Earnings Yield and Predictability in the Dry Bulk Shipping Industry

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Abstract

We examine the relation between vessel prices, net earnings and holding period returns in the dry bulk shipping industry. In doing so, we provide a framework for pricing shipping assets, with finite economic lives and also subject to wear and tear. Shipping earnings yields negatively forecast future net earnings growth while there is no consistent evidence of time-varying risk premia. We provide an economic interpretation for the obtained results and argue that the investment decisions of shipowners affect the current price of the asset through the expected cash flow stream, thus implying cash flow predictability.

Keywords: Valuation of Transportation Assets; Shipping Cash Flow Predictability; Shipping Risk Premia; Variance Decomposition of Earnings.

JEL Codes: C13, G12, R40.

Accepted for Publication in Transportation research Part E: The Logistics and transportation Review

I. Introduction

This article examines the relation between vessel prices, net earnings, and holding-period returns in the dry bulk shipping industry. The motivation for this study stems from the fact that expected returns and changes in net earnings form the rational benchmarks for the interpretation of variation in assets' valuation ratios (Bansal and Yaron, 2004). There is plentiful evidence on the predictability of those variables from the equity and real estate markets. For instance, it has been shown that in the larger equity markets, such as those of US, UK, and Germany, virtually all variation in dividend yields is the result of time-varying expected future returns or, equivalently, time-varying risk premia (Ang and Bekaert, 2007). Namely, dividend yields positively forecast future returns while dividend growth appears to be unpredictable (Cochrane, 2005). Consequently, the bulk of empirical asset pricing research has concentrated on time-varying discount-rate theories to explain the formation of asset prices (Cochrane, 2011). On the other hand, Ghysels *et al* (2012) illustrate that the bulk of rent yield volatility in the U.S. real estate sector can be attributed to variation in future rent growth as opposed to variation in future returns.

To examine the question of relative predictability in dry-bulk shipping, we extend the Campbell-Shiller variance decomposition and vector autoregression (VAR) frameworks (1988a and 1988b) to the case of real assets with limited economic lives. We illustrate, for the first time in the literature, that vessel prices appear to move mainly due to news about future shipping market conditions and not due to changes in the risk premia required by shipping investors. In addition, we provide an economic interpretation for the obtained results and a comparison to different industries.

Regarding the existing shipping literature, Kavussanos and Alizadeh (2002) identify a long-run cointegrating relationship between net earnings and vessel prices and apply the Campbell and Shiller (1988a) VAR framework to test the validity of the Efficient Market Hypothesis in the formation of dry bulk vessel prices. Alizadeh and Nomikos (2007) suggest that shipping earnings yields contain useful information about future market conditions that can benefit agents' investment decisions. Greenwood and Hanson (2015) suggest, but do not justify empirically, that the earnings yield must strongly forecast low future earnings growth. Papapostolou *et al* (2014) use the earnings yield as a market valuation proxy to construct a shipping sentiment index and, in turn, argue that a high earnings-yield ratio serves as a contrarian indicator for future shipping conditions. The latter argument is in line with Greenwood and Hanson (2015) but also with Papapostolou *et al* (2017) who use the PE ratio (that is the inverse of the earnings yield) as a valuation-specific metric to examine herd behaviour in the decision to invest in new or retire existing fleet capacity in the dry bulk shipping industry. Nevertheless, none of those papers examine formally the relation between shipping earnings yields and future net earnings growth.

Alizadeh *et al* (2017) incorporate a heterogeneous-agents model (HAM) and argue that heterogeneity in beliefs and investment behaviour by market participants can explain the price volatility of dry bulk second-hand vessels. While our motivation is similar, our model examines the behaviour of earnings yield (and in turn, vessel prices) incorporating the traditional view of asset pricing (along the lines of Campbell and Shiller, 1988a and b and Cochrane, 2005) according to which, asset prices are determined by either expectations about future cash flow growth and/or expectations about time-varying risk premia. Importantly, we illustrate that the representative market participant values second-hand vessels based on news about expected market conditions. To the best of our knowledge, we are the first to address formally this question in the shipping literature.

Extending the Campbell-Shiller asset pricing framework to shipping markets is of interest since, in contrast to equities, vessels are tangible assets with limited economic lives and thus, subject to economic depreciation. In analogy to the dividend and rent yields, the appropriate valuation ratio in shipping is the earnings yield, defined as the ratio of one-period net earnings to the current price of the respective second-hand vessel. Since shipping investors know in advance the net earnings they expect to receive for the forthcoming period, we construct a “forward-looking” earnings yield which is consistent with reality and market practice. Therefore, from a technical perspective, we extend the Campbell-Shiller variance decomposition and VAR frameworks (1988a and 1988b) to account for both “forward-looking” valuation ratios and economic depreciation in the value of the asset. To the best of our knowledge, this is the first time that these features are explicitly incorporated in this asset pricing framework. The proposed framework can also be easily extended to the valuation of assets in other real asset economies such as real estate or the airline industry; e.g. in real estate, owners also agree in advance with lessees upon the rent corresponding to the next period.

Shipping also provides an ideal environment to relate the Campbell-Shiller reduced-form estimation framework to the economic principles of the market as this is a capital-intensive industry with clear and directly observable supply and demand determinants. We argue that the major determinants of valuation ratios are the second-order effects that current cash flows have on current prices through the future (expected) cash flow stream. In the absence of second-order effects, there is no reason for future cash flows to be predictable by the current information filtration.

We illustrate that high earnings yields strongly and negatively predict future net earnings growth. Furthermore, there is no consistent evidence of time-varying expected returns in the second-hand dry bulk shipping industry. Equivalently, it seems that ship prices mainly vary due to news about expected market conditions per se and not due to time-varying risk premia; that is, when valuing vessels, shipowners appear not to require time-varying risk premia. Furthermore, since valuation ratios are indicators of the fundamental value of the asset relative to the generated cash flow, we argue that vessels are undervalued – relatively to prevailing net earnings – when freight markets are very strong and vice versa.[1]

While the main aim of our paper is to provide a mathematically rigorous asset-pricing framework applicable for ships, our results also have practical implications for market practitioners. We show that the earnings yield is a reliable indicator of the current state of the shipping industry as well as of future shipping market conditions: a high earnings yield today reflects current prosperous market conditions but also predicts a deterioration in future net earnings and thus future market conditions. Therefore, the earnings yield can be used both as a forecasting variable and an indicator in trading strategies related to shipping assets. Another potential practical application of our research is related to shipping finance. Namely, the earnings yield can be used by providers of shipping finance when evaluating the business risk of their investment. Since the earnings yield predicts future market conditions, the higher the earnings yield at the issuance of the loan, the riskier the loan becomes – ceteris paribus – and thus, the higher the interest rate that should be demanded by lenders.

Finally, we compare our findings with those from the equity and real estate markets and explain the observed similarities and differences. Specifically, our results are diametrically opposite to the ones in the US, UK, and German equity markets but in line with the ones obtained from the bulk of international equity and real estate markets. It appears that the degree of cash flow predictability by the valuation ratio depends on the magnitude of second-order effects of current cash flows on future cash flows. Since, current prices depend on the expected cash flows generated by the asset, the more intensive those second-order effects are, the more predictable future cash flows become and, in turn, the more informative prices and valuation ratios become about future market conditions. Therefore, this paper provides strong evidence for further discussion regarding the economic principles that drive the forecasting properties of valuation ratios.

The remainder of this paper is organised as follows. Section II introduces the dataset employed and analyses the main variables of interest along with some preliminary results. Section III illustrates the methodology and the main empirical findings. Section IV provides both an economic rationale behind our results and a theoretical comparison with the equity and real estate markets. Section V concludes.

II. Data and Variables of Interest

The dataset consists of monthly and quarterly observations on newbuilding (NB), second-hand (SH), and scrap vessel prices and 6-month and 1-year time-charter (TC) rates for the Capesize, Panamax,

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[1] The term over/under-valuation in our context describes the relationship between the vessel's (asset's) market value and the concurrent net earnings (cash flows) generated by the asset. Thus, it is different than the interpretation given under the Efficient Market Hypothesis that an asset is overvalued when its market price is above its fair fundamental value, or vice-versa. We thank an anonymous referee for suggesting that.

Handymax, and Handysize dry bulk sectors where, for each one, we have employed the largest available sample. In addition, we have obtained data for various supply and demand variables related to the dry bulk shipping industry. Our main shipping data source is Clarksons Shipping Intelligence Network 2010. Figures for operating and maintenance expenses for representative vessels in each sector, as of December 2014, are obtained through discussions with industry participants and our values agree with figures reported in the recent literature. These are also used as the base real value since these costs generally increase with inflation; data for the US Consumer Price Index (CPI) are obtained from Thomson Reuters Datastream Professional. Table 1 presents the sample characteristics for each dry bulk sector.

Table 1: Sample and sector characteristics for dry bulk shipping.

Sector	Sample period	T	Representative vessel (dwt)	Costs ($\$/day$)
Capesize	1/1992-12/2014	276	180,000	8,000
Panamax	1/1976-12/2011	432	76,000	7,000
Handymax	4/1986-6/2014	339	56,000	6,500
Handysize	1/1976-12/2014	468	32,000	5,500

Notes: The number of observations in the sample is denoted by T. Costs, expressed in December 2014 dollars per day, refer to the total operating and maintenance expenses of the vessel.

We use the price of the second-hand 5-year old vessel as the variable of interest. [2] We assume that vessels are leased (chartered) in consecutive 1-year TC contracts; hence, only operating and maintenance costs are borne by the shipowner. In addition, we assume that vessels spend 10 days per annum off-hire for maintenance and repairs. During this period, shipowners do not receive the corresponding TC rates but bear the operating and maintenance costs (Stopford, 2009). We also consider the commission that the shipbroker receives for bringing the shipowner and the charterer into an agreement which is 2.5% of the daily TC rate. Thus, the annual net earnings variable, Π_{t+1}, is calculated as:

$$\Pi_{t+1} \equiv \Pi_{t\to t+1} = 355 \cdot 0.975 \cdot TC_{t\to t+1} - 365 \cdot OPEX_{t\to t+1}, \tag{1}$$

[2] We use second-hand values since, due to the construction lag between the ordering and delivery of a new vessel, newbuilding prices reflect the price of a vessel for future delivery and hence, are not directly connected to the prevailing rates in the market. Our second-hand price dataset consists of observations for 5, 10, 15, and 20-year old vessels. We have chosen the price of a 5-year old vessel as this is the most liquid segment of the second-hand market. Our results, however, are not sensitive to this choice. In addition, reports for vessel prices and TC rates do not refer to vessels of the same cargo-carrying capacity over the sample period. To overcome this limitation, we have constructed an earnings series by adjusting the original earnings rates to the size of the vessel, as in Greenwood and Hanson (2015). Due to a change in the reported time-charter rates for the Panamax Bulk-carrier in the database, the sample period ends in December 2011. For robustness, we also examined a shorter subsample, referring to a 75,000-dwt vessel, which spans March 2001 to December 2014, and the obtained results are similar with the ones reported here.

where $TC_{t\rightarrow t+1}$ and $OPEX_{t\rightarrow t+1}$ refer to the corresponding daily TC rates and the summation of daily operating and maintenance expenses, respectively. Note that a feature of the shipping industry is that the shipowner knows his net earnings for the forthcoming period in advance: shipowners and charterers agree upon the TC rate of the vessel at the commencement of the corresponding period[3] while this is also the case for the respective operating and maintenance expenses.

Since vessels are real assets with finite economic lives we must account for economic depreciation. Namely, at each point in time a 6-year old vessel is less valuable than an identical 5-year one because the former has one less year of future economic life, but also lower performance compared to the latter.[4] Assuming that vessels are scrapped at the end of the 25th year of their economic life, we denote the price of a $(5+n)$-year old vessel at time t by $P_{5+n,t}$, for $0 \leq n \leq 20$. As estimated in Appendix A, ship prices are subject to 5% annual value depreciation and thus, the prices of vessels between 5 and 10 years of age can be estimated through:

$$P_{5+n,t} = (1-0.05n) \cdot P_{5,t}, \quad 1 \leq n \leq 5. \tag{2}$$

Accordingly, the 1-year horizon raw return is estimated as:

$$R_{n,t\rightarrow t+1} \equiv R_{n,t+1} = \frac{\Pi_{t+1} + P_{n+1,t+1}}{P_{n,t}}, \tag{3}$$

where $R_{n,t+1}$ is the holding-period real return realised at time $t+1$ from an investment made at time t for a n-year old vessel. Intuitively, this formula assumes that an investor at time t purchases the vessel at price $P_{n,t}$ and immediately leases her out for one year to earn the 1-period net earnings, Π_{t+1}. In turn, at $t+1$ the investor sells the vessel at the prevailing market price, $P_{n+1,t+1}$.[5] Henceforth, we drop the age index from the notation for expositional simplicity.

