Price Formation of Dry Bulk Carriers in the Chinese Shipbuilding Industry

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Abstract

In this paper we present, for the first time, the price formation of China's dry bulk carrier using vessel prices quoted by major Chinese shipyards in actual shipbuilding orders. This allows us to investigate the relationship of price and determinants in the Chinese shipbuilding industry by including generic market factors as well as Chinese elements. The analysis, employing Principal Component Regression (PCR) approach, indicates that the time charter rate has the most significantly positive impact. While increases in other four factors, namely shipbuilding cost, price cost margin, shipbuilding capacity utilization and credit rate, have descending order of positive influences. Different from traditional perception, we assert that the most important role of time charter rate plays mainly attributes to the 'China Factor' in bulk carrier sector. In addition, simulations are performed to investigate what would happen to the Chinese dry bulk carrier prices under changes of time charter rate and shipbuilding cost. This paper has implications for the Chinese shipyards, shipbuilding industry customers and industry policy makers.

Keywords: Price Formation, Dry Bulk Carrier, Chinese Shipbuilding Industry

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1. Introduction

Shipbuilding is an important cog in the shipping industry and provides the supply of marine transportation system. It is a market that major yards compete internationally for orders at their quoted prices. Shipbuilding price plays an important role for shipyards in winning orders and for ship owners in making investment decisions. The price is very much related to the world economy and other shipping sectors. When there is a strong economy and high demand for the world's seaborne trade, freight rates will firstly be driven up by the limited transport capacity. This stimulates ship owners' desire for expanding current fleet and gaining substantial profit. It usually takes years to deliver the ship after placing an order (Stopford 2009). For this reason, whether ship owners are prepared to take ship building contracts and at which price levels they are willing to pay depend on their expectations of the future shipping market. If a long term of thriving market is expected, investors are more likely to place an order. This is because the availability of shipyard berths may be scarce and shipbuilding prices may be even higher in the future if the market keeps going up. With market confidence growing and orderbook rising, shipbuilding prices will be pushed up and shipyards would expand their capacity to meet the berth shortage. But when the market turns down, ship owners will with more discretion and conservative mood face the market. Struggling with faltering demand, shipyards will lie in a weak position. On the one hand, it is usually quite slow and difficult for shipyards to reduce the capacity which was expanded in the time of prosperity or by the government subsidies. On the other hand, the overcapacity will lead to lower shipbuilding prices and acute competition. In addition to these generic factors driving shipbuilding prices up and down, there are several country, yard and ship specific factors that will influence the actual price of a new ship. These mainly include the national industrial policy, production capacity, shipyard cost of production, currency fluctuation, ship design and payment options. In essence, there is no single driving force behind the determination of shipbuilding price and above factors are having effect integrated.

As world's shipbuilding center shifts from high cost capacity in Western Europe to low cost shipbuilders in East Asia, China has taken a giant leap in the shipbuilding industry and developed into a world shipbuilding base of dry bulk carrier during the past years. There are several reasons for this great achievement. First, the industry experiences considerable expansion in parallel with China's accelerated economic growth and rising demand for the seaborne trade of dry bulk. China adopted a policy of building up the domestic fleet to meet the local growing demands of international trade, and this greatly increased the domestic output of dry bulk carriers (OECD 2008). Second, the production focus of top shipbuilders in Japan and South Korea are gradually moved from dry bulk carrier to high value-added vessel types. This provides the opportunity for the Chinese shipyards to face less competition and to develop progressively in the dry bulk carrier sector. Third, the low labour cost plays a fundamental role for the Chinese shipbuilders to compete in the dry bulk carrier sector which contains relatively low-technical content and competitive focus is the price.

Understanding the tanker prices, therefore, is important to the Chinese shipyards and industry policy makers, and it also has the implication for the Chinese shipyards moving into more advanced shipbuilding segments. Especially in recent years, the industry is confronting with new situations which may challenge China's price competitiveness. We see continuous increasing of raw material costs, labour costs and steel prices. High level of governmental investment has unfortunately led to excess shipbuilding capacity. The RMB appreciation against US dollar has also caught great attention within Chinese shipbuilding community. Which factors actually determine the Chinese dry bulk carrier prices? How would dry bulk carrier price in China react to the new circumstances? How would Beijing promote the dry bulk carrier sector by introducing new policy? Academic investigation is required to build a comprehensive view of the Chinese dry bulk carrier price and to answer above questions.

