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The impact of shipyard and shipowner heterogeneity on contracting prices in the newbuilding market

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Abstract

Purpose – The purpose of this paper is to investigate the impact of shipyard and shipowner heterogeneity on the price formation for individual newbuilding contracts.

Design/methodology/approach – The model controls for the shipbuilding market cycle, input costs, firm size, yard experience and contract-specific variables and captures the impact of yard and owner heterogeneity in fixed-effects regressions. The data sample contains contract information on 3,759 tankers, bulkers and container vessels constructed at 77 shipyards between 1990 and 2014.

Findings – Although the newbuilding price benchmarks (market conditions) and gross domestic product per capita (salary costs) are influential covariates, the main conclusion is that shipyards and, particularly, shipowners play an influential role on the US$ per Compensated Gross Tonnage price level in individual contracts.

Originality/value – The paper represents the first study of the impact of buyer and seller heterogeneity at the micro level in the shipbuilding market.

Keywords Fixed effect models, Newbuilding prices, Shipyard heterogeneity

Paper type Research paper

1. Introduction

Shipbuilding is a truly global industry, with about 30 countries – mostly in Asia or Europe – having a significant production of merchant vessels (Stopford, 2009), of which 18 countries are considered major shipbuilders according to Clarkson Research (2016). In aggregate, the industry satisfies the conditions for a perfectly competitive market (Stopford, 2009, Alizadeh and Nomikos, 2009, Bertram, 2003):

(1) both buyers and sellers are price takers;

(2) the number of firms is large;

(3) no barriers to entry;

(4) products are identical;

(5) complete market information; and

(6) sellers are profit-maximizing entities.

However, at the micro level – i.e. the matching of a specific shipyard to build a ship for a specific owner – we postulate that heterogeneity will start to play a role. First, as discussed in Wijnolst *et al.* (2009), depending on how we define the shipyard "product", ships are arguably not identical. Clearly, individual ships of the same category and size can be very different in terms of detailed technical specifications and quality. Even if we redefine the "product" to be shipyard building capacity – as most yards are willing to build any vessel from a large catalogue of designs – some heterogeneity will remain in terms of delivery times and shipyard experience with the ship type. Second, while the global number of shipyards is large, they are highly heterogeneous in terms of dock size, experience, expertise and the range of designs offered, and this may impact the number and type of orders they attract. For instance, Sauerhoff (2014) finds that shipyard competency – as determined by the variables experience, market expertise, cooperation with suppliers and external exchange of information – affects the yard's ability to secure new contracts. Stott (1995) finds that a number of attributes related to a vessel, such as ease of maintenance and operation, fuel consumption, speed, safety and delivery conditions had a positive impact on the probability of attracting orders for the shipbuilder. However, he also reports that shipowners are reluctant to pay a significant premium for such features.

The influence of buyers and sellers on price formation is a new area of research within maritime economics. In the only existing study, Adland *et al.* (2016a) find that the identity of charterers and shipowners influence fixture rates even in the highly competitive spot freight market for large bulk carriers and tankers. The impact of buyer and seller heterogeneity at the micro level (i.e. individual contracts) in the shipbuilding market has not yet been investigated. The purpose and contribution of this paper to the literature is to model the price formation for individual newbuilding contracts and, specifically, assess the impact of yard and shipowner heterogeneity while controlling for other key variables such as shipyard experience and delivery lead time.

The remainder of this paper is structured as follows. In Section 2 we review the relevant shipping and shipbuilding literature. Section 3 presents our empirical methodology to consider buyer–seller heterogeneity. Section 4 presents the data and descriptive statistics. Section 5 presents our empirical results. Section 6 concludes with recommendations for future research.

2. Literature review

The literature on the shipbuilding industry can be broadly divided in two streams:

(1) competitiveness and strategic analysis; and

(2) the formation of newbuilding prices at the macro level.

Jiang *et al.* (2013) state that shipyard competitiveness is often assessed based on internal factors, such as costs. However, since shipbuilding is exposed to general market conditions and governmental interference, the authors introduce profit rate as a means of measuring competitiveness, and thus account for both internal and external factors. They find that China is the most competitive shipbuilding nation in the tanker and bulker markets, ahead of South Korea and Japan. Moreover, they find that China's competitiveness stems from its lower cost base, while South Korea and Japan rely on a positive deviation from the market price. Importantly for our case, this suggests that a degree of price differentiation is present in the market. Jiang and Strandenes (2011) report similar results and state that China's competitiveness stems mainly from lower labour and equipment costs, with steel costs being similar across the three major shipbuilding nations.

Much research has been devoted to the modelling of equilibrium prices within the four shipping markets – newbuilding, freight, second-hand vessels and demolition (Stopford, 2009). Beenstock (1985) assumes that the price of a new vessel perfectly reflects the second-hand price of a comparable ship at the time of delivery. Beenstock and Vergottis (1989a, 1989b) relax the strict assumption of perfect correlation between newbuild and second-hand prices and estimate an aggregated econometric model in which freight rates, newbuilding and second-hand prices, among other variables, are jointly and dynamically determined. Strandenes (1984) proposes that the price of a second-hand ship must be equal to the present value of the ship's earnings. Strandenes (1986) argues that newbuilding prices are set based on the expected present value of future earnings, while second-hand prices are given by the weighted average of short- and long-term profits. Tsolakis *et al.* (2003) conclude that the main drivers for second-hand prices are the newbuilding price and time charter rates, although these variables are affecting distinct vessel types and sizes differently. Using a Vector Error Correction Model framework, Adland *et al.* (2006) test an equilibrium relationship between newbuilding prices, second-hand prices and freight rates in the 2003-2005 drybulk boom, and find that the second-hand market was closely co-integrated with the newbuilding and freight markets and behaved in accordance with maritime economic theory.

According to Stopford (2009), newbuilding prices are set by the number of slots available at shipyards in a given timeframe, and the number of vessels demanded for the same period. The demand for new orders is influenced by freight rates, prices for second-hand vessels, market sentiment, availability of credit and liquidity. Supply is affected by current capacity, shipyard costs, exchange rates and government subsidies. Despite this straightforward market mechanism, part of the literature suggests that newbuilding prices show too low volatility compared to second-hand prices and long-term freight rates. Zannetos (1966) argues that this is due to market imperfections and externalities, such as over-capacity and production smoothing incentives. This view is shared by Strandenes (2010) who suggests that one of the causes is strong labour unions in shipbuilding. Dikos (2004) suggests that an alternative explanation can be found within the framework of a functioning competitive equilibrium if the actions of shipyards are interpreted as a result of exercising real options to offer capacity under uncertainty. Adland and Jia (2015) argue that an order for a newbuilding can be interpreted as a forward contract with a typically downward-sloping price curve (i.e. there is a premium for early delivery). Since lead times and payment schedules are correlated with market conditions, this leads to an expected lower volatility of newbuilding prices. Haddal and Knudsen (1996) investigate whether the global shipbuilding market constitutes a single market by evaluating correlations between newbuilding prices for various ship types.