In the context of empirical asset pricing, we examine the source of variation in vessel prices and in particular whether vessel prices vary due to changing forecasts about future net earnings, changes in future returns or variations in the terminal (scrap) price of the vessel. The main variable of interest in our empirical estimation is the shipping earnings yield, defined as the ratio of net earnings over the

[3]This assumption is consistent with both the existing shipping literature (e.g. Greenwood and Hanson, 2015) and market practice. In practice, ship owners and charterers agree upon the time-charter rate of the vessel – for the entire leasing period – before the corresponding leasing period begins. Accordingly, the agreed rates are typically received every 15 days - sometimes also in advance - which reduces the probability of default by the charterer. In addition, a wide broking network and the fact that ship owners normally lease their vessels to solvent charterers also assure transparency and low probability of default. Finally, additional contractual agreements included in the charter party ensure that the owner will receive the full time-charter rate agreed.

[4] The implicit assumption that net earnings do not depend on the vessel's age does not have a qualitative impact on the results. As such, we ignore the fact that vessels command a lower rate as their age increases.

[5] When a vessel is sold in the second-hand market, transaction costs (the commission to the sale-and-purchase broker) amount to 1% of the resale price. In the context of this research, we ignore this transaction cost since it has no effect on the empirical results.

corresponding 5-year old vessel price, $\frac{\Pi_{t+1}}{P_{5,t}}$, which measures the profit from utilising the vessel for the period $t \rightarrow t+1$ as a fraction of the prevailing price of the asset at t. From an investor's perspective, a high (low) earnings yield reflects the relative degree of undervaluation (overvaluation) in the price of the vessel.

While the shipping earnings yield is the natural analogue in shipping of the dividend and rent yields in equity and real estate markets, respectively, there is a significant difference in the definition of our shipping valuation ratio compared to the ones in the existing asset pricing literature. Specifically, in equity (real estate) markets, dividends (rents) corresponding to period $t \rightarrow t+1$ are assumed to be unknown at time t. Thus, the ratio $\frac{D_t}{P_t}$ corresponds to the net income paid during period $t-1 \rightarrow t$ divided by the asset price at t, where the price is net of the respective cash flow value. Campbell and Shiller (1988b) argue that dividends are lagged to be $\mathcal{F}_t$-measurable. Hence, the buyer of the asset at time t is entitled to the net income stream $\{D_{t+i}\}_{i\geq 1}$. Earlier studies in the shipping literature (Kavussanos and Alizadeh, 2002; Alizadeh and Nomikos, 2007) have also used an equivalent "lagged" definition of the earnings yield which in our notation corresponds to $\frac{\Pi_t}{P_{5,t}}$.

However, in line with Papapostolou *et al* (2014), we suggest that the appropriate valuation ratio in shipping is "forward-looking" since net earnings corresponding to period $t \rightarrow t+1$, Π_{t+1}, are agreed at time t and thus, known in advance.[6] Thus, the shipping cash flow not only serves as a forecasting scheme for future cash flows but is also the first term of the expected generated cash flow series.[7] While this should also be the case for real estate, the related existing literature ignores that feature (e.g. Campbell *et al*, 2009; Ghysels *et al*, 2012).

Table 2 presents descriptive statistics related to annual net earnings, 5-year old vessel prices, and earnings yields for the four dry bulk sectors while Figure 1 illustrates their evolution. As Figure 1 depicts, all three variables are very volatile. Autocorrelation coefficients in Table 2 are highly persistent in the 1-month horizon but decrease rapidly as the horizon increases, consistent with the

[6] Namely, the owner of the vessel at time t is entitled to the value of net earnings Π_{t+1}. Thus, assuming no credit risk (as analysed in footnote 2) or other unforeseen risks and expenses (e.g. due to breakdowns, accidents, etc.), earnings are $\mathcal{F}_t$-measurable.

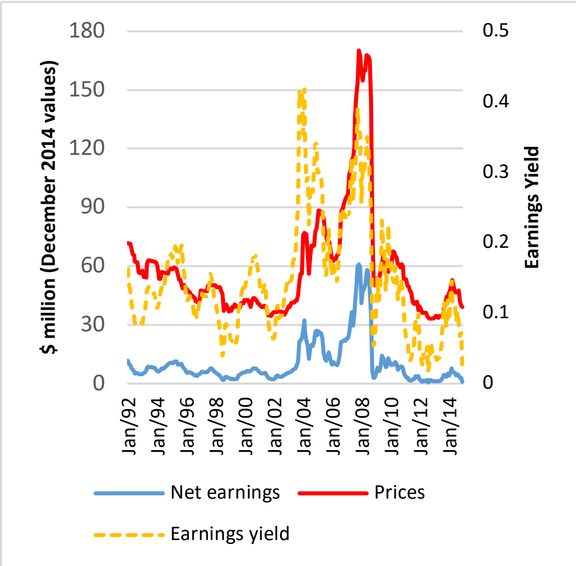
[7] In support of this statement, Fama and French (1988) argue that the most commonly incorporated dividend yield in equity markets, D_t/P_t, has the following drawback. While stock prices, P_t, are forward-looking, the incorporated dividend, D_t, is "old" relative to the dividend expectations embedded in P_t. Accordingly, positive news about future dividends results in a high price relative to the last paid dividend which, in turn, implies a low current dividend yield. In turn, this increase in P_t produces a high return $r_{t-1\rightarrow t}$ and, as a result, there is negative correlation between the disturbance ε_{t-1} and the time t shock to D_t/P_t. Consequently, the slope coefficients in regressions of $r_{t\rightarrow t+1}$ on D_t/P_t tend to be upward-biased. On the other hand, the alternative measure, D_t/P_{t-1}, does not use the entire information filtration at time t and thus, is expected to have lower forecasting ability (specifically, to be too conservative) compared to D_t/P_t. Since in shipping both net earnings and prices are forward-looking, the valuation ratio proposed here is time-consistent.

boom-bust nature of the shipping industry. In a cross-sector comparison, we observe that the means, standard deviations, and coefficients of variation of annual net earnings increase with the size of the vessel. This result suggests that larger vessels generate larger but also more volatile cash flow streams (Alizadeh and Nomikos 2007). More importantly, in all sectors under consideration, net earnings are significantly more volatile than vessel prices as they have more than two times higher coefficients of variation (Table 2).

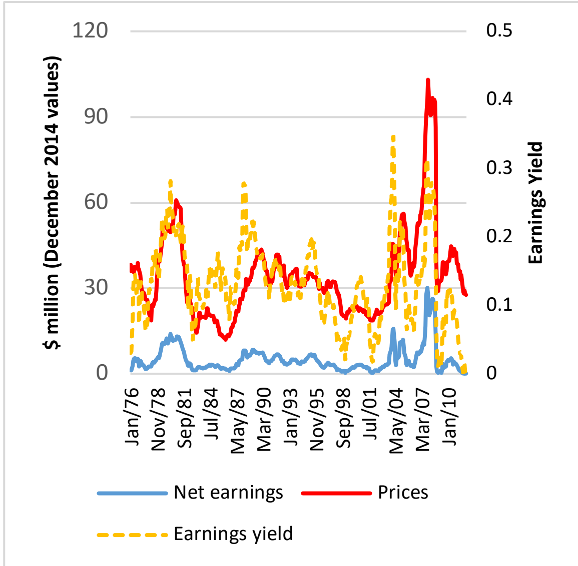
Table 2: Descriptive statistics for vessel prices, net earnings, and earnings yields.

Variable	T	Mean	SD	CV	Max	Min	ρ_1	ρ_{12}	ρ_{24}	$Correlation$	
Panel A: Capesize Sector (from January 1992 to December 2014)											
Π ($\$m$)	276	10.43	11.66	1.12	60.91	0.57	0.97	0.41	0.15	$Corr\ (P, \Pi)$	0.95
P ($\$m$)	276	58.61	28.31	0.48	170.25	33.13	0.98	0.51	0.24	$Corr\ (\Pi/P, \Pi)$	0.86
Π/P	276	0.15	0.08	0.57	0.42	0.02	0.95	0.47	0.18	$Corr\ (\Pi/P, P)$	0.72
Panel B: Panamax Sector (from January 1976 to December 2011)											
Π ($\$m$)	432	5.03	4.66	0.93	30,11	0.02	0.97	0.25	-0.06	$Corr\ (P, \Pi)$	0.89
P ($\$m$)	432	34.21	15.58	0.46	103.05	11.90	0.98	0.51	0.23	$Corr\ (\Pi/P, \Pi)$	0.81
Π/P	432	0.13	0.06	0.47	0.35	0.00	0.94	0.24	-0.07	$Corr\ (\Pi/P, P)$	0.54
Panel C: Handymax Sector (from April 1986 to June 2014)											
Π ($\$m$)	339	4.97	4.39	0.88	24.98	0.86	0.97	0.39	0.13	$Corr\ (P, \Pi)$	0.92
P ($\$m$)	339	29.82	12.67	0.42	84.01	10.15	0.98	0.52	0.20	$Corr\ (\Pi/P, \Pi)$	0.82
Π/P	339	0.15	0.07	0.45	0.47	0.04	0.97	0.40	0.09	$Corr\ (\Pi/P, P)$	0.59
Panel D: Handysize Sector (from January 1976 to December 2014)											
Π ($\$m$)	468	3.09	2.46	0.80	14.86	0.59	0.98	0.43	0.17	$Corr\ (P, \Pi)$	0.89
P ($\$m$)	468	22.16	8.46	0.38	58.64	5.61	0.98	0.60	0.31	$Corr\ (\Pi/P, \Pi)$	0.84
Π/P	468	0.13	0.05	0.43	0.32	0.04	0.96	0.41	0.12	$Corr\ (\Pi/P, P)$	0.55

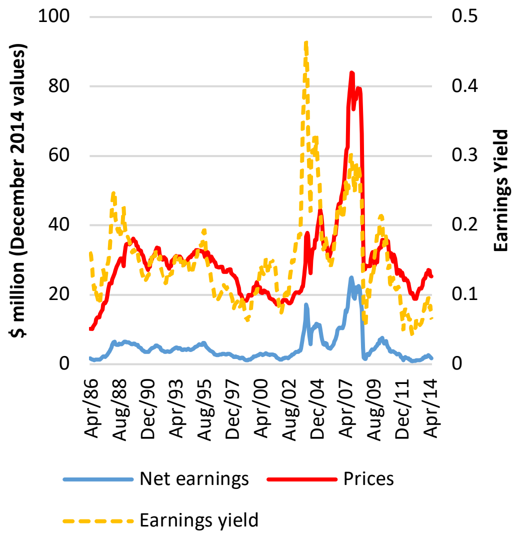
Notes: This table presents descriptive statistics related to real annual net earnings, real 5-year old second-hand vessel prices, and the corresponding earnings yields. The included statistics are the number of observations, mean, standard deviation, coefficient of variation, maximum, minimum, 1, 12, and 24-month autocorrelation coefficients. Furthermore, by $\mathrm{Corr}\ (X, Y)$ we indicate the corresponding correlation coefficient. Real net earnings, Π, refer to the one-year time-charter revenue minus the operating and maintenance expenses, all expressed in December 2014 million dollars. Real price, P, refers to the second-hand price of a 5-year old vessel, expressed in December 2014 million dollars, while Π/P denotes the net earnings yield.



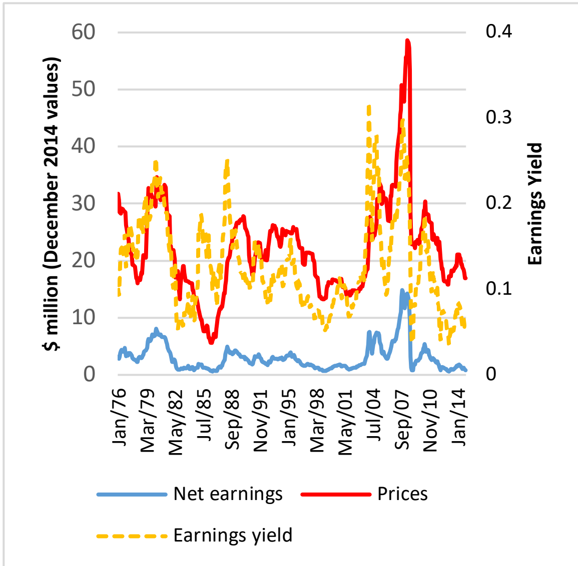
Panel A: Capesize sector from 1/1992 to 12/2014.



Panel B: Panamax sector from 1/1976 to 12/2011.



Panel C: Handymax sector from 4/1986 to 6/2014.



Panel D: Handysize sector from 1/1976 to 12/2014.

Figure 1: Net Earnings, Vessel Prices, and Net Earnings Yields.

Panels A-D present real annual net earnings, real 5-year old vessel prices, and the net earnings yield for the representative vessel of each dry bulk sector.

Furthermore, vessel prices and net earnings are strongly correlated, consistent with second-hand vessel prices being responsive to changes in net earnings. Their relative movement however is not proportional (as illustrated in Figure 1) since, if this were the case, earnings yields would be constant over time. In fact, we observe that vessels are overvalued during market troughs and vice versa. This is consistent with Papapostolou *et al* (2014) and Greenwood and Hanson (2015).