Extensive research has investigated the dynamic behavior of world shipbuilding prices. Traditional approaches for price modeling are mainly based on supply and demand equilibrium model (see Koopmans 1939; Hawdon 1978; Jin 1993; Haralambides 2005, among others). More recent studies apply portfolio theory proposed first by Beenstock (1998a,b; 1992; 1993) and he develop this idea further in following papers. By contrast, limited scholarly attention has been paid to the formation of Chinese shipbuilding price. This is due partly to the short development period of shipbuilding industry in China compared to traditional shipbuilding powers. Furthermore, the data of Chinese prices is not as detailed as world prices, since most of the shipping consultants only elaborate on the world shipbuilding prices. There is no systematic research on the Chinese shipbuilding prices across different vessel types. Also the existing evidence does not appear to bear out the impact of low costs and governmental support on Chinese shipbuilding prices. To fill the gap in the current literature, we select top 200 Chinese shipyards according to the rank of shipbuilding capacity in Compensated Gross Tonnage (CGT). Then actual shipbuilding orders from these shipyards are collected since the development of modern Chinese shipbuilding industry in 1995. Historical orders without the contract prices are excluded from the dataset and the remaining is classified according to vessel types. This unique data set is used to make the first economic analysis of Chinese shipbuilding prices in different vessel types.

The paper contributes to the literature in a number of ways. First, this article enriches the growing but still the small amount of research on the Chinese shipbuilding industry especially on the Chinese ship price. Instead of using the time series of world shipbuilding prices, this paper, to the best of our knowledge, is the first academic work based on vessel price quoted by major Chinese shipyards in actual shipbuilding orders. Second, the price formation model in this paper can account for generic market factors as well as the Chinese shipbuilding characteristics, for instance, Chinese shipbuilding cost and governmental financial support. The overall effect of cost is established through the construction of a Chinese shipbuilding cost index. The use of comprehensive cost index is superior to the use of single cost proxy as it puts into better perspective the Chinese shipbuilding industry's cost. A competition indicator is also constructed to measure the competition extent that Chinese shipyard faced in the world dry bulk carrier market. In doing so, this model enables us not only to reveal the most important determinants of the Chinese dry bulk carrier price, but also draw a dynamic picture of the price movement under world and national factor changes. In addition, we provide a Principal Component Regression (PCR) approach which is new to maritime economics field and it is proved to be an effective way especially in solving the problem of multicollinearity. Finally, the findings of this paper have implications for Chinese shipyards, shipbuilding industry customers and Chinese policy makers, and may also shed some light on the emerging shipbuilding nations who start development from dry bulk carrier sector.

The remaining sections are organized as follows: Section 2 reviews the extant literature on shipbuilding prices; Section 3 explains the econometric model and price determinants; Section 4 describes the data; The Principal Component Regression model is introduced in Section 5; Section 6 analyzes the result and discusses scenarios based on price model; finally, Section 7 addresses the conclusion.

2. Literature Review

The topic of shipbuilding price has received considerable attention in maritime field. The earlier studies can be classified into two groups. One influential group is supply and demand theory and Koopmans (1939) is among the earliest researchers who employ the theory to model the shipbuilding market. Koopmans argues that the time lag between the demand for shipping capacity and actual availability of this capacity triggers expectation of the future market. Then Hawdon (1978) uses current and lagged freight rate to represent different market conditions during the time lag. Besides, he also takes labour costs, costs of steel, and ship size into consideration. Hawdon finds that current freight rate has a significant coefficient, while lagged freight rate is insignificant. Jin (1993) enriches the literature by not only utilizing previous theory but also integrating it with cost-base approach. More specifically, he models the relationship of tanker market factors regarding endogenous and exogenous variables, such as shipbuilding cost, shipyard capacity and technology changes. Major factors affecting the tanker new building market are identified, but his way of using average number of employees in the Japanese shipbuilding industry as a proxy for shipbuilding capacity is under controversy, not to mention his small number of observations. One of most recent researches on shipbuilding prices is from Haralambides (2005) which utilizes new econometric method of SEM (Structural Equation Model) and both short and long term impacts of variables are included in the price model.