To our knowledge, no authors have investigated price formation in the shipbuilding market at the micro (individual contract) level and so our paper is the first attempt at filling this gap in the literature. However, such studies are common in the empirical literature on freight rate formation, with Tamvakis (1995), Tamvakis and Thanopoulou (2000), Mokia and Dinwoodie (2002), Alizadeh and Talley (2011a, 2011b), Köhn and Thanopoulou (2011), Agnolucci *et al.* (2014) and Adland *et al.* (2016a, 2016b), all estimating models on the determinants of the freight rate for individual contracts (fixtures) in both the spot and timecharter bulk shipping markets.

3. Methodology

3.1 Dependent variable

The contracting price for an individual vessel is dependent on many technical specifications, for instance, the engine type and maker, the number and make of discharge pumps for tankers and the anti-fouling paint. Developing a model that accounts for all possible differences between individual vessels is clearly not a workable solution, mainly because the number of potential variables is very large, restricting the degrees of freedom, but also because not all vessel specifications are observable to the researcher. Additionally, models would have to differ across ship types to account for very different designs and equipment types. To obtain at a parsimonious model that is applicable across ship types, we here proxy the sophistication of a vessel by its Compensated Gross Tonnage (CGT) value. The CGT unit of measurement was introduced by Organisation for Economic Co-operation and Development as an indicator of the work amount required to build a ship and is calculated based on the following formula, where A and B are factors specific to the various ship types (OECD, 2007):

$$\textit{Compensated Gross Tonnage}\ (CGT) = A \times \textit{Gross Tonnage}^{B} \quad (1)$$

For contract prices to be comparable, we inflate all numbers to 2014 levels and convert all currencies into US$ based on the exchange rate at the contract date. Our dependent variable, the US$/CGT price for contract i is thus defined as:

$$U_i = \frac{\textit{Inflated and currency exchange rate adjusted contract price}}{CGT} \quad (2)$$

While CGT is widely accepted as the best unit of shipyard production (Bertram, 2003), it is not without flaws. The CGT value will assume a standard ship for each vessel category; thus, Stopford (2009) points out that the CGT measure has decreasing value the more sophisticated or complex a ship is. Bertram (2003) makes a similar point when stating that differences in equipment can shift the number of required man-hours, while leaving the CGT value unchanged.

Our independent variables are summarized in Table I below, with further explanations in subsequent paragraphs. To avoid having to perform partial analyses by shipping segment, we purposely choose variables that are generic and meaningful all possible vessel types and sizes. That is, we avoid, type-specific variables that are applicable only to a certain type of vessels, e.g. the number of cranes for small bulkers or pump capacity for tankers. We acknowledge that in doing so we may omit variables that are important for the price formation within individual segments. However, as we are here primarily looking to isolate

Variable	Unit	Predicted effect on US$/CGT price
Firm-specific variables		
Shipowner size	Dummy	Negative
Shipyard size	Dummy	Negative
Shipyard experience	Years	Positive
Contract-specific variables		
Delivery time	Months	Negative
Top speed	Knots	Positive
Gross tonnage	m3	Positive
Macroeconomic variables		
Delivery time * Freight rate interaction		Negative
Freight rate	US$/day	Positive
Newbuilding price index	US$/CGT	Positive
GDP per capita	US$	Positive
Steel price	US$/tonne	Positive
Oil price	US$/bbl	Positive

Table I. Predicted effects on US$/CGT from explanatory variables the market-wide effect of buyer and seller heterogeneity on newbuilding prices, and since any individual yard and owner is likely to build several types of ships throughout our sample, this is a necessary trade-off.

3.2 Firm-specific variables

3.2.1 Owner size. Clarksons (2016a) categorizes ship-owning firms by fleet size: single ship, very small (2-5), small (6-10), medium (11-20), large (21-50), very large (51-100) and extra-large (100+). We assign dummy variables for each category mentioned, in addition to one for firms of unknown size. We note that both shipyard and shipowner sizes are a snapshot at the time of contract signing, and the same firm can thus be a different size for different observations. This is important, as we are implicitly able to account for the impact of organic growth or merger and acquisition activity over time. Porter (1979) postulates that buyers can affect the price they pay to their suppliers if the firm is of a certain size, or purchases in large volumes (i.e. a negative relationship between owner size and price paid). These two criteria are likely to be highly correlated in the shipbuilding market, as larger shipowners are more likely to contract new vessels more frequently for fleet renewal purposes.

3.2.2 Shipyard size. Clarksons (2016b) classifies shipyard size based on the size of the order book in millions of CGT: very small (<0.049), small ($0.049 < 0.01$), medium ($0.1 < 0.49$), large ($0.49 < 1$) and mega (>1). These groups make up our shipyard size dummy variables, in addition to one for yards of unknown size. Porter (1979) suggests that larger producers are able to influence the price, particularly if producers are more concentrated than buyers, as in shipbuilding. Larger shipyards could also potentially obtain higher prices because of the flexibility that comes with size. These yards are presumably capable of competing for even the largest vessels, while this might not be feasible for smaller yards. Hence, large shipbuilders are possibly operating in segments with fewer competitors, as well as having a greater variety of contracts to bid on. On the other hand, larger shipyards might be better able to utilize economies of scale, pushing costs down. This is notably the case if the shipbuilder receives several orders for identical vessels (Stopford, 2009). Whether yard size affects shipbuilding prices in a positive or negative manner is thus dependent on which of these effects is dominant.

3.2.3 Shipyard experience. Sauerhoff (2014) finds that practical experience affects a shipyard's ability to secure contracts. We therefore postulate that shipyard experience at the signing of a contract, defined here as the contracting year less the first year of delivery for a yard, has a positive impact on price.

3.3 Contract-specific variables

3.3.1 Delivery time. A vessel with shorter delivery time will have a higher value to the shipowner in present value terms than an equal vessel with longer delivery time (Adland *et al.*, 2006, Adland and Jia, 2015). Stott (1995) finds partial empirical evidence for this hypothesis, as shipbuilders with superior delivery times are more likely to attract orders. Bertram (2003) states that differences in delivery times are likely to be captured in contract prices, which is also the point of Adland and Jia (2015). Following the theory presented in the latter paper, we postulate a negative impact on price from the delivery time, defined here as the build date less the contracting date (months).