We move next to examine the main source of the documented earnings yield volatility and to this end, we consider the log transformation of the earnings yield. Accordingly:

$$\ln\left(\frac{\Pi_{t+1}}{P_{5+n,t}}\right) = \ln(\Pi_{t+1}) - \ln(P_{5+n,t}) = \pi_{t+1} - p_{5,t}, \tag{4}$$

where $\pi_{t+1} - p_{5,t} \sim I(0)$ is the log net earnings yield. The n-period log net earnings growth rate is estimated through:

$$\pi_{t+n} - \pi_t = \ln\left(\frac{\Pi_{t+n}}{\Pi_t}\right) = \sum_{i=1}^{n} \ln\left(\frac{\Pi_{t+i}}{\Pi_{t+i-1}}\right) = \sum_{i=1}^{n} \Delta\pi_{t+i}, \tag{5}$$

where $\Delta\pi_{t+1} = \pi_{t+1} - \pi_t \sim I(0)$ is the 1-period log net earnings growth.

The 1-year horizon log return is defined as $r_{t+1} = \ln(R_{t+1})$. Since we assume that the vessel is employed in consecutive 1-period time-charters, the n-period log return is calculated by summing the corresponding 1-year returns while adjusting for economic depreciation in the price of the vessel:

$$r_{t+n} = \sum_{i=1}^{n} \ln\left(\frac{\Pi_{t+i} + P_{5+i,t+1}}{P_{5+i-1,t}}\right), \qquad 1 \leq n \leq 20. \tag{6}$$

Finally, the 1-year horizon vessel price growth refers to the growth in the price of a specific vessel across time which, due to economic depreciation, is calculated as:

$$\Delta p_{n+1,t+1} = p_{n+1,t+1} - p_{n,t} = \ln\left(\frac{P_{n+1,t+1}}{P_{n,t}}\right). \tag{7}$$

Equation (7) quantifies the annual change in the price of a given vessel which is closely related to the 1-period return. Henceforth, price growth refers to the change in the price of a specific vessel between her fifth and sixth years of economic life. Using equations 4-7, we compute log earnings yields, 1-, 2-, and 3-year horizon net earnings growth rates, 1-, 2-, and 3-year horizon raw log returns, and 1-year horizon vessel-specific price growth rates for each of the four dry bulk markets –for a representative 5-year old vessel. For statistical robustness, the Augmented Dickey-Fuller (1981) test confirms that all incorporated log variables are stationary.

III. Empirical Results

III.A. Predictability of Net Earnings in Shipping

Given that ships are assets with finite economic lives and subject to depreciation, we apply backwards iteration to the shipping earnings yield equation (4) to obtain an exact present value relation that links the price-net-earnings ratio to future net earnings growth, $\frac{\Pi_{t+1}}{\Pi_t}$, to future returns, $R_{n,t+1}$, and to the scrap-net earnings ratio, $\frac{S_{t+20}}{\Pi_{t+21}}$ (see Appendix A for derivation):

$$\frac{P_{5,t}}{\Pi_{t+1}} = E_t\left[R_{t+1}^{-1} + R_{t+1}^{-1} \cdot \sum_{i=1}^{19}\left(\prod_{j=1}^{i} R_{t+j+1}^{-1} \cdot \frac{\Pi_{t+j+1}}{\Pi_{t+j}}\right) + \left(\prod_{j=1}^{20} R_{t+21-j}^{-1} \cdot \frac{\Pi_{t+22-j}}{\Pi_{t+21-j}}\right) \cdot \frac{S_{t+20}}{\Pi_{t+21}}\right], \qquad (8)$$

where $S_{t+20} \equiv P_{t+20}^{25}$ denotes the terminal – scrap – price of the vessel 20 years ahead. Note that equation (8) holds ex post as an identity (Appendix A). Equation (8) suggests that a high price-net earnings ratio should forecast either high future net earnings growth or/and low future returns or/and a high terminal ratio. To facilitate the use of time series tools, we linearise equation (8) using the Campbell-Shiller (1988a) and Cochrane (2005) frameworks. Importantly, though, we extend the existing methodology by (i) accounting for the fact that our net earnings yield is forward-looking and (ii) adjusting for economic depreciation in the value of the asset. An immediate consequence of the latter is that we do not need to impose the transversality or "no-bubbles" condition. Accordingly, we derive the following equation for the log net earnings yield (Appendix B):

$$\begin{aligned}\pi_{t+1} - p_{5,t} \approx & -\sum_{i=1}^{n}\left(\prod_{j=1}^{i}\rho_{j-1}\right)k_i \\ & + E_t\left[-\sum_{i=1}^{n}\left(\prod_{j=1}^{i}\rho_j\right)\Delta\pi_{t+i+1} + \sum_{i=1}^{n}\left(\prod_{j=1}^{i}\rho_{j-1}\right)r_{t+i} + \left(\prod_{i=1}^{n}\rho_i\right)\left(\pi_{t+n+1} - p_{5+n,t+n}\right)\right],\end{aligned} \qquad (9)$$

where $\rho_i = \frac{P_{5+i}/\Pi}{1+P_{5+i}/\Pi}$ for $i \in \{1, \cdots, n\}$ while for $i = 0$ we set $\rho_0 = 1$. In addition, $k_i = -(1-\rho_i)\ln(1-\rho_i) - \rho_i \ln(\rho_i)$, for $i \in \{1, \cdots, n\}$. Notice that for $n = 20$ we obtain $p_{25,t+20} \equiv s_{t+20} = \ln(S_{t+20})$ which corresponds to the log scrap price of the vessel.

Equation (9) illustrates that a high "forward-looking" log net earnings yield is a consequence of either expectations about deteriorating future market conditions (that is, negative net earnings growth) and/or high required risk premia by shipping investors (that is, high expected returns) and/or expectations about a high terminal scrap price relative to prevailing market conditions at the end of the investment horizon (i.e. high terminal net earnings yield or, equivalently, terminal spread).

To examine the contribution of each of the above factors to the observed shipping earnings yields, we estimate one- and multi-year horizon forecasting OLS regressions (as in Fama and French, 1988; Cochrane, 2005 and 2011) of log returns, r_{t+n}, log net earnings growth, $\pi_{t+n+1} - \pi_{t+1}$, and terminal spreads, $\pi_{t+n+1} - p_{5+n,t+n}$, on the current log net earnings yield, $\pi_{t+1} - p_{5,t}$:

$$r_{t+n} = \alpha_{r,t+n} + \beta_{r,t+n} \cdot \left(\pi_{t+1} - p_{5,t}\right) + \varepsilon_{r,t+n}, \tag{10}$$

$$\pi_{t+n+1} - \pi_{t+1} = \alpha_{\Delta\pi,t+n} + \beta_{\Delta\pi,t+n} \cdot \left(\pi_{t+1} - p_{5,t}\right) + \varepsilon_{\Delta\pi,t+n}, \tag{11}$$

$$\pi_{t+n+1} - p_{5+n,t+n} = \alpha_{\pi-p,t+n} + \beta_{\pi-p,t+n} \cdot \left(\pi_{t+1} - p_{5,t}\right) + \varepsilon_{\pi-p,t+n}, \tag{12}$$

where $n \in \{1, \cdots, 20\}$. Table 3 summarises the results from those predictive regressions for the 1-, 2-, and 3-year horizon cases.[8]

We note that shipping earnings yields strongly and negatively forecast future net earnings growth across all sectors and horizons. Furthermore, consistent with the present-value linearisation, the signs of the growth coefficients are negative whereas the R^2s are consistently above 10% and, in some cases, they are even close to 30%. Hence, there is clear evidence of cash flow predictability in the dry bulk shipping industry. Note as well that the slope coefficients and R^2s of growth regressions increase in the 2-year horizon compared to the 1-year case. From an economic perspective, this may be related to the time-lag required for the delivery of a new vessel which is on average 2 years.

Turning next to the returns regressions, we note that there is no consistent evidence of significant statistical relationship between shipping earnings yields and expected returns. The slope coefficients, t-statistics, and R^2s are much smaller compared to the corresponding growth regressions and the returns coefficients are mainly insignificant, even at the 10% level; only in the Capesize and Handysize sectors – and solely in the 3-year horizon case – the returns coefficients are significant at the 5% level or higher.

Finally, for the earnings yield regressions in the 1-year horizon, the slope coefficients are positive and statistically significant for the Capesize, Handymax, and Handysize but not for the Panamax sectors. This is consistent with the Capesize, Handymax, and Handysize sectors' earning yields being more persistent at longer horizons, compared to the Panamax sector, as evidenced by the 12-month autocorrelation coefficients in Table 2. In line with Cochrane (2005), when the forecasting variable is

[8] To deal with the overlapping nature of returns and growth rates, we report Newey-West (1987) heteroskedasticity and autocorrelation consistent (HAC) standard errors. We have also estimated standard errors using the method of Hodrick (1992) which gives very similar values.

highly persistent the slope coefficients and the R^2s of the forecasting regressions add up over longer horizons.[9]

Table 3: Regressions of future earnings yield, returns, and earnings growth on current earnings yield.

		Earnings yield			Return			Net earnings growth		
n	T	β	t^{NW}	R^2	β	t^{NW}	R^2	β	t^{NW}	R^2
Panel A: Capesize Sector										
1	264	0.48***	3.57	0.23	0.07	1.25	0.03	-0.60***	-2.91	0.17
2	252	0.24	1.03	0.05	0.08	0.57	0.01	-0.95***	-2.84	0.26
3	240	0.14	1.04	0.01	0.17***	2.62	0.03	-1.01***	-5.16	0.20
Panel B: Panamax Sector										
1	420	0.22	0.89	0.03	-0.02	-0.29	0.00	-0.93***	-3.27	0.21
2	408	0.08	0.67	0.00	-0.10	-0.98	0.02	-1.20***	-5.72	0.28
3	396	0.27*	1.70	0.04	-0.16	-1.17	0.03	-1.08***	-3.94	0.20
Panel C: Handymax Sector										
1	327	0.47**	2.50	0.20	0.09	1.32	0.03	-0.60**	-2.42	0.13
2	315	0.17	1.13	0.02	0.09	0.53	0.01	-1.01***	-3.94	0.20
3	303	0.25**	2.40	0.05	0.16	1.28	0.02	-0.87***	-4.28	0.14
Panel D: Handysize Sector										
1	456	0.47***	2.75	0.21	0.12*	1.85	0.03	-0.55**	-2.48	0.13
2	444	0.17	0.80	0.03	0.18	1.48	0.03	-0.84***	-3.66	0.17
3	432	0.18	1.26	0.03	0.22**	2.31	0.03	-0.81***	-4.59	0.13
Panel E: Dry Bulk Industry										
n		β	t^W	R^2	β	t^W	R^2	β	t^W	R^2
1		0.34***	5.57	0.10	0.06*	1.92	0.02	-0.70***	-7.64	0.17
2		0.16***	4.64	0.04	0.04	0.62	0.01	-1.02***	-13.09	0.23
3		0.21***	7.76	0.04	0.06	0.62	0.01	-0.96***	-16.21	0.17

Notes: Panels A-D report 1-, 2-, and 3-year horizon OLS forecasting regressions of future log earning yield, real log return, and real log net earnings growth on current log earnings yield for each dry bulk sector. To account for the overlapping nature of returns, t-statistics, t^{NW}, are estimated using the Newey-West (1987) HAC correction. The predictive coefficient, β, is accompanied by *, **, or *** when the absolute t^{NW} statistic indicates significance at the 10%, 5% or 1% levels, respectively. In addition, Panel E summarises results from 1, 2, and 3-year horizon pooled-time series least squares forecasting regressions of future log earning yield, real log return, and real log net earnings growth on current log earnings yield for each dry bulk sector. Regressions embody cross-section fixed effects while the incorporated sample is unbalanced. The corresponding t-statistics are estimated using the "White period" method.

[9] A further implication of the rapid mean reversion of the shipping earnings yield is the fact that we do not observe any clear pattern related to the magnitude of the slope coefficients and the R^2s of the growth and returns regressions across different horizons and sectors. In a cross-industry comparison, shipping earnings yields are much less persistent than dividend yields and rent yields in the post-WWII U.S. equity (Cochrane, 2005) and real estate markets (Ghysels *et al*, 2012), respectively. As a result, the slope coefficients and R^2s of shipping net earnings growth regressions do not increase linearly with the forecasting horizon as in the case of the U.S. equity markets' returns regressions.

We further assess the robustness of our findings by examining the aggregate dry bulk industry through pooled-time-series regressions; to account for the differences across the four shipping sectors we employ fixed effects in the cross-section. Accordingly, we run the following set of regressions for the 1-, 2-, and 3-year horizons:

$$x_{i,t+n} = c + \alpha_{i,x} + \beta_x \cdot (\pi_{i,t+1} - p_{i,5,t}) + \varepsilon_{i,t+n}, \qquad n \in \{1, 2, 3\}, \tag{13}$$

where $x_{i,t+n}$ alternately denotes $r_{i,t+n}$, $\pi_{i,t+n+1} - \pi_{i,t+1}$, and $\pi_{t+n+1} - p_{i,5+n,t+n}$. Moreover, $\alpha_{i,x}$ represents the cross-section fixed effects while by i we index the corresponding dry bulk sector. Note that we incorporate the “White period” method for standard errors which assumes that the errors within a cross-section suffer from heteroscedasticity and serial correlation. The results, summarised in Panel E of Table 3, indicate precisely the same patterns as the ones obtained from the simple time-series estimation.