The second group of research presents a very different point of view. Beenstock (1985) argues that the supply and demand theory is not appropriate for analyzing the ship price, because a ship has a considerable longevity. He adopts the asset pricing approach and Rational Expectation Hypothesis (REH) into maritime field as the starting point of his research. In the following cooperation with Vergottis (1989a; 1989b; 1992; 1993), Beenstock contributes several papers focusing on modeling shipping market by using asset pricing method. He argues that new building and secondhand ships are perfect substitute only differing in age, therefore prices of new ships adjust to the expected prices of secondhand ships overtime. It should be noted that Beenstock's argument has been debated by the following research. Haralambides (2005) explains that secondhand prices are volatile whereas new prices are relatively sticky and two prices are not perfectly correlated. In Adland (2007) the newbuilding order is a forward contract for the delivery of an age zero vessel in the future and not the value of a vessel *per se*. For this reason, we adopt the classical supply and demand theory for analyzing the price formation of the Chinese dry bulk carrier.

There are several recent studies on the Chinese shipbuilding industry due to its dramatic growth. Most of extant literatures about the Chinese shipbuilding have mainly focused on product technology (Bai et al. 2007), shipbuilding management (Lu et al. 2000), labour cost (Chou 2001), industrial policy (Song 1990) and restructuring (Smyth 2004). Using the actual prices from Chinese shipyards, this paper makes the first attempt to analyze the price formation of dry bulk carrier in the Chinese shipbuilding industry based on a traditional supply and demand view.

3. The Econometric Model and Price Determinants

Prices are determined by the interaction of supply and demand in the market. In this section, we assume dry bulk carrier prices and observed quantity represent equilibrium by the interaction of supply and demand in dry bulk carrier market.

3.1. The econometric model

The dry bulk carrier supply Q_t^s is a function of price P_t , exogenous supply side shifter W_t and error term ε_t

$$Q_t^s = g(P_t, W_t, \varepsilon_t)$$

W_t includes three variables indicating changes in supply curve, which are shipbuilding capacity utilization ($CAPA$), shipbuilding cost index (C) and ship export credit rate ($CRATE$). The dry bulk carrier demand Q_t^d is a function of price P_t , exogenous demand side shifters Z_t and error term v_t

$$Q_t^d = h(P_t, Z_t, v_t)$$

Z_t includes two variables indicating movements in demand curve, which are time charter rate (TRATE) and price-cost margin (PCM). It is assumed that supply and demand of new tankers operate simultaneously to determine ship prices. A reduced form of price in equilibrium $Q_t^s = Q_t^d$ will relate price to determinants that influence both supply and demand

$$P_t = f(CAPA_t, C_t, CRATE_t, TRATE_t, PCM_t, e_t)$$

3.2. The Price determinants

Shipbuilding capacity utilization (CAPA)

Shipbuilding capacity is largely constrained by physical facilities. But under the same condition, the output may also be different when yards produce at different productivity levels and product mixes (Strandenes 1990). The reason is the shipbuilding capacity utilization varies rather than the shipbuilding capacity goes up and down. A low level of utilization rate means yards run at less than full capacity and hence shipbuilders have a weak pricing power. Conversely shipyards operate at almost full capacity and shipowners may have to pay higher prices for the limited berth. Utilization of the shipbuilding capacity is measured by deliveries relative to total capacity (Strandenes 1990). In this paper, the capacity utilization of the Chinese shipbuilding is calculated by the Chinese annual delivery relative to China's total shipbuilding capacity.

Shipbuilding cost index (C)

In terms of the traditional production theory, the producer will produce a positive amount as long as the price is at least equal to the average variable cost. If the prices are lower than that, then the producer will not produce at all (Wijnolst et al.1997). The main variable costs for building ships contain labour cost, steel cost and cost of equipment (including main engine). These three components account for 90% of total variable costs and it is within these components that the biggest difference will be found (Wijnolst et al.1997). A simple form of cost index for the Chinese shipbuilding can be expressed as follow,