3.3.2 Top speed and gross tonnage. As CGT is only an approximate measure of the work content of a ship of a certain type (Bertram, 2003), we introduce two variables – design speed (knots) and vessel size as measured by Gross Tonnes (GT) – as proxies for the scope of work for individual vessels within a vessel type category. For instance, higher-speed vessels may have more slender hull form or larger engine installation. We acknowledge that these are imperfect measures, but they are commonly available and comparable across contracts for different vessel types.

3.4 Macro variables

3.4.1 Newbuilding price index. In a competitive shipbuilding industry (Stott, 1995; Stopford, 2009), we expect that a large part of the contracting price for a newbuilding is explained by the shipbuilding market cycle, which we can consider as exogeneous to our micro-level model. To isolate this effect, we introduce an index of estimated competitive market prices as an explanatory variable. Clarksons (2016b) provides a monthly price index (US$/CGT) for a standard vessel built at a top-tier competitive shipyard. There are three separate indices covering bulk carriers, fully cellular container (FCC) vessels and tankers, which we match with the corresponding vessel types in the data set.

3.4.2 Delivery time and freight rate interaction variable. As established by Adland *et al.* (2006) and Adland and Jia (2015), the value of shorter delivery time is partly a function of freight rates (the opportunity cost). To account for this effect, we introduce an interaction variable between delivery time and a freight rate factor variable. The factor variable is constructed such that values at or below the 33rd percentile make up our low freight rates scenario, values between the 33rd and 66th percentile make up our normal scenario and values above the 66th percentile make up the high freight rates scenario. The freight rate here represents the one-year timecharter rate for each of the vessel types at the time of contract signing. As the value of early delivery is increasing in freight rates (Adland *et al.*, 2006; Adland and Jia, 2015), we expect a greater negative impact on US$/CGT from the interaction variable in a high freight rate scenario than in a low-rate environment. To avoid specification errors in the model that might arise from leaving out variables included in an interaction variable (Wooldridge, 2013, p. 191), freight rates and delivery time are incorporated as stand-alone variables. The positive effect of freight rates on shipbuilding demand and prices is well understood (Strandenes, 2010).

3.4.3 Gross domestic product per capita. Costs are the single most important factor in determining the competitive position of a shipyard (Bertram, 2003). Furthermore, nearly half of the costs incurred during the construction of a standardized bulk carrier are related to overheads and labour (Stopford, 2009). Obtaining reliable time series for wages is tricky, particularly for China which is a dominant player in the industry. We therefore introduce gross domestic product (GDP) per capita as proxy for wages, as recommended by ILO (2008). Further empirical support is found by Rodrik (1999) who demonstrates significant effects from GDP per capita on wages. This variable will also to some extent capture other cost elements specific to the country of manufacture that are hard to include by other means. We expect a positive impact on price from GDP per capita.

3.4.4 Oil and steel prices. Steel is the most important of all materials used in shipbuilding, amounting to 17 per cent of construction costs for a standard bulker (Stopford, 2009), and is proxied here by the global average price for hot rolled coil steel at the time of contract signing. The cost of energy in production is proxied by the average price of crude (i.e. a basket of dated Brent, West Texas Intermediate (WTI) and Dubai crude oil). Both cost drivers expectedly have a positive impact on US$ per CGT.

3.5 Omitted variables

3.5.1 Currency exchange rates. Currency exchange rates affect the relative competitiveness of shipyards as nearly all shipbuilding contracts are quoted in US$, while shipbuilders have most of their costs in local currency (Wijnolst *et al.*, 2009). However, currency effects will eventually materialize in current market prices, and so the newbuilding price indices should indirectly capture this element.

3.5.2 Government subsidies. Shipbuilding is a labour-intensive and export-oriented industry with spill-over effects on the domestic economy, making it the repeated beneficiary of various forms of government aid in pretty much any nation with shipbuilding output of some size (Strandenes, 2010). These subsidies are known to distort pricing mechanisms in the market, as the true production costs might not be covered by the shipyard (Jon, 2010). However, subsidies are hard to quantify, in part because not all aid is given in the form of direct monetary support. However, these effects will be at least partly captured by either shipyard fixed effects – for subsidies such as beneficial financing that remain relatively constant over time – or by the current competitive market prices for more short-term aid.

3.6 Econometric approach

When analysing data with repeated interactions of entities, in our case shipyards and shipowners, fixed- or random-effects models are suitable. However, only fixed-effects models allow estimates to account for heterogeneity, as they adjust for time-invariant unobserved effects that vary across entities, and/or constant time-varying effects across entities (Wooldridge, 2013, p. 477). Let the dependent variable, the US$/CGT price for contract i, be denoted by U_i. Furthermore, G_i is a vessels' gross tonnage, D_i is the delivery time, E_i is a measure of yard experience, $Y_{i,y}$ is the dummy variable for shipyard size, $O_{i,o}$ is the dummy variable for owner size and θ_k represents the coefficients for the size dummy variables. We first propose three purely microeconomic model specifications, starting with only firm size effects:

$$U_i = \beta_0 + \beta_1 G_i + \beta_2 D_i + \beta_3 E_i + \sum_y \theta_k Y_{i,y} + \sum_o \theta_k O_{i,o} + \varepsilon_i \tag{3}$$

In the second specification, we control for shipyard characteristics, excluding yard size, as this is rather constant and explained by yard fixed effects. The γ represents fixed-effect coefficients, while δ represents dummy variables generated for the respective yards and owners:

$$U_i = \beta_0 + \beta_1 G_i + \beta_2 D_i + \beta_3 E_i + \sum_y \gamma_y \delta_y + \sum_o \theta_k O_{i,o} + \varepsilon_i \tag{4}$$

In the third specification, we have a two-way fixed-effect model controlling for both shipyard and owner fixed effects:

$$U_i = \beta_0 + \beta_1 G_i + \beta_2 D_i + \beta_3 E_i + \sum_y y_y \delta_y + \sum_o \gamma_o \delta_o + \varepsilon_i \tag{5}$$