We quantify formally the relative magnitude of each of the three potential sources of variation by decomposing the variance of the shipping earnings yield using the following equation (Appendix C):

$$1 \approx b_{\pi-p,n} + b_{r,n} - b_{\Delta\pi,n}, \tag{14}$$

where $b_{i,n}$ is the n-year horizon coefficient corresponding to the i^{th} element of the decomposition. Following Cochrane (1992, 2005, and 2011), these regression coefficients can be interpreted as the relative magnitude of the net earnings yield variation attributed to each of the three sources. In particular, $b_{\pi-p,n}$, $b_{r,n}$ and $b_{\Delta\pi,n}$ correspond, respectively, to the relative magnitude attributed to the terminal spread, future returns, and future net earnings growth. Notice that the elements of this decomposition do not have to be between 0 and 100%. Accordingly, we run the following set of exponentially weighted regressions, for each of the four dry bulk sectors:

$$\left(\prod_{j=1}^{n} \rho_j\right)(\pi_{t+n+1} - p_{5+n,t+n}) = \alpha_{\pi-p,n} + b_{\pi-p,n} \cdot (\pi_{t+1} - p_{5,t}) + \varepsilon_{\pi-p,t+n}, \tag{15}$$

$$\sum_{i=1}^{n}\left(\prod_{j=1}^{i} \rho_{j-1}\right) r_{t+i} = \alpha_{r,n} + b_{r,n} \cdot (\pi_{t+1} - p_{5,t}) + \varepsilon_{r,t+n}, \tag{16}$$

$$\sum_{i=1}^{n}\left(\prod_{j=1}^{i} \rho_{j}\right) \Delta\pi_{t+i+1} = \alpha_{\Delta\pi,n} + b_{\Delta\pi,n} \cdot (\pi_{t+1} - p_{5,t}) + \varepsilon_{\Delta\pi,t+n}, \tag{17}$$

where $n \in \{1, \cdots, 20\}$. Table 4 presents the results from the variance decomposition corresponding to a 5-year horizon ($n = 5$). We have tested various horizons and the obtained results indicate precisely the same patterns.

Table 4: Variance decomposition of the earnings yield.

		Returns	Net Earnings Growth	Terminal Spread
Sector	n	$b_{r,5}$	$b_{\Delta\pi,5}$	$b_{\pi-p,5}$
Capesize	5	-0.04	-1.38	-0.23
Panamax	5	-0.22	-1.25	-0.08
Handymax	5	0.01	-1.28	-0.20
Handysize	5	-0.09	-1.30	-0.18

Notes: $b_{i,5}$ is the exponentially weighted 5-year horizon regression coefficient corresponding to the i^{th} element of the decomposition. See equations $14-17$ of the main text.

In line with the previous results, almost all variation in net earnings yields is due to variation in expected net earnings growth. Therefore, it seems that high vessel prices relative to current net earnings imply high future net earnings growth, i.e. a stronger freight market. On the other hand, they do not imply low required risk premia by shipping investors, i.e. low expected returns, nor expectations about a low terminal price relative to the prevailing market conditions at the end of the investment horizon, i.e. a low terminal net earnings yield. The latter precludes the existence of a "rational bubble" which may occur in equity markets yet is unlikely to happen in freight markets since the terminal value of the vessel is the scrap value.[10] Finally, it should be noted that, in practice, we observe different investment decisions and policies across different shipping companies. The data used in this study though, measure average prices and average time-charter rates observed in the market for a given vessel size with specific characteristics on given dates. As a result, the dataset does not allow us to distinguish among different valuations of vessels depending on the type of investor and we focus instead, on the average market participant's behaviour.

III.B. An Extension of the Campbell and Shiller (1988a) VAR Framework to Shipping

The previous results suggest that there is no consistent statistical evidence of time-varying one-period required returns which, in turn, implies that shipping investors do not require time-varying risk premia. To further examine this point, we compare the observed price-earnings yields with their theoretical counterparts, generated by an unrestricted econometric Vector Autoregressive (VAR) model.

Following Campbell and Shiller (1988a) and Lof (2015), the series of model-implied log price-net earnings ratios, δ_t', can be generated through the following equation (Appendix D):

[10] For robustness, we have tested numerous subperiods (by including and/or excluding the 2008 crisis and the last shipping super-cycle, from 2003 to 2008) for each dry bulk sector as well as various horizons (in addition to $n = 5$) and the results are qualitatively similar to those reported in Table 3.

$$\delta_t' = \left[\sum_{i=1}^{n}\left(\prod_{j=1}^{i}\rho_j\right)\boldsymbol{e2}'\mathbf{A}^i + \left(\prod_{j=1}^{n}\rho_j\right)\boldsymbol{e3}'\mathbf{A}^n\right]\boldsymbol{z_t}, \tag{18}$$

where $\boldsymbol{z_t}$ is a $3p \times 1$ matrix of state variables and p is the optimal number of lags corresponding to the incorporated VAR model. The state variables in this case are the actual log price-net earnings ratio, $\delta_t = p_t - \pi_{t+1}$, the one period log net earnings growth, $\Delta\pi_{t+1}$, and the log scrap-net earnings ratio, $\tau_t = s_t - \pi_{t+1}$, plus $(p-1)$ lags of each state variable. Note that all variables in this equation are demeaned. Furthermore, $\mathbf{A}$ is a $3p \times 3p$ matrix of constants and $\boldsymbol{e2}$, $\boldsymbol{e3}$ are selection vectors such that $\boldsymbol{e2}'\boldsymbol{z_t} = \Delta\pi_{t+1}$ and $\boldsymbol{e3}'\boldsymbol{z_t} = \tau_t$.

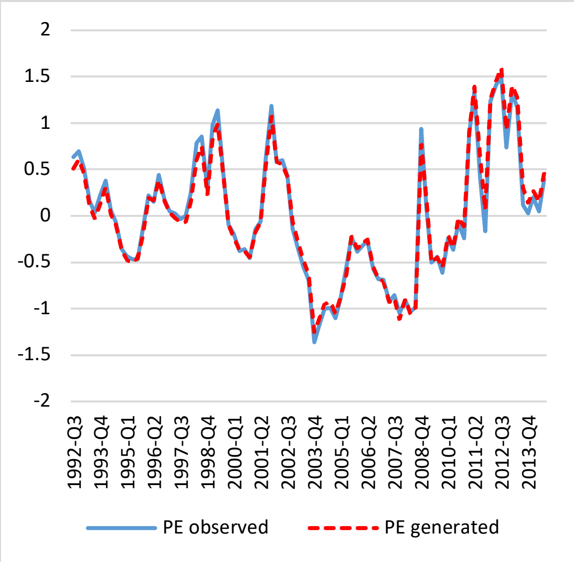
The intuition behind this model is that if market agents require constant returns and value shipping assets accordingly, the observed price-net earnings ratios will be close to the theoretical ones generated by (18). Thus, we estimate the time-series of $\delta_t, \Delta\pi_{t+1}$, and τ_t for the four dry bulk sectors. Due to data limitations related to the scrap price time-series (there is no data for scrap prices before 1990), we assume consecutive quarterly operating periods as opposed to annual ones. Accordingly, after discussions with industry participants, we also adjust for the out-of-service period and the operating and maintenance expenses of the vessel to be consistent with reality.

Table 5: Comparison between the observed and generated PE ratios.

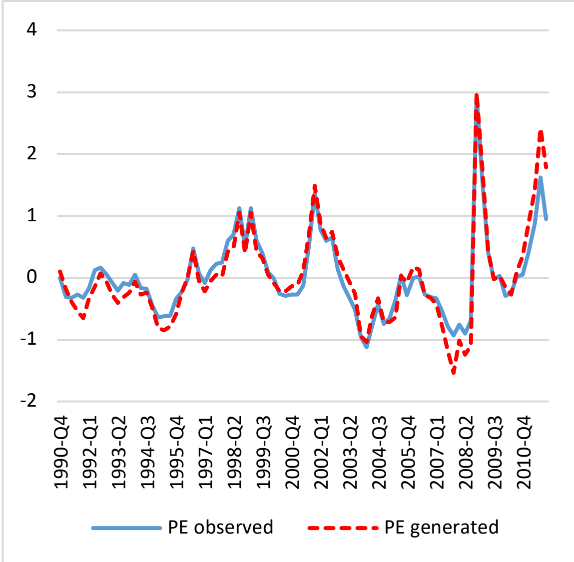
Sector	Correlation	Volatility Ratio
Capesize	0.99	1.01
Panamax	0.96	0.84
Handymax	0.88	0.83
Handysize	0.95	0.97

Notes: This table illustrates a comparison between the observed and generated log price-net earnings ratios. The latter are estimated through equation (18) of the main text. Correlation refers to the correlation coefficient between the two variables while the volatility ratio corresponds to the fraction between the volatility of the observed price-net earnings ratio and the volatility of the generated one.

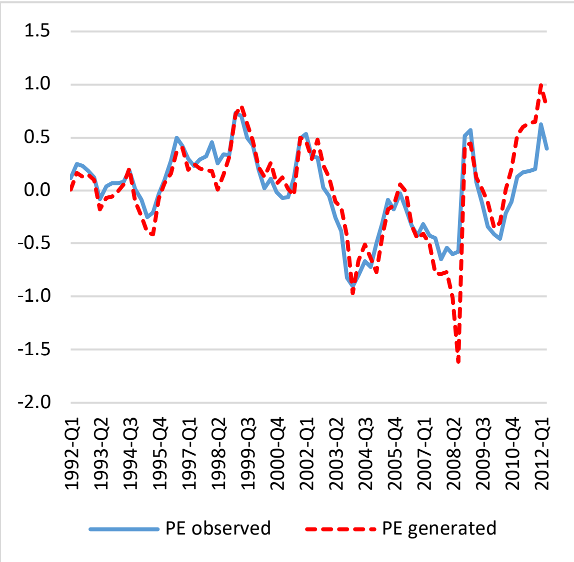
The optimal lag length, $p = 2$, of the unrestricted VAR(p) model is selected using the Akaike Information Criterion (Akaike, 1973). All models are stable according to the VAR Stability Condition Test. Figure 2 compares the observed log price-net earnings ratios and the ones generated by equation (18) for each dry bulk sector and Table 5 presents the correlation coefficients between the two variables and the ratios between their respective standard deviations; that is, the corresponding



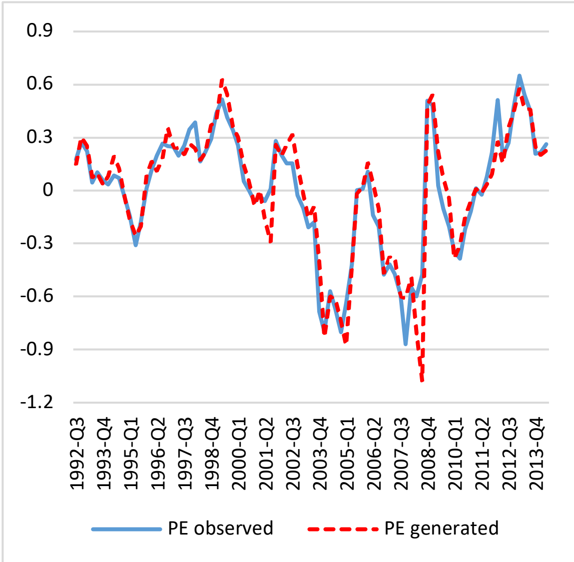
Panel A: Capesize sector from 1992:Q3 to 2014:Q3.



Panel B: Panamax sector from 1990:Q2 to 2011:Q4.



Panel C: Handymax sector from 1992:Q1 to 2012:Q2.



Panel D: Handysize sector from 1992:Q3 to 2014:Q2.

Figure 2: Observed and Generated Price-Net Earnings Ratios.

Panels A-D present the observed price-net earnings ratios and the ones generated by the VAR model in equation (18) for each dry bulk sector.

volatility ratios, denoted by $\frac{\sigma(\delta_t)}{\sigma(\delta_t')}$. Evidently, the unrestricted VAR model with constant required returns matches sufficiently well the observed data in each dry bulk shipping sector. Therefore, we can argue that there does not appear to be any consistent or significant evidence of time-varying required returns in the valuation of dry bulk vessels.[11]

IV. Economic Interpretation and Discussion

In the Campbell-Shiller variance decomposition methodology, the earnings yield is the sole state variable and as such summarises all the information that we need to know about the market. In line with this argument, Table 6 shows that the earnings yield is much more informative regarding future market conditions compared to lagged net earnings growth. This is confirmed by looking at the estimated coefficients in the univariate and bivariate forecasting regressions: in all cases, the earnings yields' coefficients are much larger and more significant than the corresponding lagged net earnings growth ones. Furthermore, in the bivariate regressions, lagged net earnings growth is significant only in the 3-year horizon for the Capesize, Panamax, and Handymax sectors; however, the signs are opposite to the respective ones in the univariate case. The economic intuition behind this finding can be explained by the supply and demand mechanism for shipping services and the role of the "time-to-build" lag.