$$C = ERATE*(W_1*ULC + W_2*S) + W_3*E$$

Where ULC is the unit labour cost index, S is the steel cost index, E is the cost index of equipment, $ERATE$ is the RMB exchange rate against US dollar, and W_i $(\sum W_i = 1, i = 1,2,3)$ is the weight of respective cost. Most of labour and steel costs occur in the Chinese currency, while shipbuilding equipment has a high import content counted in US dollar. Therefore, we use $ERATE$ to convert the domestic labour and steel prices into US dollar instead. The data availability prevented us from constructing cost for individual shipyard, and instead an integrated national level of Chinese shipbuilding cost is used. Among the cost components, variations of labour cost between shipbuilders will bring on a great difference in shipbuilding cost. It is mainly due to other components are available as products in the world market and technology in dry bulk carrier market is fairly equal (Wijnolst et al.1997). The main strength of the Chinese shipyards is the significantly low wage which provides the price advantage comparing to other shipbuilders. But the advantage of cheaper Chinese labour is partly offset by the low productivity compared to industry leaders such as Japan and South Korea (Lu 2005). For this reason, labour cost needs to be adjusted for productivity and the unit labour cost index (ULC) which measures the labour cost per unit of output is as follow,

$$ULC = \frac{Wage}{V / No.}$$

Where $Wage$ is the average annual industrial wage, V is the annual industry added value and $No.$ is the industrial average number of employee per year. Unlike the domestic supplied labour and steel, the majority of Chinese shipbuilding equipment is imported. The cost index of equipment can be written as,

$$E = \frac{I}{r * D}$$

Where I is China's annual import amount of shipbuilding equipment, r the loading rate of import equipment, and D the annual delivery of Chinese shipbuilding industry.

Ship export credit rate (CRATE)

Export credit for ships is a major government support and provides Chinese shipyards with financing channels for newbuilding. It can take the form of interest rate support where the government provides a preferential rate for the life of credit. Clearly the availability of credit rate support will suppress the Chinese price.

Time charter rate (TRATE)

The way time charter rate makes impact on the dry bulk carrier price is quite straight forward. The shipbuilding orders are determined by ship owner's expectation of future earnings from new vessels. The higher the freight rate is, the more profitable for ship owners to operate the vessels, and the more ship owners are willing to place orders. It is customary to assume that time charter rate contains more information of future market comparing to the spot freight rate.

Price-cost margin (PCM)

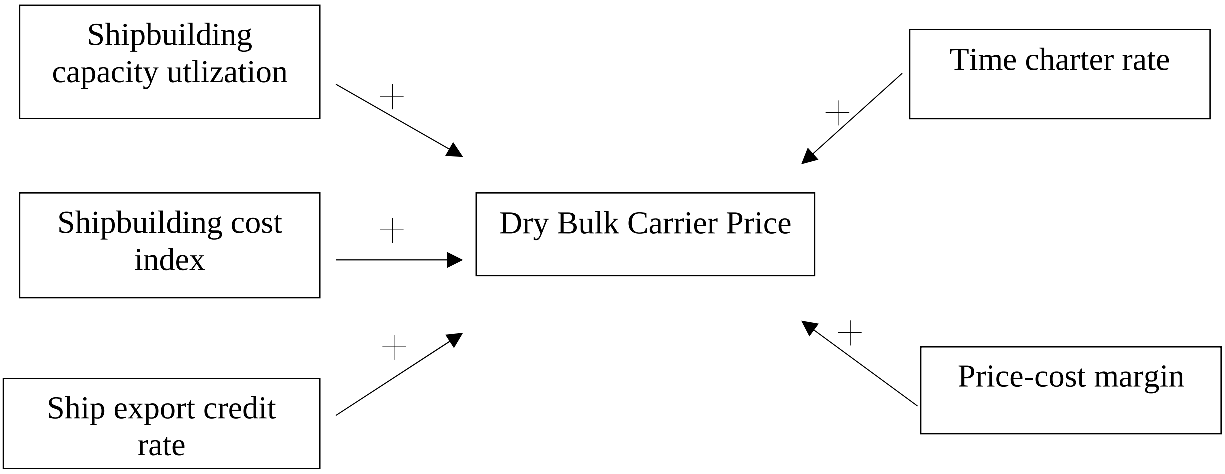
Price-cost margin refers to the shipyard's ability to set its price above its marginal cost and it is the indicator of competition degree in the market. The measure of price-cost margin (PCM) is defined as,

$$PCM = \frac{(p_i - c_i)}{p_i} * s_i$$

Where p_i and c_i represent average price index and marginal cost index of the Chinese dry bulk carrier respectively. s_i denotes the Chinese market share of dry bulk carrier in terms of new orders. In practice, the marginal cost is represented by the average variable cost and therefore cost index C will be adopted. The fiercer competition is reflected by the lower price-cost margin due to lower prices or smaller market share (Creusen 2006). If there is a low level of demand in dry bulk carrier market, then the strong competition with major shipbuilding nations may force Chinese yards to reduce prices until marginal costs.