As we want to isolate firm fixed effects, we also introduce a second set of specifications that include macroeconomic variables to control for time-varying effects. First, we control for firm sizes [Equation (6)], second, we introduce shipyard fixed effects [Equation (7)] and thirdly, we include both yard and owner fixed effects [Equation (8)]. We here introduce an interaction variable between delivery time and freight rates, with τ being the coefficient and F_i representing dummies for low, medium or high freight rate level. Additionally, our macroeconomic specifications include I_t representing the competitive market price for average ships, S_t representing the steel price, P_t is the oil price and G_t is the shipyard nations' GDP per capita:

$$U_i = \beta_0 + \beta_1 G_i + \beta_2 D_i + \beta_3 E_i + \beta_4 I_t + \beta_5 S_t + \beta_6 P_t + \beta_7 G_t + \sum_f \tau_k F_{i,f} + \sum_f \tau_k F_{i,f} \times D_i + \sum_y \theta_j Y_{i,y} + \sum_o \theta_j O_{i,o} + \varepsilon_i \quad (6)$$

$$U_i = \beta_0 + \beta_1 G_i + \ldots + \beta_7 G_t + \sum_f \tau_f F_{i,f} + \sum_f \tau_f F_{i,f} \times D_i + \sum_y \gamma_y \delta_y + \sum_o \theta_j O_{i,o} + \varepsilon_i \quad (7)$$

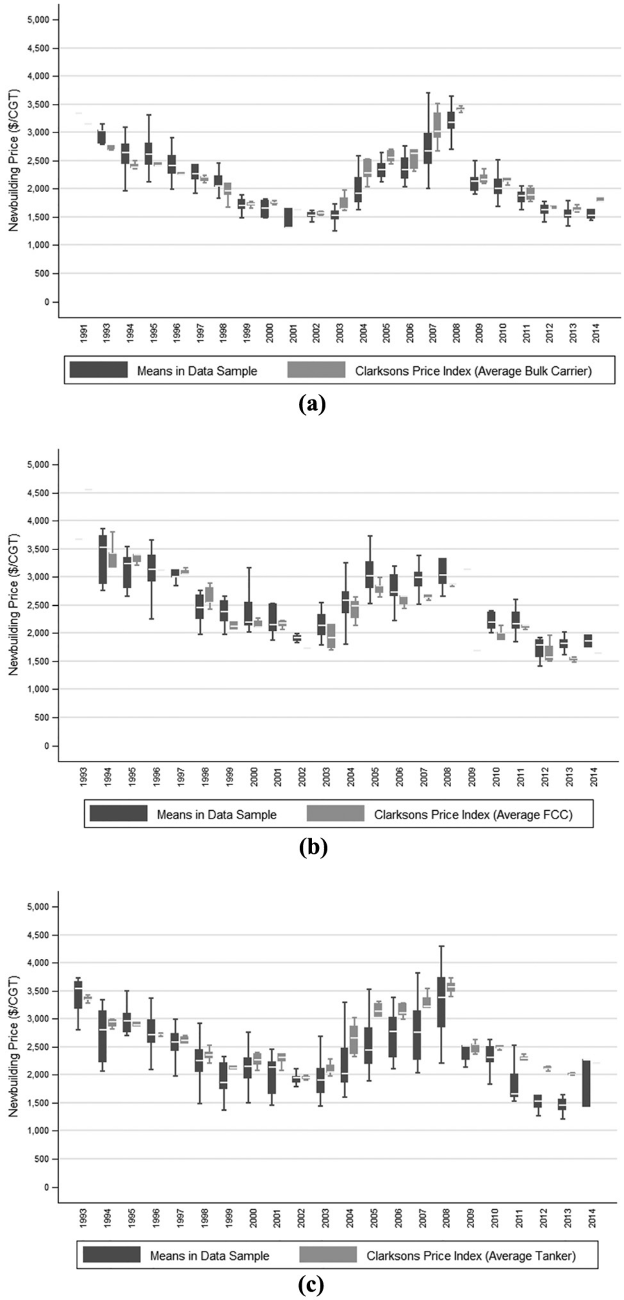
$$U_i = \beta_0 + \beta_1 G_i + \ldots + \beta_7 G_t + \sum_f \tau_f F_{i,f} + \sum_f \tau_f F_{i,f} \times D_i + \sum_y y_y \delta_y + \sum_o \gamma_o \delta_o + \varepsilon_i \quad (8)$$

We do not look at specific shipyard–owner relationships (match effects), as repeated transactions between a yard and an owner occur very rarely in our sample and is unlikely to cause distinct effects. All regressions are done with a clustered sandwich estimator[1] to correct standard errors in the presence of heteroscedasticity (Cameron and Miller, 2015).

4. Data

Our data sample contains newbuilding contracts extracted from Clarksons (2016a), covering vessels built in the period between 1970 and 2014 that are still trading. We note that while the database contains some newbuilding contract information on 91,112 vessels, only 7,604 observations included a usable contract price. The observations contain information regarding vessel name, contract parties, contract and delivery dates, carrying capacity [deadweight (DWT) and GT], CGT and vessel type. Information specific to the contract parties is also included, such as name, size of shipyard or shipowner and year of first delivery from the shipyard. These variables enable us to calculate delivery times, yard experience, contract price in US$ per CGT, in addition to creating firm size dummies. Contracts stated in currencies other than US$ are converted based on exchange rates at the time of contract signing. We inflate prices to 2014 values by using the US consumer price index (CPI). Although the USA is not a major player in either shipping or shipbuilding, its domestic inflation measure appears to be the most widely used to obtain real prices in similar studies (Jiang *et al.*, 2013; Akram, 2009; Lizardo and Mollick, 2010).

We remove observations with missing data for at least one of our variables. Furthermore, we remove all vessel types other than tankers, bulkers and container vessels (FCCs) – for two reasons. First, the remaining three vessel types all have a large number of observations. Second, they have relatively low standard deviation of US$/CGT values, reflecting a high degree of standardization. Also, specialized vessels, such as offshore service vessels, will show a greater variation in equipment levels. As CGT does not explicitly account for variations in technical specifications within a vessel category, our model will be less suitable in these cases. The final data set includes 3,759 observations for vessels built between 1990 and 2014, constructed for 835 different shipowners by 77 different shipyards located in 11 countries. We acknowledge that the low sample size relative to the true population may distort the outcome of our analysis, for instance, if certain types of contracts are more likely to have their value publicly known. Furthermore, the database only includes vessels in the current fleet, and one could imagine that vessels from certain (poor) yards are more inclined to be scrapped early. As an indication of whether our sample is representative, Figure 1 compares the US$/CGT annual average values observed in our data set to the price indices reported by Clarksons (2016b). The observation that the two move closely in tandem gives us confidence that our data sample provides a satisfactory representation of the shipbuilding



Source: Authors calculations, data from Clarksons WFR

Figure 1.
Yearly means of contract prices: Bulk, FCC and Tanker markets

market. The larger spread in values found in the data set is expected, simply because there is one observation per vessel – as opposed to one per month for the index.

