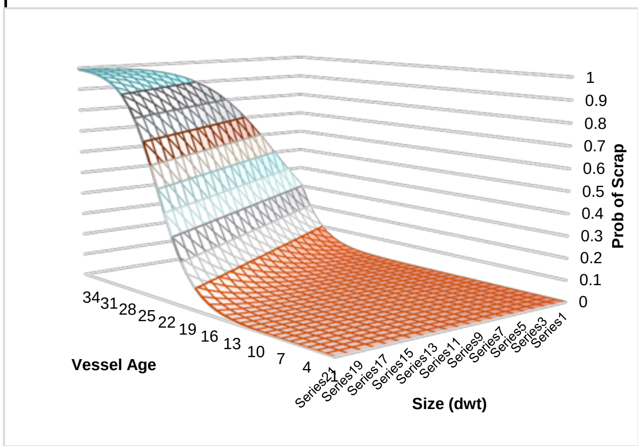
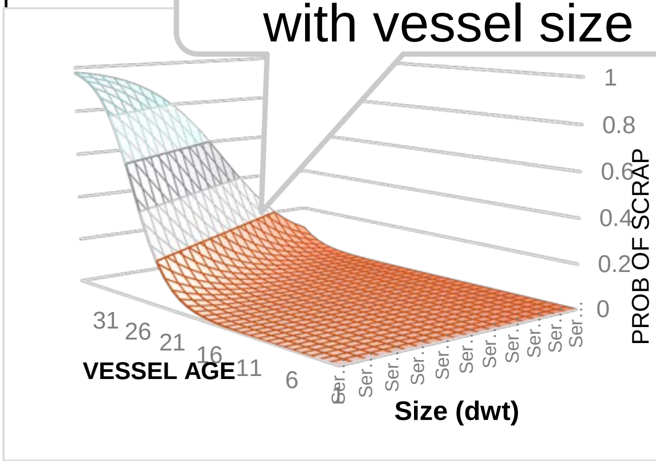
Probability of scrapping Capesize vessels for different age, dwt and freight rate levels

The probability of a Capeszie vessel being scrapped for different levels of 1 Year TC earnings when bunker price is $500/mt		
Earnings at $15,000/day	Earnings at the historical mean level ($27,000/day)	Earnings at $39,000/day



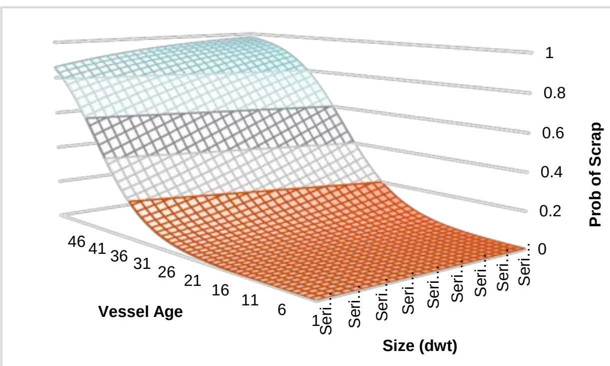
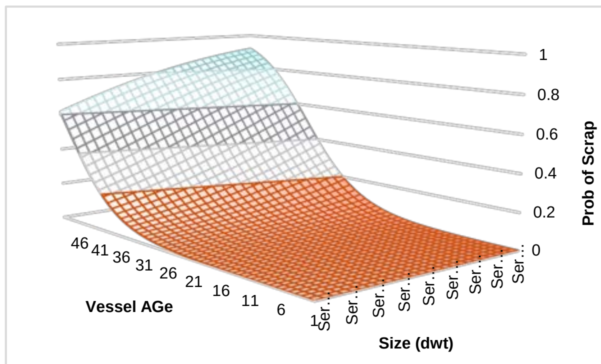
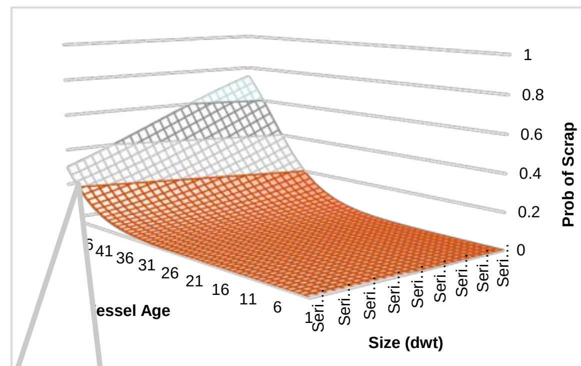




scrapping reduced with vessel size

The probability of scrapping increases with vessel age

Probability of scrapping Handysize vessels for different age, dwt and freight rate levels