Time-to-build is the lag between the time an order for a new vessel is placed and the time the vessel is delivered. In shipping, this construction lag is not fixed but exhibits cyclical variation as delivery lags are lengthened during periods of high investment activity due to capacity constraints and order backlog at shipyards (Kalouptsidi, 2014). As a result, this lag can be between 18 to 60 months depending on the prevailing market conditions (Stopford, 2019). Due to "time-to-build" constraints, shipping supply adjusts sluggishly to changes in demand. Consequently, while aggregate supply and demand variables exhibit a high degree of co-movement (Panel A of Figure 3), their respective growth rates are less correlated (Panel B of Figure 3). Since freight rates and, in turn, net earnings are the equilibrium outcome of the supply and demand mechanism, net earnings growth is expected to be negatively related to the spread between supply and demand growth rates, defined as:

$$S_{t+1} = \ln\left(\frac{F_{t+1}}{F_t}\right) - \ln\left(\frac{D_{t+1}}{D_t}\right), \tag{19}$$

[11] As noted, due to data limitations, the respective samples from the variance decomposition and VAR frameworks do not coincide. However, when we repeat the variance decomposition exercise for the shorter sample period covered in the VAR analysis, the results are qualitatively similar to the ones reported in the main text.

where D_t is the aggregate demand for shipping services during period $t \to t+1$ and F_t is the aggregate fleet capacity at time t.[12] The strong negative relation between net earnings growth, $\Delta\pi_{t+1}$, and the supply-demand spread, S_{t+1}, across all dry bulk sectors is also confirmed by the respective correlation coefficients which range between -0.79 and -0.87.

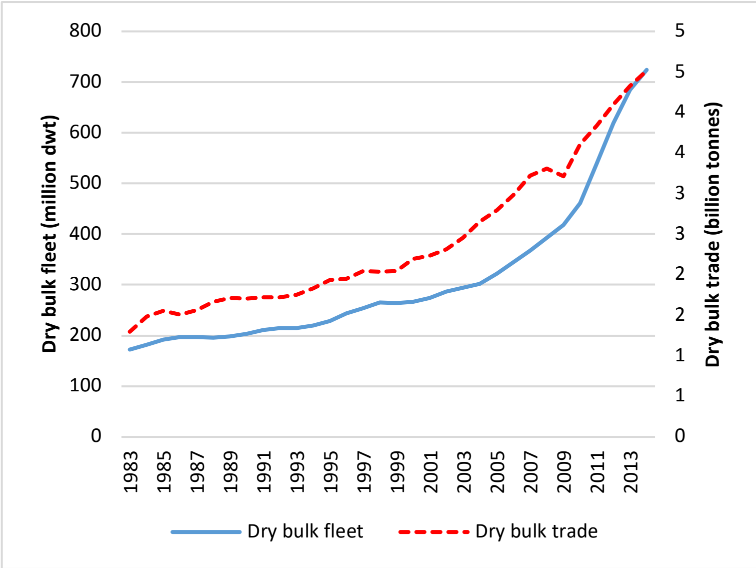
Table 6: Regressions of future net earnings growth on lagged net earnings growth and current earnings yields.

		Lagged net earnings growth			Earnings yield			Bivariate Regressions		
n	T	$\beta^{\Delta\pi(-12)}$	t^{NW}	R^2	$\beta^{\pi-p}$	t^{NW}	R^2	$\beta^{\Delta\pi(-12)}$	$\beta^{\pi-p}$	R^2
Panel A: Capesize Sector										
1	252	-0.22	-1.50	0.04	-0.59***	-2.85	0.17	0.05	-0.63***	0.17
2	240	-0.42**	-2.23	0.10	-0.94***	-2.81	0.25	0.03	-0.97***	0.25
3	228	-0.19**	-2.27	0.02	-0.99***	-5.27	0.19	0.41***	-1.45***	0.24
Panel B: Panamax Sector										
1	408	-0.32***	-2.82	0.08	-0.92***	-3.05	0.21	0.05	-0.99***	0.21
2	396	-0.52***	-3.94	0.16	-1.22***	-5.67	0.28	-0.05	-1.15***	0.28
3	384	-0.30	-1.56	0.04	-1.06***	-3.61	0.19	0.24***	-1.34***	0.21
Panel C: Handymax Sector										
1	315	-0.19	-1.42	0.04	-0.56**	-2.22	0.12	0.08	-0.65***	0.13
2	303	-0.43**	-2.56	0.13	-0.94***	-3.7	0.19	-0.12	-0.79***	0.20
3	291	-0.18***	-2.82	0.02	-0.77***	-4.13	0.12	0.19***	-1.00***	0.13
Panel D: Handysize Sector										
1	444	-0.17	-1.05	0.03	-0.54**	-2.45	0.13	0.08	-0.62***	0.13
2	432	-0.40***	-2.87	0.10	-0.85***	-3.68	0.17	-0.11	-0.74**	0.17
3	420	-0.26***	-2.72	0.03	-0.82***	-4.82	0.13	0.09	-0.91***	0.14

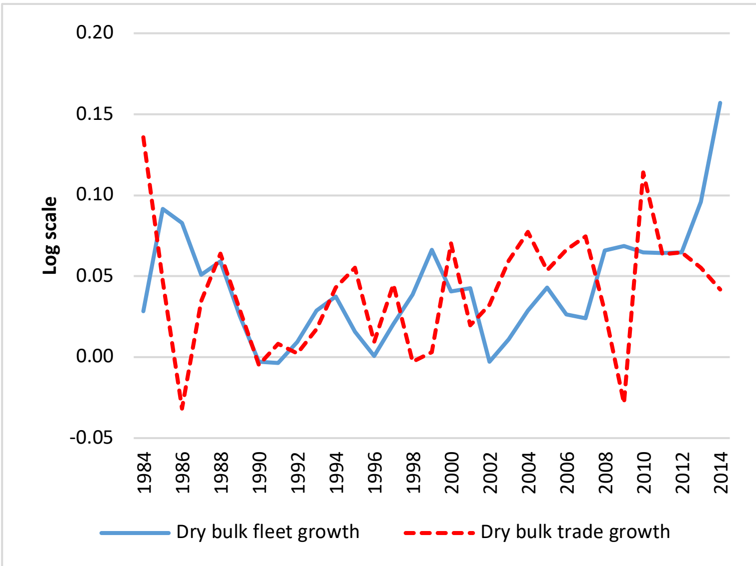
Notes: This table reports results from 1-, 2-, and 3-year horizon univariate and bivariate forecasting regressions of real log net earnings growth on lagged (i.e. 1-year lag or, equivalently, 12 months) real net earnings growth, $\Delta\pi(-12)$, and log net earnings yields, $\pi - p$. Since our data consists of monthly overlapping observations we use the Newey-West (1987) HAC and the Hodrick (1992) corrections. Since both methods yield very similar results, for reasons of brevity, we present only the Newey-West (1987) HAC t-statistics, denoted by t^{NW}. *, **, or *** indicate significance at the 10%, 5% or 1% levels, respectively.

This is consistent with the way the shipping supply and demand mechanism operates in practice. Random shocks in demand perturb the short-run equilibrium and, consequently, prevailing net earnings; we define this as a first-order effect (FOE). Combined with the time-to-build lag, an increase in current net earnings has an indirect effect on future net earnings through the current investment decisions of shipowners; we define this as a second-order effect (SOE). Combined with the mean-

[12] We proxy shipping demand through aggregate dry bulk seaborne trade; due to data limitations we can't quantify the sector-specific demand, but we find a significant positive relationship between net earnings growth and shipping demand growth across all dry bulk sectors (ranging from 0.49 to 0.63). We have also estimated the spread through a linear inverse demand curve; results obtained from both specifications indicate precisely the same patterns.



Panel A: Dry bulk fleet and trade development, from 1983 to 2014.



Panel B: Dry bulk fleet and trade growth from 1983 to 2014.

Figure 3: Annual Dry Bulk Shipping Supply and Demand.

Panel A provides a comparison between the total dry bulk fleet development (measured in million dwt) and the evolution of the total dry bulk trade (measured in billion tonnes). Panel B compares the evolutions of the one-period growth rates of the two variables.

reverting nature of shipping demand growth, this results in extremely volatile shipping cash flows. Consequently, shipping net earnings are partially endogenously determined by the investment decisions of shipowners as also suggested by Stopford (2009) and Greenwood and Hanson (2015).

To illustrate this in greater detail, consider a discrete time environment. At each t, annual net earnings for period $t \to t+1$ are determined through the supply and demand mechanism. Assume that due to an unexpected positive demand shock, current net earnings, $\Pi_{t \to t+1}$, increase. The owner of a vessel at time t can immediately exploit the strong prevailing market conditions. As a result, current vessel prices, P_t, not only increase compared to their previous level, P_{t-1}, but they also increase by more than what would have been the case if, for the same positive shock in the shipping economy, the owner of the vessel could not charter his vessel at the prevailing net earnings for the forthcoming period. This is a positive FOE and is caused by the fact that net earnings for period $t \to t+1$ are $\mathcal{F}_t$-measurable.

This FOE can be interpreted as a “delivery premium” or “convenience yield” for having the vessel readily available for leasing and is reflected on the relation between net earnings and the ratio of the 5-year old to the contemporaneous newbuilding vessel prices: during market upturns the ratio is significantly higher than one and vice versa (Kyriakou *et al*, 2018). At the same time, higher net earnings result in higher current net investment, defined as:

$$NI_t = (order_{t+1} - order_t + del_t) - scrap_t, \qquad (20)$$

where $order_t$ is the order book for new vessels at the beginning of period $t \to t+1$, del_t the delivery of newly built fleet capacity during period $t \to t+1$, $scrap_t$ the demolished fleet capacity during the same period, and net investment is scaled by the fleet size at the beginning of period $t \to t+1$ (all variables are measured in dwt). The high positive correlation between current net earnings and net investment is also confirmed by the correlation coefficients which range from 0.52 to 0.77, across the different sectors.

Increase in net investment will result in an increase in future fleet capacity which, ceteris paribus, will result in lower future net earnings. We confirm this conjecture by performing 1-, 2-, and 3-year horizon predictive OLS regressions of future log net earnings growth on current scaled net investment, for each of the four dry bulk sectors:

$$\pi_{t+12n} - \pi_t = \alpha_{NI,n} + \beta_{NI,n} \cdot NI_{t,n} + \varepsilon_{NI,t+12n}, \qquad n \in \{1,2,3\}, \qquad (21)$$

where $\pi_{t+12n} - \pi_{t+1}$ is the n-year log net earnings growth and $12n$ is the forecasting horizon measured in months.

For robustness, since the orderbook data starts in January 1996, we examine the relation between net investment and net earnings over a longer period by incorporating an additional investment variable based on data related to deliveries and scrapping activity. Following Greenwood and Hanson (2015), we assume that current newbuilding contracting is realised within the next 13 to 24 months, i.e. during period $t+13 \rightarrow t+24$ while current demolitions take place over the period $t \rightarrow t+12$. Accordingly, we define "realised net investment", RI_t, as:

$$RI_t = del_{t+13\rightarrow t+24} - scrap_{t\rightarrow t+1}. \tag{22}$$

Once again, we scale the investment variable by the fleet size at the beginning of period $t \rightarrow t+1$. Accordingly, we perform a second set of regressions as the ones in equation (21), using realised net investment as the explanatory variable. The results in Table 7 suggest that current net investment negatively predicts future net earnings growth. Interestingly, we observe that there is a big spike in the significance and magnitude of the slope coefficients in the 2-year horizon which we believe reflects the time lag required for the delivery of a newbuilding order.

Table 7: Regressions of future net earnings growth on current net investment.

	Net Investment					Realised Net Investment				
n	T	β	t^{NW}	t^{H}	R^2	T	β	t^{NW}	t^{H}	R^2
Panel A: Capesize Sector										
1	216	-13.97*	-1.66	-1.68	0.07	264	-3.78*	-3.18	-3.27	0.09
2	204	-26.71***	-10.78	-11.23	0.16	252	-7.73***	-3.72	-3.69	0.24
3	192	-32.01***	-7.45	-7.09	0.20	240	-10.29***	-3.50	-3.40	0.38
Panel B: Panamax Sector										
1	180	-47.00***	-3.40	-3.35	0.12	420	-5.73***	-3.29	-3.34	0.08
2	168	-53.91***	-5.15	-5.60	0.11	408	-11.62***	-3.64	-3.70	0.22
3	156	-52.74***	-7.03	-7.19	0.13	396	-10.86***	-5.72	-5.76	0.18
Panel C: Handymax Sector										
1	210	-14.41	-1.31	-1.34	0.05	327	-2.75***	-2.69	-2.58	0.06
2	198	-33.87***	-5.40	-5.46	0.18	315	-6.60***	-5.11	-5.15	0.21
3	186	-32.04***	-5.26	-5.56	0.16	303	-7.85***	-9.30	-9.30	0.31
Panel D: Handysize Sector										
1	216	-30.33	-1.60	-1.60	0.10	456	-2.94*	-1.92	-2.00	0.03
2	204	-46.71***	-4.43	-4.54	0.16	444	-10.30***	-4.01	-4.09	0.18
3	192	-50.69***	-4.79	-5.51	0.18	432	-13.53***	-4.56	-4.55	0.28

Notes: This table reports results from 1-, 2-, and 3-year horizon forecasting regressions of real log net earnings growth on current net investment and realised net investment. The data for the net investment regressions start from January 1996 while the data for the realised net investment are from January 1976. We use the Newey-West (1987) HAC (t^{NW}) and Hodrick (1992) (t^{H}) corrections to account for the overlapping nature of returns. *, **, or *** indicate significance at the 10%, 5% or 1% levels, respectively (according to the t^{NW} statistic).