Macroeconomic data were collected from several sources. Clarksons (2016b) provided newbuilding price indices and freight rates. Oil prices were extracted from the International Monetary Fund's (2016) commodity database, while steel prices were collected through the World Bank Commodity Database (2016a) supplemented with missing data points from Bloomberg (2016). Currency exchange rates and GDP per capita were obtained from the World Bank WDI database (2016b). All macroeconomic price variables were inflated in line with contract prices.

Presenting data for each individual shipowner and shipyard is impractical due to the large number of firms. Therefore, Table II presents yard experience and delivery times by country rather than by yard. This aggregation seems reasonable because individual yards within a nation are likely to have emerged in the same period and share other common traits (Stopford, 2009). Yard experience appears affected by established shipyards appearing frequently throughout our sample period, as there is one observation per newbuilding contract. Chinese shipyards exhibit the greatest spread in terms of experience, as expected due to the industry's relatively recent emergence in the country. We observe outliers in delivery times, as a ship rarely arrives as early as four months, or as late as 96 months, after contract signing. However, none of the values are implausible, and could be caused by the state of the shipping market and size of the orderbook (Adland and Jia, 2015; Adland *et al.*, 2006).

Table III reports owner and builder frequency for the ten largest players, with the remainder grouped as "other". Market concentration among the top ten shipbuilders varies across segments, from a 42.4 per cent market share for bulkers, to 79.8 per cent for tankers and 84.5 per cent for FCCs. This reflects the lower technological complexity of bulk vessels, and the generally larger size of tankers and FCCs – presumably favouring established shipbuilders of some size (Stopford, 2009). In terms of shipowner concentration, we find that the top ten owners represent just above 20 per cent for tankers and bulkers and 39.5 per cent of the market for FCCs. COSCO, Maersk and China Shipping are the most frequent owners in the data set as a whole, which seems reasonable, as they are among the world's largest ship operators across segments (Fan *et al.*, 2011).

Table IV presents the descriptive statistics for our macroeconomic variables. We note the impact of the shipping and commodity supercycle in the middle of the last decade, which has caused great volatility in our sample.

Country	Observation	No. of yards	Yard experience (years) Average	Min	Max	SD	Delivery times (months) Average	Min	Max	SD
China P.R.	1,319	37	13.2	−5	41	13.3	35.0	5.3	95.9	13.4
Croatia	50	2	43.0	36	49	4.0	35.0	19.2	53.8	7.8
Germany	20	1	34.6	32	38	1.8	17.9	11.5	30.1	4.4
Japan	332	12	29.8	19	45	6.1	25.7	7.9	81.9	9.4
Philippines	30	1	1.8	−2	5	2.4	28.1	15.7	40.0	6.6
Poland	56	3	31.7	28	40	2.9	28.6	8.0	63.3	10.9
Romania	21	1	8.0	6	10	1.3	39.1	24.4	52.0	8.1
South Korea	1,789	16	19.3	−3	43	11.1	29.8	3.7	70.8	10.2
Spain	14	1	29.3	19	33	4.5	26.3	18.3	43.2	6.9
Taiwan	100	2	25.1	17	36	5.8	29.5	15.6	88.7	14.3
Vietnam	28	1	0.3	−2	4	2.2	28.4	13.6	57.8	11.5
Grand Total	3,759	77	18.5	−5	49	12.9	31.2	3.7	95.9	11.9

Table II. Shipyard experience and delivery time (pr. shipyard nation)

Builder yard	Contracts	(%)	Cumulative	Owner (buyer)	Contracts	(%)	Cumulative
A. Bulk market (1,354 contracts)							
Jiangnan SY Group	75	5.54	5.54	COSCO Group	56	4.14	4.14
Sinopacific	71	5.24	10.78	China Shipping (H.K.)	54	3.99	8.12
Hyundai HI	66	4.87	15.66	Pan Ocean	29	2.14	10.27
STX SB	64	4.73	20.38	Eagle Bulk Shipping	27	1.99	12.26
Oshima SB Co	64	4.73	25.11	Genco Shipping and Trading	22	1.62	13.88
Shanghai Waigaoqiao	55	4.06	29.17	Grieg Star	20	1.48	15.36
CSC Jinling Shipyard	48	3.55	32.72	U.Ming Marine Transport	18	1.33	16.69
Hyundai Mipo	45	3.32	36.04	Sino Shipping Group	18	1.33	18.02
Hudong Zhonghua	43	3.18	39.22	Jinhui Shipping and Transportation	18	1.33	19.35
Sungdong SB	43	3.18	42.39	Dryships	17	1.26	20.61
Other	780	57.61	100.00	Other	1,075	79.39	100.00
Total	1,354	100.00			1,354	100.00	
B. FCC market (1,239 contracts)							
Hyundai HI	287	23.16	23.16	Maersk Company	91	7.34	7.34
Samsung HI	189	15.25	38.42	COSCO Group	60	4.84	12.19
Daewoo (DSME)	154	12.43	50.85	CSC Group	58	4.68	16.87
CSBC Group	74	5.97	56.82	MSC	47	3.79	20.66
Hanjin HI (Yeongdo)	70	5.65	62.47	OOCL	45	3.63	24.29
Dalian Shipbuilding	54	4.36	66.83	CMA.CGM	41	3.31	27.60
Jiangsu New YZJ	48	3.87	70.70	APL	41	3.31	30.91
Hyundai Mipo	41	3.31	74.01	Seaspan Corporation	40	3.23	34.14
Shanghai Shipyard	39	3.15	77.16	Rickmers Reederei	33	2.66	36.80
Jiangnan SY Group	33	2.66	79.82	Hapag.Lloyd Cont	33	2.66	39.47
Other	250	20.18	100.00	Other	750	60.53	100.00
Total	1,239	100.00			1,239	100.00	
C. Tanker market (1,166 contracts)							
Hyundai HI	197	16.90	16.90	China Shipping (H.K.)	49	4.20	4.20
Hyundai Mipo	154	13.21	30.10	Scorpio Group	45	3.86	8.06
Samsung HI	143	12.26	42.37	Teekay Tankers	38	3.26	11.32
Daewoo (DSME)	121	10.38	52.74	Bahri	31	2.66	13.98
Dalian Shipbuilding	108	9.26	62.01	Nat Iranian Tanker	25	2.14	16.12
STX SB	91	7.80	69.81	TORM A/S	24	2.06	18.18
Guangzhou SY Intl	72	6.17	75.99	AET Tanker	23	1.97	20.15
SPP Sacheon SY	38	3.26	79.25	Maersk Company	21	1.80	21.96
Shanghai Waigaoqiao	33	2.83	82.08	BW Maritime	21	1.80	23.76
Brodosplit	28	2.40	84.48	Minerva Ship Mngt	20	1.72	25.47
Other	181	15.52	100.00	Other	869	74.53	100.00
Total	1,166	100.00		Total	1,166	100.00	