<table>
<tr><th colspan="3">The probability of a handy size vessel being scrapped for different levels of 1 Year TC earnings when bunker price is $500/mt</th></tr>
<tr><td>Earnings $7000/day</td><td>Earnings at the historical mean level ($10,000/day)</td><td>Earnings $13,000/day</td></tr>
<tr><td>
</td><td>
</td><td>
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Probability of scrapping increases with vessel size

Highlights

- There is a positive relation between age and probability of scrapping a vessel
- The relation between vessel size and scrapping probability varies across vessel classes reflecting the differences in age size profile for these fleet segments
- Scrapping probability falls with earnings, but rises with scrap prices, volatility and interest rates
- We use a panel logit model to estimate the probability of scrapping dry bulk vessels

Thank you for listening!

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Estimation results of the logit model for Panamax scrapping

$$\Pr(v_i = 1 \mid \Omega) = \frac{1}{(1 + e^{-(\beta_0 + \beta_1 Age_i + \beta_2 Dwt_i)})}$$

	2012	2013	2014	2015
B_0	-5.943	4.310	-0.241	-6.042***
	(-1.408)	(1.079)	(-0.075)	(-2.167)
B_1 (age)	0.476***	0.257***	0.228***	0.222***
	(9.538)	(8.857)	(10.451)	(11.057)
B_2 (DWT)	-10.346*	-17.515***	-9.787**	-0.701
	(-1.943)	(-3.244)	(-2.317)	(-0.194)
McFadden-R-Squared	0.708	0.528	0.389	0.339
Log-Likelihood	-93.122	-127.160	-168.374	-237.717
SBIC	0.160541	0.19566	0.232516	0.263
Hosmer-Lemeshow stat	1.662	5.969	9.773	21.078
	[0.990]	[0.651]	[0.281]	[0.007]

Estimation results of the logit model for Supramax scrapping

NHH

$$\Pr(v_i = 1 | \Omega) = \frac{1}{(1 + e^{-(\beta_0 + \beta_1 Age_i + \beta_2 Dwt_i)})}$$

	2012	2013	2014	2015
B_0	-12.622***	-7.226***	-5.004***	-4.019*
	(-4.284)	(-2.836)	(-1.758)	(-1.656)
B_1 (age)	0.345***	0.289***	0.260***	0.242***
	(10.672)	(10.357)	(9.411)	(9.443)
B_2 (DWT)	6.224	-3.385	-7.504	-8.532*
	(1.150)	(-0.693)	(-1.403)	(-1.845)
McFadden-R-Squared	0.525	0.502	0.462	0.450
Log-Likelihood	-161.909	-178.496	-172.604	-175.805
SBIC	0.151017	0.14483	0.13059	0.128
Hosmer-Lemeshow stat	3.212	1.818	2.885	3.504
	[0.920]	[0.986]	[0.941]	[0.899]

Estimation results of the logit model for Handysize scrapping

$$\Pr(v_i = 1 | \Omega) = \frac{1}{(1 + e^{-(\beta_0 + \beta_1 Age_i + \beta_2 Dwt_i)})}$$

	2012	2013	2014	2015
B_0	-9.827***	-9.323***	-7.856***	-9.614***
	(-15.753)	(-18.149)	(-16.053)	(-18.860)
B_1 (age)	0.241***	0.215***	0.164***	0.174***
	(14.017)	(17.184)	(17.041)	(18.735)
B_2 (DWT)	7.241***	7.668***	5.381***	11.153***
	(6.538)	(7.027)	(4.424)	(8.518)
McFadden-R-Squared	0.446	0.428	0.326	0.381
Log-Likelihood	-421.717	-466.978	-406.694	-401.846
SBIC	0.328807	0.322324	0.259488	0.242
Hosmer-Lemeshow stat	9.341	13.115	8.706	14.449
	[0.314]	[0.115]	[0.368]	[0.071]