In summary, hypotheses about the price determinants are presented below and five factors are assumed positively related to the price of Chinese dry bulk carrier.

Figure 1. Hypotheses of price determinants



4. Data

4.1. Data Collection

In this study, the Chinese dry bulk carrier prices are analyzed by referring to the Capesize (over 100,000 dwt), Panamax (60,000-100,000 dwt), Handymax (40,000-60,000 dwt), and Handysize (10,000-40,000 dwt) types. The sample period is from January 1995 to December 2009.

Prices of dry bulk carrier are collected from the Clarkson Shipping Intelligence Network (Clarkson SIN) for top 200 Chinese shipyards, which account for 98.63% of national total Compensated Gross Tonnage (CGT). Prices are reported for all new orders at contract time in million US dollar. Independent variables use the data in corresponding contract months. There are only few dry bulk carrier contracts in late 1990s, several between 2000 and 2005, and numerous between 2006 and 2009. Besides, small vessels started to be built much earlier than large ones due to gradual technology development. For the sake of effective analysis, we pool the data of all four types and distinguish the size effect by dummy variables. Other shipping and shipbuilding data are also collected from Clarkson SIN. Time charter rate is the monthly average rate (thousand $/day) for corresponding vessel type. Utilization of the shipbuilding capacity is measured by annual delivery of China (CGT) relative to yearly Chinese shipbuilding capacity. Shipbuilding capacity is calculated as the maximum annual output (CGT) in China since 1991 (according to the definition from Clarkson).

The data of average annual industrial wage (RMB / person per year), annual industry added value (RMB / year) and number of employee are especially for the Chinese manufacturing of transport equipment industry. These data are collected from yearbooks of the Chinese National Bureau of Statistics and Chinese Ministry of Labour and Social Security. Monthly price (RMB/ ton) of medium and heavy steel plate in China is collected from the MYSTEEL database. The annual import amount of shipbuilding equipment (US dollar) is collected from China Customs. Monthly exchange rate of RMB against US dollar and ship export credit rate are collected from the People's Bank of China. In this study we assume labour, steel and equipment respectively account for 10%, 38% and 52% of average variable cost according to previous studies (Wijnolst et al.1997). These are rough data of the cost structure since they are heavily depend on ship type, ship size and more detailed design particulars, related to onboard trans-shipment facilities, cargo facilities an speed of the ship(Hopman and Nienhuis 2009).

Three dummy variables are used to control for four types. D_1 equals to 1 if Capesize, D_2 equals to 1 if Panamax, D_3 equals to 1 if Handymax and others is Handysize. Prices and costs in RMB are deflated by the Chinese CPI (1995=100) and those in US dollar are deflated by the US CPI (1995=100).

There are 851 observations for each variable, but there is a limitation of our sample. 72% of the data concentrate on year 2006-2008 during which the market is clearly in a boom state. In contrast, only 16% of the data was in start decade and about 11% of sample stands for the recent period of post financial crisis 2008. This unbalanced data structure will limit the explanation power of our model, which will be improved in the future study.

According to the correlation matrix of variables, three of 10 coefficients are larger than 0.6 and one of them is larger than 0.9. This is consistent with the reality that many parameters in shipping sector are interdependent. The test results of VIF (larger than 10) and Tolerance values (close to 0) in multiple linear regression also suggest there is a multicollinearity problem. The Principal Component Regression approach will be used as an alternative way to model the price formation of dry bulk carrier.

5. Methodology

5.1. Principal Component Analysis

When highly correlated predictors are used in a multiple linear regression, the model can face a serious multicollinearity problem. This high correlation or multicollinearity can be even serious when the goal is to understand how the various independent variables impact dependent variable. When high multicollinearity is present, confidence intervals for coefficients tend to be very wide and t-statistics tend to be very small. This can become the cause of incorrect rejection of variables and inaccuracies in computing the estimates of model coefficients (Jennrich 1995).