Table III.
Top ten shipyards and owners in the data sample

5. Empirical results

5.1 Testing for multicollinearity

The Variance Inflation Factor (VIF) test is a common tool to examine the risk of multicollinearity. A VIF value of 10 is usually set as a warning level, above which determinants are said to carry risk of multicollinearity in regression estimates, though such a cut-off value is necessarily arbitrary (Wooldridge, 2013, p. 94). In Table V, the only

Macroeconomic determinants	*N*	Mean	SD	Minimum	Maximum
Oil price	3,759	62.7	32.3	15.1	145.7
Steel	3,759	620.7	172.6	263.2	1,099.6
Freight rates (US$/day)					
Bulk carrier	1,354	28,334.9	18,970.7	6,857.2	73,759.4
FCC	1,239	19,445.4	7,719.0	5,097.3	34,710.4
Tanker	1,166	33,605.5	16,009.2	6,909.3	99,832.9
Market prices (US$/CGT)					
Bulk carrier	1,354	2,452.7	577.3	1,522.4	3,513.3
FCC	1,239	2,472.0	501.7	1,482.0	4,552.2
Tanker	1,166	2,649.1	464.8	1,903.3	3,715.1

Table IV. Descriptive statistics of macroeconomic variables

Determinants	VIF
GT	1.580
Speed	1.480
Delivery time	3.160
Low freight rate	14.15
High freight rates	13.63
Delivery time × Low freight rates	12.62
Delivery time × High freight rates	15.03
Yard experience	1.280
Market price	3.300
Steel price	4.510
Oil price	2.600
GDP per capita	1.230
Yard size	
Large	1.120
Medium	1.190
Small	1.280
Very small	1.140
Unknown	1.370
Owner size	
Extra large	1.180
Very large	1.590
Large	1.990
Small	1.520
Very small	1.390
Unknown	1.060

Table V. Variance inflation factor (VIF) test of multicollinearity

variables displaying high VIF values are the interaction variables and freight rates. Freight rates appear both in the interaction variable and separately as control variables, resulting in four values surpassing the threshold value. However, it is generally accepted that high VIF values for variables constituting an interaction variable safely can be ignored (Allison, 2012). No other values even remotely close to 10 are observed and, thus, we conclude that the remainder of determinants show no risk of multicollinearity.

5.2 Microeconomic regressions

Table VI shows the regression results for our set of microeconomic specifications, grouped by bulk carriers, FCCs and tankers to isolate segment-specific effects. For firm sizes, we use mega yards and medium owners as base levels to test our hypotheses. Specifications without fixed effects are estimated using ordinary least squares (OLS). One should keep in mind when assessing results that these estimates do not account for time effects or current market conditions.

The basic OLS specifications with only firm- and contract-specific variables result in an R^2 of only 17-20 per cent across segments, but this increases to 34-42 per cent once we add shipyard fixed effects, and as much as 60-78 per cent once we add both shipyard and shipowner fixed effects. This indicates that time-invariant unobservable and observable characteristics of both yards and, especially, owners are important in determining contract prices. Heterogeneity across yards could, for instance, be related to specialization premiums, bargaining power or superior ship designs. For owners, it could reflect differing market timing ability, where some owners look at the newbuilding market as a source of asset play profits, while others take a more strategic long-term view of fleet renewal.

There is a positive and highly significant effect of *delivery time* across segments and specifications. While this is contrary to our expectations, this can here be explained by the fact that we do not account separately for the market cycle. Consequently, as delivery time and market prices are positively correlated (Adland *et al.*, 2006; Adland and Jia, 2015), what this variable picks up is simply the effect of higher newbuilding demand increasing prices and filling up the orderbook, thus lengthening delivery times. The impact of design *speed*, where significant, is positive as expected. The impact of vessel size (*GT*) is positive and highly significant for tankers, in accordance with our expectations, but negative for container vessels. This could well be an artefact related to the different impact of vessel size (GT) in the CGT calculations (ref. Table A1 in the Appendix) for the various vessel types.

We note that shipyards of all sizes obtain lower prices on a US$/CGT basis than the mega yards, though apart from this observation the trend with regards to yard size is not clear. This indicates the possible presence of a two-tier market where the behemoth yard groups in the Far East have a degree of pricing power. While an alternative explanation could be that these yards are capable of building vessels towards the more sophisticated end of the spectrum for each vessel type, and that such effects are not properly captured by our US$/CGT price measure, we would expect this to be picked up in part by our vessel size (GT) and speed variables.

Broadly speaking, shipyard experience has the predicted positive impact on prices in the tanker segment, negative for bulkers and mixed for FCC (depending on whether fixed yard effects are included). Keeping in mind that the market cycle is not accounted for in this set of specifications, and knowing that a lot of the new greenfield yards in China were set up to build basic bulkers during the 2003-2008 shipping boom, we suggest that this relationship is simply reflecting the combination of high bulker contracting prices and low/no experience of certain yards at the time. This explanation may also hold for parts of the FCC segment.

In Table VII, our second set of model specifications adds macroeconomic variables, including an interaction variable between freight rates and delivery time that is assessing the impact of high/low rate deviations. Discussions of the two variables separately are irrelevant, as they appear merely to avoid specification errors when we introduce the interaction variable.