In conclusion, market participants are, at least partially, anticipating this mechanism and value second-hand vessels expecting future net earnings to decrease compared to their prevailing levels. Thus, current net earnings, through current investment, have a negative SOE on current second-hand prices and, in turn, the growth rate of net earnings is higher than the one of vessel prices. Consequently, net earnings are more volatile than vessel prices and earnings yields are strongly positively related with both current net earnings and prices but negatively related with future market conditions. Since valuation ratios are used as indicators of the fundamental value of the asset relative to the generated cash flow (Campbell and Shiller, 1988b), we can argue that vessels are relatively undervalued when freight markets are very strong and vice versa.

While our results are in line with recent findings from the majority of international (Rangvid *et al*, 2014) and the pre-WWII U.S. (Chen 2009) equity markets, they are different to the ones from the Germany, UK, and post-WWII U.S. equity markets (Cochrane, 2011). In the latter case, the dividend yield is strongly and positively associated with future returns while future dividend growth appears to be unpredictable.

Since though, one might argue that equities are a financial asset class while vessels a real one, we also compare our respective findings with the real estate markets. Namely, regarding residential and commercial real estate, Hamilton and Schwab (1985) and Gallin (2008) find a strong negative relation between the rent yield and future rent growth. Ghysels *et al* (2012) estimate predictive regressions of future returns on the current rent yield and their results suggest that returns are statistically insignificant; they also find that cash flow predictability is much stronger than predictability of returns. In line with Plazzi, Torous, and Valkanov (2010), predictability is stronger in the commercial part of the industry which is arguably closer to shipping markets. Thus, the question of interest is what drives the observed similarities and differences across different industries and stock markets.

Research in equity markets suggests that dividend predictability increases with dividend volatility or, equivalently, decreases with dividend smoothing. Fama and French (1988) find that in the post-WWII period, U.S. stock returns are at least 2.4 times more volatile than dividend changes, that is dividends are smoother compared to stock prices. Similarly, Chen *et al* (2009) show that dividend smoothing is more widespread in the U.S. stock market, especially in the post-WWII period. Dividend smoothing increases the persistence of dividend yields and expunges the predictability of future dividend growth since it disentangles dividends from fluctuations in dividend yields. In other words, in the absence of dividend smoothing, dividends depend on the corresponding earnings and their predictability increases accordingly. In this case, a high current dividend has a negative SOE on current prices and vice versa. In turn, current dividend yields strongly and negatively predict future dividend growth. In line with this argument, Rangvid *et al* (2014) show that predictability is stronger in countries where dividends are less smooth, the typical firm is small, and volatility is higher; that is in relatively small and less developed markets. Since net earnings are the natural analogue in shipping of dividends in equity markets, the argument above is in line with the empirical results presented in this paper.

In conclusion, the degree of cash flow predictability by the valuation ratio depends on the magnitude of SOEs of current cash flows on future cash flows. Since current asset prices reflect the expected cash flows to be generated by the asset, the more powerful the SOEs are, the more predictable future cash flows become and, the more informative prices and the valuation ratio are about future market conditions. Similarly, in the absence of SOEs, future cash flows should not be predictable by the current valuation ratio. In other words, if future cash flows are not economically predictable using the time t information filtration then they cannot be predicted by valuation ratios.

The same argument applies to the real estate industry as well. Abraham and Hendershott (1996) find that rent growth predictability in residential markets is positively related to supply elasticity (e.g. the availability of land to build). Furthermore, Wheaton and Torto (1988) illustrate a strong relationship between future rent growth and current excess vacancy. Namely, for a given shock in current rents, the higher the elasticity of local supply, the stronger the SOEs become on future rents and on current real estate prices.; as a result, the predictability of future market conditions from the current rent yield increases accordingly. The results in Table 7 suggest that this is also the case in the shipping industry. Namely, the higher the elasticity of shipping supply – approximated by current or realised net investment – the stronger the SOEs on future net earnings and thus, the higher the predictability of future market conditions from the earnings yield.

V. Conclusion

This article analyses the relation between second-hand vessel prices, net earnings, and holding period returns in the Capesize, Panamax, Handymax, and Handysize sectors of the dry bulk shipping industry. In order to determine the main driver of vessel prices, we incorporate the Campbell-Shiller (1988b) variance decomposition framework.

We show that high shipping earnings yields strongly and negatively predict future net earnings growth. Furthermore, there is no consistent evidence of time-varying expected returns in the second-hand dry bulk shipping industry. Equivalently, it seems that ship prices mainly vary due to news about expected market conditions per se and not due to news about the terminal scrap price of the vessel or because shipowners, when valuing vessels, require time-varying risk premia. These arguments are further reinforced using the Campbell-Shiller (1988a) VAR framework. To the best of our knowledge, those stylised facts had never been documented before in the shipping literature.

From a technical perspective, we contribute to the empirical asset pricing literature by extending the Campbell-Shiller variance decomposition (1988b) and VAR (1988a) frameworks to account for both a "forward-looking" valuation ratio and economic depreciation in the value of the asset. Accordingly, we provide a more rigorous framework for pricing real assets which limited economic lives, such as vessels and other transportation assets as well as commercial real estate.

Finally, we provide an economic interpretation for the obtained empirical results and compare them to the respective findings from the equity and real estate markets. Specifically, shipping results agree with recent findings from the pre-WWII U.S. equity markets, the bulk of international equity markets, and the bulk of the US real estate industry. They are different, however, to the corresponding findings in more mature equity markets such as the ones of Germany, UK, and post-WWII US. We argue that the degree of cash flow predictability by the valuation ratio depends on the magnitude of second-order effects of current cash flows on future cash flows. Since current prices depend on the expected cash flows to be generated by the asset, the greater the impact of those second-order effects, the more predictable future cash flows become and, in turn, the more informative prices and valuation ratios become about future market conditions. This argument can be further tested in other transportation sectors by relating the predictability of future cash flows – from the respective valuation ratio – to the elasticity of supply and demand in the industry.

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Appendix

A. Depreciation Scheme and Exact Present Value Relation

Vessels are real assets with finite economic lives and thus, subject to economic depreciation. Following the literature, we assume that a newly built vessel has an economic life of 25 years. Since we only have 5-, 10-, 15-, 20-year old, and scrap vessel prices, we adopt a depreciation scheme to approximate the price of $(5+n)$-year old vessels at each time t. We denote this price by $P_{5+n,t}$ for $0 \leq n \leq 20$; hence, $P_{5,t}$ denotes the price of a 5-year old vessel at time t.

We first estimate the average price ratios of 10-year to 5-year, 15-year to 10-year, 20-year to 15-year, and scrap to 20-year old vessels. These ratios are approximately equal to 0.75 in all dry bulk categories. Consequently, the assumption of a straight-line depreciation scheme for each 5-year age window implies a 5% annual value reduction compared to the price of the youngest vessel in the interval at each corresponding time t. To illustrate the depreciation mechanism, consider the prices of vessels with ages between 5 and 10 years. At each t, these prices are estimated using the formula:

$$P_{5+n,t} = (1 - 0.05n) \cdot P_{5,t}, \quad 1 \leq n \leq 5. \tag{A1}$$

We now derive equation (8) of the main text. We use the identity $1 = R_{t+1}^{-1} \cdot R_{t+1}$ and incorporate equation (3) of the main text to obtain:

$$1 = R_{t+1}^{-1} \cdot R_{t+1} = R_{t+1}^{-1} \cdot \left[\frac{\Pi_{t+1} + P_{6,t+1}}{P_{5,t}}\right]. \tag{A2}$$

Accordingly, multiplying both sides of $(A2)$ by $P_{5,t}/\Pi_{t+1}$ and re-arranging terms:

$$\frac{P_{5,t}}{\Pi_{t+1}} = R_{t+1}^{-1} \cdot \left[1 + \frac{P_{6,t+1}}{\Pi_{t+1}}\right]. \tag{A3}$$

Equation $(A3)$ can be generalised to:

$$\frac{P_{5+n,t+n}}{\Pi_{t+n+1}} = R_{t+n+1}^{-1} \cdot \left[1 + \frac{P_{5+n+1,t+n+1}}{\Pi_{t+n+1}}\right]. \tag{A4}$$

Equation $(A3)$ cannot be iterated forward as in Campbell and Shiller (1988a) and Cochrane (2005). Rather, since ships have finite economic lives, we can apply backward iteration to obtain $P_{6,t+1}/\Pi_{t+1}$ which also implies that it is not necessary to impose the transversality or "no bubbles" condition. Adjusting for economic depreciation of the asset, the terminal (scrap) price of the vessel 20 years ahead (i.e. at $t+20$) is denoted by $S_{t+20} \equiv P_{25,t+20}$. Using $(\mathrm{A}4)$ with $n=19$ and multiplying both sides of the equation by Π_{t+20}/Π_{t+19} yields:

$$\frac{P_{24,t+19}}{\Pi_{t+19}} = R_{t+20}^{-1} \cdot \left[1 + \frac{S_{t+20}}{\Pi_{t+20}}\right] \cdot \frac{\Pi_{t+20}}{\Pi_{t+19}}.$$

Iterating backwards, we observe that the ratio $P_{5+n,t+n}/\Pi_{t+n}$ can be obtained at any $n \in \{1, \cdots, 19\}$ using the formula:

$$\frac{P_{5+n,t+n}}{\Pi_{t+n}} = \sum_{i=1}^{20-n} \left(\prod_{j=1}^{i} R_{t+n+j}^{-1} \cdot \frac{\Pi_{t+n+j}}{\Pi_{t+n+j-1}} \right) + \left(\prod_{j=1}^{20-n} R_{t+21-j}^{-1} \cdot \frac{\Pi_{t+21-j}}{\Pi_{t+20-j}} \right) \cdot \frac{S_{t+20}}{\Pi_{t+20}}. \tag{A5}$$

For $n=1$, equation $(\mathrm{A}5)$ implies:

$$\frac{P_{6,t+1}}{\Pi_{t+1}} = \sum_{i=1}^{19} \left(\prod_{j=1}^{i} R_{t+j+1}^{-1} \cdot \frac{\Pi_{t+j+1}}{\Pi_{t+j}} \right) + \left(\prod_{j=1}^{19} R_{t+21-j}^{-1} \cdot \frac{\Pi_{t+21-j}}{\Pi_{t+20-j}} \right) \cdot \frac{S_{t+20}}{\Pi_{t+20}}. \tag{A6}$$

In turn, by substituting $(\mathrm{A}6)$ into $(\mathrm{A}3)$ we obtain:

$$\frac{P_{5,t}}{\Pi_{t+1}} = R_{t+1}^{-1} \cdot \left[1 + \sum_{i=1}^{19} \left(\prod_{j=1}^{i} R_{t+j+1}^{-1} \cdot \frac{\Pi_{t+j+1}}{\Pi_{t+j}} \right) + \left(\prod_{j=1}^{19} R_{t+21-j}^{-1} \cdot \frac{\Pi_{t+21-j}}{\Pi_{t+20-j}} \right) \cdot \frac{S_{t+20}}{\Pi_{t+20}} \right].$$

Multiplying the last term within the square brackets by $\frac{\Pi_{t+21}}{\Pi_{t+21}}$ and performing some algebraic manipulation results in:

$$\frac{P_{5,t}}{\Pi_{t+1}} = R_{t+1}^{-1} + R_{t+1}^{-1} \cdot \sum_{i=1}^{19} \left(\prod_{j=1}^{i} R_{t+j+1}^{-1} \cdot \frac{\Pi_{t+j+1}}{\Pi_{t+j}} \right) + \left(\prod_{j=1}^{20} R_{t+21-j}^{-1} \cdot \frac{\Pi_{t+22-j}}{\Pi_{t+21-j}} \right) \cdot \frac{S_{t+20}}{\Pi_{t+21}}.$$

Finally, taking conditional expectations and exploiting the fact that Π_{t+1} is $\mathcal{F}_t$-measurable yields equation (8) of the main text:

$$\frac{P_{5,t}}{\Pi_{t+1}} = E_t \left[R_{t+1}^{-1} + R_{t+1}^{-1} \cdot \sum_{i=1}^{19} \left(\prod_{j=1}^{i} R_{t+j+1}^{-1} \cdot \frac{\Pi_{t+j+1}}{\Pi_{t+j}} \right) + \left(\prod_{j=1}^{20} R_{t+21-j}^{-1} \cdot \frac{\Pi_{t+22-j}}{\Pi_{t+21-j}} \right) \cdot \frac{S_{t+20}}{\Pi_{t+21}} \right]. \tag{A7}$$

B. Linearisation of the Present Value Relation

Equation (9) of the main text corresponds to the linearisation of equation $(\mathrm{A}7)$. For this purpose, we follow Campbell and Shiller (1988a), Cochrane (2005), and Alizadeh and Nomikos (2007). In addition, we extend the existing framework by (i) accounting for the fact that the shipping earnings yield is forward-looking and (ii) adjusting for economic depreciation in the value of the asset which in turn, results in not imposing the trasversality ondition.