The key difference when including benchmark newbuilding prices in the regression is that even the basic OLS specification, with firm size effects only, has a relatively high explanatory power ranging from 55 per cent for tankers to 74 per cent for bulkers. Adding

Table VI. Microeconomic regression results

Regression #	1	2	3	4	5
Group	Bulk	Bulk	Bulk	FCC	FCC
Dependent variables	US$/CGT	US$/CGT	US$/CGT	US$/CGT	US$/CGT
Constant	354.7 (438.1)	1,357*** (423.0)	1,669*** (563.2)	1,296*** (184.4)	1,574*** (193.7)
GT	0.000143 (0.000483)	0.000120 (0.000611)	0.00178* (0.00102)	−0.00364*** (0.000317)	−0.00345*** (0.000365)
Speed	107.4*** (31.10)	35.88 (29.11)	−2.160 (38.92)	40.99*** (7.742)	17.57** (7.706)
Delivery time	16.29*** (1.242)	14.66*** (1.343)	8.910*** (2.021)	15.16*** (1.101)	19.61*** (1.128)
Experience	−1.076 (1.189)	−13.18*** (2.858)	−7.598* (4.567)	3.180*** (1.200)	−6.689*** (2.494)
L-Yard	−93.64** (37.00)			−132.1** (61.25)	
M-Yard	−91.69** (42.98)			−135.7*** (49.45)	
S-Yard	−82.43 (59.56)			−137.5** (65.42)	
VS-Yard	53.06 (116.7)			−656.3*** (94.42)	
XL-Owner	80.20 (115.9)	7.060 (116.4)		176.8*** (50.13)	177.8*** (44.65)
VL-Owner	112.6** (43.67)	67.41 (44.22)		85.43** (42.37)	124.7*** (37.06)
L-Owner	−36.38 (39.68)	−40.52 (40.76)		86.99* (48.79)	125.3*** (44.96)
S-Owner	−130.9*** (46.26)	−140.9*** (48.12)		131.2* (69.60)	135.8** (67.81)
VS-Owner	93.26** (46.07)	20.25 (47.66)		184.6* (94.39)	99.81 (76.34)
Yard FE	NO	YES	YES	NO	YES
Owner FE	NO	NO	YES	NO	NO
Observations	1,354	1,354	1,354	1,239	1,239
R-squared	0.179	0.339	0.779	0.171	0.418

(*continued*)

Notes: Robust standard errors in parentheses; *statistically significant at a 10% level; **statistically significant at a 5% level; ***statistically significant at a 1% level; XL = extra large, VL = very large, L = large, M = medium, S = small, VS = very small

Regression #	6	7	8	9
Group	FCC	Tanker	Tanker	Tanker
Dependent variables	US$/CGT	US$/CGT	US$/CGT	US$/CGT
Constant	1,755*** (339.9)	1,545*** (266.5)	877.1*** (316.2)	560.0 (419.8)
GT	−0.00304*** (0.000429)	0.00430*** (0.000399)	0.00292*** (0.000541)	0.00205*** (0.000681)
Speed	25.64** (9.977)	7.575 (17.78)	3.916 (19.59)	31.15 (30.42)
Delivery time	18.10*** (1.159)	10.67*** (1.531)	16.12*** (1.772)	12.24*** (2.945)
Experience	−2.515 (2.773)	5.148*** (1.224)	8.114*** (2.163)	6.725** (3.295)
L-Yard		−58.90 (65.66)		
M-Yard		−51.20 (49.69)		
S-Yard		−262.4*** (76.53)		
VS-Yard		−113.9 (112.2)		
XL-Owner		150.5* (79.50)	170.8** (79.26)	
VL-Owner		−20.29 (46.84)	−26.54 (46.98)	
L-Owner		77.70 (47.97)	66.53 (45.24)	
S-Owner		103.6** (49.22)	168.3*** (49.44)	
VS-Owner		108.3* (61.52)	137.9** (61.77)	
Yard FE	YES	NO	YES	YES
Owner FE	YES	NO	NO	YES
Observations	1,239	1,166	1,166	1,166
R-squared	0.597	0.202	0.407	0.721

Table VI.

Table VII. Macroeconomic regression results

Regression #	1	2	3	4	5
Group	Bulk	Bulk	Bulk	FCC	FCC
Dependent variables	US$/CGT	US$/CGT	US$/CGT	US$/CGT	US$/CGT
Constant	−1,671*** (325.5)	−921.2*** (335.9)	152.0 (328.5)	−13.09 (153.8)	−361.3** (163.9)
GT	−0.000275 (0.000290)	−0.000653* (0.000365)	−0.000249 (0.000477)	−0.000616*** (0.000227)	−0.00104*** (0.000263)
Speed	97.61*** (23.09)	52.07** (23.09)	−5.723 (20.21)	22.81*** (4.892)	20.01*** (6.175)
Delivery time	−0.452 (1.233)	1.043 (1.352)	−0.404 (2.144)	3.771*** (0.990)	4.922*** (1.043)
L-Rates	−84.42 (86.94)	−56.51 (82.26)	52.43 (103.7)	−166.0** (73.92)	−217.2*** (80.42)
H-Rates	−32.59 (70.72)	16.96 (73.50)	−25.92 (92.87)	−107.5 (83.32)	−123.6 (83.02)
L-Rates*Delivery time	7.781** (3.254)	4.863* (2.931)	0.461 (3.254)	0.628 (2.391)	3.326 (2.650)
H-Rates*Delivery time	−3.061* (1.680)	−4.396** (1.739)	−3.195 (2.460)	3.658* (1.944)	3.776* (2.002)
Experience	4.246*** (0.672)	−0.110 (1.456)	−1.365 (1.751)	1.069 (0.824)	3.376** (1.583)
Index	0.969*** (0.0336)	0.930*** (0.0341)	0.971*** (0.0511)	0.668*** (0.0419)	0.668*** (0.0402)
Steel price	0.390*** (0.101)	0.264** (0.106)	−0.0786 (0.187)	0.392** (0.155)	0.220 (0.164)
Oil price	−1.097** (0.476)	−0.799 (0.582)	0.678 (0.968)	−0.403 (0.845)	−0.743 (0.915)
GDP/capita	0.00305*** (0.000573)	0.00839*** (0.00176)	0.0106*** (0.00250)	0.00760*** (0.000929)	0.0176*** (0.00285)
L-Yard	−38.24* (20.06)			−89.89*** (31.63)	
M-Yard	−6.475 (26.61)			−52.42* (31.56)	
S-Yard	12.75 (36.70)			−71.32* (41.25)	
VS-Yard	−90.80** (38.13)			−303.6*** (68.63)	
XL-Owner	−30.64 (62.55)	−8.469 (62.83)		82.11*** (26.84)	113.4*** (26.79)
VL-Owner	29.70 (22.53)	34.38 (21.76)		56.12** (24.32)	61.34** (23.98)
L-Owner	25.93 (21.88)	34.85* (20.39)		55.96* (30.34)	100.3*** (32.25)
S-Owner	−7.228 (23.47)	8.805 (24.27)		64.84* (33.61)	111.4*** (33.21)
VS-Owner	53.01** (26.52)	39.48 (28.60)		−35.30 (69.39)	−56.77 (60.78)
Yard FE	NO	YES	YES	NO	YES
Owner FE	NO	NO	YES	NO	NO
Observations	1,354	1,354	1,354	1,239	1,239
R-squared	0.739	0.795	0.946	0.715	0.754

(*continued*)

Notes: Robust standard errors in parentheses; *statistically significant at a 10 per cent level; **statistically significant at a 5 per cent level; ***statistically significant at a 1 per cent level; XL = extra large, VL = very large, L = large, M = medium, S = small, VS = very small

Table VII.

Regression #	6	7	8	9
Group	FCC	Tanker	Tanker	Tanker
Dependent variables	US$/CGT	US$/CGT	US$/CGT	US$/CGT
Constant	−365.9 (249.2)	−412.9* (228.6)	−11.86 (242.8)	−170.5 (325.8)
GT	−0.000995*** (0.000296)	0.00347*** (0.000271)	0.00177*** (0.000314)	0.00144*** (0.000431)
Speed	29.34*** (8.218)	33.51** (13.63)	9.051 (13.85)	9.820 (22.19)
Delivery time	4.940*** (1.146)	−4.639** (2.167)	−3.058* (1.814)	−5.973*** (2.187)
L-Rates	−309.1*** (90.55)	−154.7* (92.01)	−157.2* (86.77)	−262.8*** (100.4)
H-Rates	−73.43 (86.53)	−486.3*** (86.08)	−396.3*** (81.44)	−402.9*** (112.3)
L-Rates*Delivery time	7.804** (3.171)	3.118 (3.029)	2.434 (3.101)	9.307*** (3.535)
H-Rates*Delivery time	3.065 (2.073)	10.66*** (2.609)	8.085*** (2.442)	10.39*** (3.553)
Experience	0.965 (1.689)	9.016*** (0.986)	1.598 (1.290)	2.403 (1.931)
Index	0.662*** (0.0460)	0.805*** (0.0450)	0.735*** (0.0458)	0.825*** (0.0657)
Steel price	0.263 (0.193)	0.357** (0.149)	0.0182 (0.135)	−0.00750 (0.202)
Oil price	−0.230 (1.056)	−4.719*** (0.812)	−1.422* (0.787)	−0.943 (1.228)
GDP/capita	0.0159*** (0.00354)	0.00231** (0.000959)	0.0290*** (0.00398)	0.0203*** (0.00614)
L-Yard		11.87 (45.59)		
M-Yard		−44.02 (36.68)		
S-Yard		−193.2*** (72.62)		
VS-Yard		46.02 (69.27)		
XL-Owner		79.86 (53.23)	27.53 (54.15)	
VL-Owner		−51.71 (34.85)	−53.59 (34.53)	
L-Owner		64.42* (36.77)	52.01 (32.90)	
S-Owner		−25.75 (38.44)	12.40 (36.95)	
VS-Owner		−42.83 (50.85)	−41.80 (45.50)	
Yard FE	YES	NO	YES	YES
Owner FE	YES	NO	NO	YES
Observations	1,239	1,166	1,166	1,166
R-squared	0.825	0.554	0.703	0.876

yard fixed effects increases the R^2 to the 70-80 per cent range, increasing further to 82-95 per cent for both yard and owner fixed effects. Again, therefore, fixed yard and owner effects play a considerable role in the price formation for individual newbuilding contracts. Moreover, owner heterogeneity remains more important than yard heterogeneity in the explanation of contract price variation.

As expected, both the price benchmark and GDP/capita (as a proxy for wages) show a positive and highly significant relationship with the US$/CGT pricing across specifications and market segments. The coefficients for steel prices, where significant, are also positive as expected. The statistically significant estimates for yard experience are now positive across segments, which supports our earlier explanation that the observed negative values for the microeconomic specifications were caused primarily by a failure to account for the addition of new yard capacity at high price levels. The impact of delivery time is now negative for tankers, as predicted by theory, though still positive for container vessels. We can only speculate that in a market with oligopolistic competition such as the container market, there may be a strategic value of occupying newbuilding slots further out in time in strong markets to prevent competitors from gaining market share.

Where significant, all yard sizes display negative price deviations when compared to mega yards, confirming the earlier findings. However, there are no other clear trends in contracting prices with regards to neither yard size nor owner size. The remainder of our variables either show similar behaviour as in the microeconomic regression (speed and GT) or show mixed results with regards to signs across specifications, making any conclusions difficult.

6. Concluding remarks

In this paper we have proposed and estimated a new model for price formation in the newbuilding market where shipowner and shipyard heterogeneity is accounted for. Using data on individual contracts in the tanker, bulker and container segments, our empirical methodology relies on the estimation of fixed-effect models. Although the newbuilding price benchmarks (market conditions) and GDP/capita (salary costs) are influential covariates, our main conclusion is that shipyards and, particularly, shipowners play an influential role on the US$/CGT price level in individual contracts. Additionally, steel prices and yard experience have a positive impact on prices. Delivery times have the expected negative impact on prices for tankers, but positive for container vessels, which we suggest relate to the possible strategic value of newbuilding slots in an oligopolistic market.

From a practical point of view, our proposed model and methodology can in principle be used to benchmark the performance of individual yards and owners in negotiations for newbuilding contracts. Similarly, knowledge about the effect of yard identity, size and experience on contracting prices can assist shipowners in the selection of which yards to approach.

We acknowledge that the lack of observable contract prices for such a large share of the trading world fleet means we are analysing only a relatively small sample and cannot be sure of unbiasedness. Another limitation of our study is that our empirical framework is dedicated to the measurement of time-invariant owner and yard effects rather than to their explanation. There are also limitations in our data that are difficult to rectify, for instance, the fact that only relatively few contracts per year have a known value.

While shipbuilding productivity almost certainly has increased over the course of our sample, we note that the impact on prices of such macro effects is embedded in our market price index, which reflects the US$/CGT price of a standard vessel built at a “first class” yard at the time. As such, this variable incorporates both an element of technological change and the "size creep" that we can observe in the fleet.

Future research should focus on developing the ideas presented here further, particularly in identifying variables that can shed further light on the sources of price variation due to yard and owner heterogeneity.

Note

1. Huber-White Sandwich estimator in STATA.

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Further reading

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Appendix

Ship type	A	B
Oil tankers	48	0.57
Chemical tankers	84	0.55
Bulk carriers	29	0.61
Combined carriers	33	0.62
General cargo ships	27	0.64
Reefers	27	0.68
Full container carrier	19	0.68
RoRo vessels	32	0.63
Car carriers	15	0.70
LPG carriers	62	0.57
LNG carriers	32	0.68
Ferries	20	0.71
Passenger ships	49	0.67
Fishing vessels	24	0.71
NCCV	46	0.62

Source: OECD (2007)

Table A1. CGT coefficients by vessel type