Specifically, starting from equation $(\mathrm{A3})$:

$$P_{5,t} = R_{t+1}^{-1} \cdot \left[1 + \frac{P_{6,t+1}}{\Pi_{t+1}}\right] \cdot \Pi_{t+1}$$

and taking logs on both sides the equation, we obtain:

$$p_{5,t} = -r_{t+1} + \pi_{t+1} + \ln(1 + e^{p_{6,t+1} - \pi_{t+1}}),$$

where $p_{n,t} = \ln(P_{n,t})$, $\pi_t = \ln(\Pi_t)$ and $r_t = \ln(R_t)$.

Applying a first-order Taylor expansion of the last term around a point $p_6 - \pi = \ln(P_6/\Pi)$ yields:

$$p_{5,t} \approx -r_{t+1} + \pi_{t+1} + \ln\left(1 + \frac{P_6}{\Pi}\right) + \frac{P_6/\Pi}{1 + P_6/\Pi} \cdot \left[p_{6,t+1} - \pi_{t+1} - (p_6 - \pi)\right]$$

$$\Rightarrow p_{5,t} \approx -r_{t+1} + \pi_{t+1} + \rho_1\left(p_{6,t+1} - \pi_{t+1}\right) + k_1, \tag{B1}$$

where

$$\rho_1 = \frac{P_6/\Pi}{1+P_6/\Pi} \quad \text{and} \quad k_1 = -(1-\rho_1)\ln(1-\rho_1) - \rho_1 \ln(\rho_1).$$

As illustrated by Campbell and Shiller (1988a), the higher-order terms of the Taylor expansion that are neglected from $(\mathrm{B1})$ create an approximation error and as a result $(\mathrm{B1})$ does not hold exactly.[13] Furthermore, for equities, the point of expansion is usually assumed to be the natural logarithm of the sample mean price-dividend ratio although, as Cochrane (2011) argues, this does not need to be the case. For instance, Lof (2015) approximates ρ by the sample mean of the ratio $\frac{P_t}{P_t + D_t}$. Alternatively, one can use as an approximation point the natural logarithm of the inverse of the sample mean dividend-price ratio (Cochrane, 2005) or the natural logarithm of the fraction of the geometric mean of prices to the geometric mean of the corresponding cash flows (Alizadeh and Nomikos, 2007). Accordingly, for the first Taylor expansion, we set $P_6/\Pi = 1/\left(\overline{\Pi_{t+1}/P_{6,t+1}}\right)$. Notice that the choice of the expansion point and, consequently, of ρ, does not affect the results. Specifically, for robustness, we

[13] Campbell and Shiller (1988a) show that this error is in practice small and almost constant. Moreover, they argue that a constant approximation error does not have any implication on the empirical results when no restrictions on the means of the data are tested.

experimented with a variety of expansion points and the empirical results remain approximately the same while the obtained conclusions are identical. [14]

Accordingly, iterating equation (B1) forward yields:

$$
\begin{aligned}
p_{5,t} \approx & \sum_{i=1}^{n}\left(\prod_{j=1}^{i}\rho_{j-1}\right)(1-\rho_i)\pi_{t+i} - \sum_{i=1}^{n}\left(\prod_{j=1}^{i}\rho_{j-1}\right)r_{t+i} + \left(\prod_{i=1}^{n}\rho_i\right)p_{5+n,t+n} \\
& + \sum_{i=1}^{n}\left(\prod_{j=1}^{i}\rho_{j-1}\right)k_i, \qquad 1 \le n \le 20,
\end{aligned}
\tag{B2}
$$

where $p_{5,t}$ is the current log price of a 5-year old vessel while $p_{5+n,t+n} = \ln(P_{5+n,t+n})$ is the log price of a $(5+n)$-year old vessel after n years. In addition, for $n = 20$ we obtain $p_{25,t+20} \equiv s_{t+20} = \ln(S_{t+20})$ which corresponds to the log scrap price of the vessel.

To account for economic depreciation in the value of the asset, the i^{th} subsequent Taylor expansion is taken around the corresponding age-varying approximation point, defined as:[15]

$$
p_{5+i,t} - \pi_{t+1} = \ln(P_{5+i}/\Pi) = \ln\left[1/\left(\overline{\Pi_{t+1}/P_{5+i.t+1}}\right)\right], \qquad i \in \{1,\cdots,20\}.
$$

Subsequently,

$$
\rho_i = \frac{P_{5+i}/\Pi}{1+P_{5+i}/\Pi} \qquad \text{and} \qquad k_i = -(1-\rho_i)\ln(1-\rho_i) - \rho_i\ln(\rho_i), \quad i \in \{1,\cdots,20\}.
$$

Note that in equity markets, assets are assumed to be infinitely lived and the approximation points are constant and not age-varying. Consequently, ρ and k are also constant and (B2) reduces to the well-known Campbell and Shiller (1988a) linear present-value formula. Thus, equation (B2) provides a generalisation of the existing framework that can cover in a mathematically rigorous manner the class of real assets with limited economic lives (e.g. ships, airplanes, real estate, etc.).

The intuition behind formula (B2) is straightforward: high vessel prices are related to either high future net earnings or/and low future returns or/and high future vessel prices. However, since log prices and log net earnings are – usually – nonstationary variables, it is not appropriate to apply variance-bounds tests to equation (B2). Following Alizadeh and Nomikos (2007), a natural solution to this problem is to capitalise the cointegrating relationship between log vessel prices and log net

[14] Campbell and Shiller (1988b) also demonstrate that letting ρ vary within a plausible range does not have a significant impact on the results and the conclusions.

[15] Specifically, we construct new net earnings-price ratios variables, the numerators of which are equal to Π_{t+1}, while the denominators are equal to the prices of the corresponding $(5+i)$-year old vessels one-period ahead, $P_{5+i.t+1}$. In turn, we find the sample (arithmetic) means of those ratios. Mathematically, $\Pi/P_{5+i} = \overline{\Pi_{t+1}/P_{5+\iota.t+1}}$. Notice as well that $\rho_0 = 1$ since $i = 0$ corresponds to no Taylor expansion.

earnings. Specifically, this can be achieved by subtracting the corresponding net earnings from both sides of equation (B2). However, since our definition of the net earnings-price ratio is forward-looking, we deviate from the existing asset pricing literature by subtracting π_{t+1} instead of π_t. Accordingly, we obtain:

$$p_{5,t} - \pi_{t+1} \approx \sum_{i=1}^{n-1}\left(\prod_{j=1}^{i}\rho_j\right)\Delta\pi_{t+i+1} - \sum_{i=1}^{n}\left(\prod_{j=1}^{i}\rho_{j-1}\right)r_{t+i} + \left(\prod_{j=1}^{n}\rho_j\right)\left(p_{5+n,t+n} - \pi_{t+n}\right) + \sum_{i=1}^{n}\left(\prod_{j=1}^{i}\rho_{j-1}\right)k_i.$$

Equivalently,

$$\pi_{t+1} - p_{5,t} \approx -\sum_{i=1}^{n-1}\left(\prod_{j=1}^{i}\rho_j\right)\Delta\pi_{t+i+1} + \sum_{i=1}^{n}\left(\prod_{j=1}^{i}\rho_{j-1}\right)r_{t+i} + \left(\prod_{j=1}^{n}\rho_j\right)\left(\pi_{t+n} - p_{5+n,t+n}\right) - \sum_{i=1}^{n}\left(\prod_{j=1}^{i}\rho_{j-1}\right)k_i, \tag{B3}$$

where $\pi_{t+1} - p_{5,t}$ is the forward-looking log net earnings-price ratio and $\Delta\pi_{t+1} = \pi_{t+1} - \pi_t$ is the 1-year horizon (log) net earnings growth. Notice that $\Delta\pi_{t+i}$ and r_{t+i} do not enter (B3) symmetrically since the log-net earnings growth series has one less term compared to the log-returns one. However, since both $P_{5+n,t+n}$ and Π_{t+n+1} are $\mathcal{F}_{t+n}$-measurable, we modify (B3) by adding and subtracting $\left(\prod_{j=1}^{n}\rho_j\right)\pi_{t+n+1}$ to and from the right-hand side of the equation:

$$\pi_{t+1} - p_{5,t} \approx -\sum_{i=1}^{n}\left(\prod_{j=1}^{i}\rho_j\right)\Delta\pi_{t+i+1} + \sum_{i=1}^{n}\left(\prod_{j=1}^{i}\rho_{j-1}\right)r_{t+i} + \left(\prod_{j=1}^{n}\rho_j\right)\left(\pi_{t+n+1} - p_{5+n,t+n}\right) - \sum_{i=1}^{n}\left(\prod_{j=1}^{i}\rho_{j-1}\right)k_i. \tag{B4}$$

Finally, since equation (B4) holds ex post, we can take conditional expectations at time t:

$$\pi_{t+1} - p_{5,t} \approx -\sum_{i=1}^{n}\left(\prod_{j=1}^{i}\rho_{j-1}\right)k_i$$
$$+\mathrm{E}_t\left[-\sum_{i=1}^{n}\left(\prod_{j=1}^{i}\rho_j\right)\Delta\pi_{t+i+1} + \sum_{i=1}^{n}\left(\prod_{j=1}^{i}\rho_{j-1}\right)r_{t+i} + \left(\prod_{j=1}^{n}\rho_j\right)\left(\pi_{t+n+1} - p_{5+n,t+n}\right)\right] \tag{B5}$$

This corresponds to equation (9) of the main text.

C. Variance Decomposition

In order to decompose the variance of the shipping net earnings yield (equation [14] of the main text), we start by multiplying both sides of (B4) by $\left[\left(\pi_{t+1} - p_{5,t}\right) - \mathrm{E}\left(\pi_{t+1} - p_{5,t}\right)\right]$. Accordingly, taking expectations at time t on both sides, we obtain:

$$var\left(\pi_{t+1} - p_{5,t}\right) \approx -cov\left[\pi_{t+1} - p_{5,t}, \sum_{i=1}^{n}\left(\prod_{j=1}^{i}\rho_j\right)\Delta\pi_{t+i+1}\right]$$
$$+cov\left[\pi_{t+1} - p_{5,t}, \sum_{i=1}^{n}\left(\prod_{j=1}^{i}\rho_{j-1}\right)r_{t+i}\right] \tag{C1}$$
$$+cov\left[\pi_{t+1} - p_{5,t}, \left(\prod_{i=1}^{n}\rho_j\right)\left(\pi_{t+n+1} - p_{5+n,t+n}\right)\right].$$

The three terms in the right-hand side of (C1) are numerators of exponentially weighted long-run regression coefficients. Finally, dividing both sides of (C1) by $var\left(\pi_{t+1} - p_{5,t}\right)$ yields:

$$1 \approx -b_n^{\Delta\pi} + b_n^r + b_n^{\pi-p}, \tag{C2}$$

where b_n^i is the n-year horizon coefficient corresponding to the i^{th} element of the decomposition.

D. Extension of the Campbell and Shiller (1988a) VAR Framework to Shipping

We begin from the log-linear relation between the one-period holding return, the one-period net earnings, and the current and future prices for a 5-year old vessel (see Appendix B):

$$p_{5,t} \approx -r_{t+1} + \pi_{t+1} + \rho_1\left(p_{5+1/f,t+1} - \pi_{t+1}\right) + k_1, \tag{D1}$$

where f is the frequency of observations per annum, in this case f = 4. For expositional simplicity, the age subscript will be dropped in the analysis below. Therefore, p_t corresponds to the price of a 5-year old vessel at time t, while p_{t+1} to the price of the same vessel after one period –at which point the asset will be 6 years old. In addition, as stated in the main text, we impose the assumption that expected returns from holding the vessel for one period are constant; hence, $r_{t+1} = \mathrm{E}_t[r_{t+1}] = r$. Incorporating these modifications in equation $(\mathrm{D}1)$, we obtain:

$$p_t \approx -r + \pi_{t+1} + \rho_1(p_{t+1} - \pi_{t+1}) + k_1. \tag{D2}$$

Iterating $(\mathrm{D}2)$ forward yields:

$$\begin{aligned} p_t \approx & \sum_{i=1}^{n}\left(\prod_{j=1}^{i}\rho_{j-1}\right)(1-\rho_i)\pi_{t+i} - \sum_{i=1}^{n}\left(\prod_{j=1}^{i}\rho_{j-1}\right)r + \left(\prod_{i=1}^{n}\rho_i\right)p_{t+n} \\ & + \sum_{i=1}^{n}\left(\prod_{j=1}^{i}\rho_{j-1}\right)k_i, \end{aligned}$$

where $n = 20 \cdot f$. Equivalently,

$$\begin{aligned} p_t \approx & \sum_{i=1}^{n}\left(\prod_{j=1}^{i}\rho_{j-1}\right)(1-\rho_i)\pi_{t+i} + \left(\prod_{i=1}^{n}\rho_i\right)p_{t+n} \\ & + \sum_{i=1}^{n}\left(\prod_{j=1}^{i}\rho_{j-1}\right)(k_i - r), \end{aligned} \tag{D3}$$

where, due to the finite economic life of the vessel, we do not need to impose the transversality or "no-bubbles" condition when iterating forward the difference equation $(\mathrm{D}2)$. Next, in order to create the forward-looking log price-net earnings ratio, we subtract π_{t+1} from both sides of $(\mathrm{D}3)$:

$$\delta_t \approx \sum_{i=1}^{n-1}\left(\prod_{j=1}^{i}\rho_j\right)\Delta\pi_{t+i+1} + \left(\prod_{j=1}^{n}\rho_j\right)(p_{t+n} - \pi_{t+n}) + \sum_{i=1}^{n}\left(\prod_{j=1}^{i}\rho_{j-1}\right)(k_i - r), \tag{D4}$$

where, for expositional simplicity, we denote the price-net earnings ratio for the 5-year old vessel by $\delta_t = p_t - \pi_{t+1}$. Finally, adding and subtracting $\left(\prod_{j=1}^{n}\rho_j\right)\pi_{t+n+1}$ to and from the right-hand side of equation $(\mathrm{D}4)$ results in:

$$\delta_t \approx \sum_{i=1}^{n}\left(\prod_{j=1}^{i}\rho_j\right)\Delta\pi_{t+i+1} + \left(\prod_{j=1}^{n}\rho_j\right)\tau_{t+n} + \sum_{i=1}^{n}\left(\prod_{j=1}^{i}\rho_{j-1}\right)(k_i - r), \tag{D5}$$

where $\tau_{t+n} = s_{t+n} - \pi_{t+n+1}$ is the terminal – scrap – spread between the log of the scrap price of the vessel and the log of the prevailing net earnings at time t.

Redefining all variables as deviations from their means enables us to drop the constant term and, thus, simplify further equation (D5):

$$\delta_t \approx \sum_{i=1}^{n}\left(\prod_{j=1}^{i}\rho_j\right)\Delta\pi_{t+i+1} + \left(\prod_{j=1}^{n}\rho_j\right)\tau_{t+n}. \tag{D6}$$

Accordingly, parameters k_i and r are omitted from the analysis below.

Finally, the age-varying approximation points, ρ_i, are estimated through:

$$\rho_i = \overline{\left(\frac{1}{1+\Pi_t/P_{5+\frac{i}{f},t}}\right)} = \overline{\left(\frac{1}{1+\Pi_t/(1-\frac{i}{25f})P_{5,t}}\right)} = \overline{\left(\frac{1}{1+\Pi_t/(1-\frac{i}{100})P_{5,t}}\right)}, i \in \{1,\cdots,80\},$$

where the overbar denotes the sample (arithmetic) mean of the respective quantity. We can empirically test the model in equation (D6) using a log-linear Vector Autoregressive Model with p lags, following the procedure described in Campbell and Shiller (1988a). In particular, we compare the observed log price-net earnings ratio, δ_t, with the forecast of the net earnings growth and scrap spread generated by the VAR(p) model, δ_t'.

To begin with, consider the case where at the beginning of period $t \to t+1$ all market agents observe a vector of state variables denoted by $\boldsymbol{y_t}$ which is assumed to summarise the current state of the economy. This vector includes the log price-net earnings ratio, δ_t, the log net earnings growth, $\Delta\pi_{t+1}$, and the terminal spread, τ_t. Equivalently, $\boldsymbol{y_t} = [\delta_t, \Delta\pi_{t+1}, \tau_t]'$. In addition, assume that all market participants at time t have access to precisely the same information set; that is the history of state vectors, $\{\boldsymbol{y_t}, \boldsymbol{y_{t-1}}, \boldsymbol{y_{t-2}}, \cdots\}$, denoted by the information filtration $\mathcal{F}_t$. Specifically, the state vector is assumed to follow a linear stochastic process with constant coefficients which are known to all market agents. This feature is very important since it implies that all market agents are symmetrically informed. Mathematically, the stochastic linear process that characterises the evolution of $\boldsymbol{y_t}$ is expressed as a VAR(p):

$$\boldsymbol{y_t} = A_1\boldsymbol{y_{t-1}} + A_2\boldsymbol{y_{t-2}} + \cdots + A_p\boldsymbol{y_{t-p}} + \boldsymbol{\varepsilon_t}, \tag{D7}$$

where A_i with $i = 1, 2, \cdots, p$ are 3×3 matrices of coefficients known to market participants. Accordingly, A_{ijk} is the (j, k) element of matrix A_i which measures the effect of the j^{th} variable in the state vector $\boldsymbol{y_t}$ on the k^{th} variable with a time lag equal to i. Furthermore, $\boldsymbol{\varepsilon_t}$ is a 3×1 matrix consisting of error terms (white noises). Therefore, the equations for the three state variables at time t are:

$$\delta_t = \sum_{i=1}^{p} A_{i11}\delta_{t-i} + \sum_{i=1}^{p} A_{i12}\Delta\pi_{t+1-i} + \sum_{i=1}^{p} A_{i13}\tau_{t-i} + \varepsilon_{1,t}$$

$$\Delta\pi_{t+1} = \sum_{i=1}^{p} A_{i21}\delta_{t-i} + \sum_{i=1}^{p} A_{i22}\Delta\pi_{t+1-i} + \sum_{i=1}^{p} A_{i23}\tau_{t-i} + \varepsilon_{2,t}$$

$$\tau_t = \sum_{i=1}^{p} A_{i31}\delta_{t-i} + \sum_{i=1}^{p} A_{i32}\Delta\pi_{t+1-i} + \sum_{i=1}^{p} A_{i33}\tau_{t-i} + \varepsilon_{3,t}.$$

Following Sargent (1979), we can write this VAR(p) model in companion form (as a first-order autoregressive model) to take advantage of the convenient conditional expectations formula. Namely, we define a new vector, $\boldsymbol{z_t}$, which consists of $3p$ elements instead of 3; that is, apart from the 3 initial variables, $\delta_t, \Delta\pi_{t+1}$, and τ_t, it also includes $(p-1)$ lags of each state variable. We demonstrate this conversion below by considering a VAR(2) model. In this case, $\boldsymbol{z_t} = [\delta_t, \delta_{t-1}, \Delta\pi_{t+1}, \Delta\pi_t, \tau_t, \tau_{t-1}]'$ and $\boldsymbol{\varepsilon_t} = [\varepsilon_{1,t}, 0, \varepsilon_{2,t}, 0, \varepsilon_{3,t}, 0]'$. The evolution of $\boldsymbol{z_t}$ is characterised by a first-order VAR written in the following form:

$$\begin{bmatrix} \delta_t \\ \delta_{t-1} \\ \Delta\pi_{t+1} \\ \Delta\pi_t \\ \tau_t \\ \tau_{t-1} \end{bmatrix} = \begin{bmatrix} A_{111} & A_{211} & A_{112} & A_{212} & A_{113} & A_{213} \\ 1 & 0 & 0 & 0 & 0 & 0 \\ A_{121} & A_{221} & A_{122} & A_{222} & A_{123} & A_{223} \\ 0 & 0 & 1 & 0 & 0 & 0 \\ A_{131} & A_{231} & A_{132} & A_{232} & A_{133} & A_{233} \\ 0 & 0 & 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} \delta_{t-1} \\ \delta_{t-2} \\ \Delta\pi_t \\ \Delta\pi_{t-1} \\ \tau_{t-1} \\ \tau_{t-2} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1,t} \\ 0 \\ \varepsilon_{2,t} \\ 0 \\ \varepsilon_{3,t} \\ 0 \end{bmatrix}.$$

Note that the rows describing the initial state variables are stochastic, while the remaining ones deterministic. In general, a VAR(p) in companion form can be expressed as:

$$\boldsymbol{z_t} = \mathbf{A}\boldsymbol{z_{t-1}} + \boldsymbol{\varepsilon_t}, \tag{D8}$$

where $\boldsymbol{z_t}$ and $\boldsymbol{\varepsilon_t}$ are $3p \times 1$ matrices and $\mathbf{A}$ is a $3p \times 3p$ matrix of constants. The VAR(p) written in the form of equation (D8) has the following, very convenient, property:

$$\mathrm{E}[\boldsymbol{z_{t+1}}|\mathcal{F}_t] = \mathrm{E}_t[\boldsymbol{z_{t+1}}] = \mathbf{A}\boldsymbol{z_t} \Rightarrow \mathrm{E}_t[\boldsymbol{z_{t+n}}] = \mathbf{A}^n\boldsymbol{z_t}, \tag{D9}$$

which implies that once matrix $\mathbf{A}$ is estimated it can be incorporated to forecast n periods ahead, simply by multiplying $\boldsymbol{z_t}$ by the n^{th} power of $\mathbf{A}$.

The VAR(p) model above is also connected to the log-linear present-value model in equation $(\mathrm{D}6)$. Specifically, taking conditional expectations at time t on both sides of equation $(\mathrm{D}6)$ and exploiting the fact that δ_t is $\mathcal{F}_t$-measurable yields:

$$\delta_t \approx \mathrm{E}_t\left[\sum_{i=1}^{n}\left(\prod_{j=1}^{i}\rho_j\right)\varDelta\pi_{t+i+1} + \left(\prod_{j=1}^{n}\rho_j\right)\tau_{t+n}\right] \equiv \delta_t', \tag{D10}$$

where δ_t' is the unrestricted VAR forecast of $\sum_{i=1}^{n}\left(\prod_{j=1}^{i}\rho_j\right)\varDelta\pi_{t+i+1} + \left(\prod_{j=1}^{n}\rho_j\right)\tau_{t+n}$. We define the selection vectors $\boldsymbol{e1}$, $\boldsymbol{e2}$, and $\boldsymbol{e3}$ such that $\boldsymbol{e1}'\boldsymbol{z_t} = \delta_t$, $\boldsymbol{e2}'\boldsymbol{z_t} = \varDelta\pi_{t+1}$, and $\boldsymbol{e3}'\boldsymbol{z_t} = \tau_t$, respectively. Multiplying the selection vectors by $(\mathrm{D}9)$ and iterating forward results in:

$$\mathrm{E}_t[\delta_{t+1}] = \boldsymbol{e1}'\mathbf{A}\boldsymbol{z_t} \Rightarrow \mathrm{E}_t[\delta_{t+i}] = \boldsymbol{e1}'\mathbf{A}^i\boldsymbol{z_t}$$

$$\mathrm{E}_t[\varDelta\pi_{t+2}] = \boldsymbol{e2}'\mathbf{A}\boldsymbol{z_t} \Rightarrow \mathrm{E}_t[\varDelta\pi_{t+i+1}] = \boldsymbol{e2}'\mathbf{A}^i\boldsymbol{z_t}$$

$$\mathrm{E}_t[\tau_{t+1}] = \boldsymbol{e3}'\mathbf{A}\boldsymbol{z_t} \Rightarrow \mathrm{E}_t[\tau_{t+i}] = \boldsymbol{e3}'\mathbf{A}^i\boldsymbol{z_t}.$$

Accordingly, equation $(\mathrm{D}10)$ can be written as:

$$\begin{aligned}\delta_t = \boldsymbol{e1}'\boldsymbol{z_t} &\approx \sum_{i=1}^{n}\left(\prod_{j=1}^{i}\rho_j\right)\boldsymbol{e2}'\mathbf{A}^i\boldsymbol{z_t} + \left(\prod_{j=1}^{n}\rho_j\right)\boldsymbol{e3}'\mathbf{A}^n\boldsymbol{z_t} \\ &= \left[\sum_{i=1}^{n}\left(\prod_{j=1}^{i}\rho_j\right)\boldsymbol{e2}'\mathbf{A}^i + \left(\prod_{j=1}^{n}\rho_j\right)\boldsymbol{e3}'\mathbf{A}^n\right]\boldsymbol{z_t} \equiv \delta_t'\end{aligned} \tag{D11}$$

In order for the left- and right-hand sides of equation $(\mathrm{D}11)$ to be equal, the following condition has to be satisfied:

$$\boldsymbol{e1}' = \sum_{i=1}^{n}\left(\prod_{j=1}^{i}\rho_j\right)\boldsymbol{e2}'\mathbf{A}^i + \left(\prod_{j=1}^{n}\rho_j\right)\boldsymbol{e3}'\mathbf{A}^n, \tag{D12}$$

Equation $(\mathrm{D}12)$ imposes a set of $3p$ nonlinear restrictions on the coefficients of the VAR model. In conclusion, the series of model-implied log price-net earnings ratios, δ_t', can be generated through the following equation – which corresponds to equation (18) of the main text:

$$\delta_t' = \left[\sum_{i=1}^{n}\left(\prod_{j=1}^{i}\rho_j\right)\boldsymbol{e2}'\mathbf{A}^i + \left(\prod_{j=1}^{n}\rho_j\right)\boldsymbol{e3}'\mathbf{A}^n\right]\boldsymbol{z_t}. \tag{D13}$$