One method of removing such multicollinearity in regression is to use Principal Component Regression (PCR) approach (Jolliffe 2002). PCR actually is the combination of Principal Component Analysis (PCA) and multiple linear regression techniques. The central idea of PCA is to transform a number of possibly correlated variables into a smaller number of uncorrelated principal components. Small amount of components can be extracted and contain the most of the information of original data (Jolliffe 2002). The component C_i is given by

$$C_i = \alpha_{i1} * Z(X_1) + \alpha_{i2} * Z(X_2) + \cdots + \alpha_{ik} * Z(X_k)(i = 1, \ldots k) \tag{1}$$

Where C_i stands for the i^{th} principal component, $Z(X_k)$ stands for the k^{th} standardized independent variable, α_{ik} stands for the component score coefficient of k^{th} standardized independent variable on i^{th} principal component.

5.2. Principal Component Regression

By using PCA, the extracted components become ideal to use as predictors in a regression equation since they have optimized spatial patterns and removed the possible multicollinearity (Al-Alawi 2007). Thus, Principal Component Regression can be expressed as,

$$Z(Y) = \beta_1 C_1 + \beta_2 C_2 + \cdots + \beta_i C_i (i = 1, \ldots p \leq k) \tag{2}$$

Where $Z(Y)$ is the standardized dependent variable, C_i stands for the i^{th} principal component, β_i is the i^{th} standardized coefficient of the standardized principal component regression equation. The component equation (1) will be applied to the equation (2) and then the standardized linear regression equation will be yielded after sorting out all the X_i variables. Thus,

$$Z(Y) = b_1 * Z(X_1) + b_2 * Z(X_2) + \cdots + b_k * Z(X_k) \tag{3}$$

Where, b_k is the partial regression coefficient of principal component regression equation and then b_k has to be changed to unstandardized coefficient (Liu et al. 2003).

6. Results

6.1. Principal Component Analysis

SPSS 16.0 is used to run the Principal Component Analysis first and then the Principal Component Regression. In our case, the KMO test result is 0.544 which normally should be larger than 0.6. It indicates there are some limits by using PCA to fully represent our data and it will be improved in the future study. The PCA involves several areas as follows.

First, five components are extracted from independent variables. Then varimax rotation technique is used to maximize the loading of a variable on one component and to produce a ranked series of factors (Al-Alawi et al. 2005). We select the first three as principal components which together account for 95.838% of total variance. The Table 1 reports the result of component extraction, varimax rotation and component score coefficient.

Table 1. Summary of the Principal Component Analysis

Total Variance Explained				Rotated Component				Component Score Coefficient			
Component	Total	% of Variance	% of Cumulative	Variables	C1	C2	C3	Variables	C1	C2	C3
1	2.759	55.176	55.176	CAPA	.941	.242	.173	CAPA	.358	.057	.036
2	1.119	22.381	77.557	C	-.927	-.244	.015	C	-.441	.349	.073
3	0.914	18.282	95.838	TRATE	.096	.976	.059	TRATE	-.106	.832	-.055
4	.175	3.509		CRATE	.102	.057	.993	CRATE	-.086	-.071	1.011
5	.033	.652		PCM	.870	.413	.076	PCM	.314	.227	-.074

Then, component score coefficients in Table 1 are used to obtain the expressions of three principal components.

$$C_1 = 0.358 * Z(CAPA) - 0.441 * Z(C) - 0.106 * Z(TRATE) - 0.086 * Z(CRATE) + 0.314 * Z(PCM) \quad (4)$$

$$C_2 = 0.057 * Z(CAPA) + 0.349 * Z(C) + 0.832 * Z(TRATE) - 0.071 * Z(CRATE) + 0.227 * Z(PCM) \quad (5)$$

$$C_3 = 0.036 * Z(CAPA) + 0.073 * Z(C) - 0.055 * Z(TRATE) + 1.011 * Z(CRATE) - 0.074 * Z(PCM) \quad (6)$$

Where C_1, C_2 and C_3 stand for the three principal components, $Z(X_k)$ stands for the standardized independent variables.

6.2. *Principal Component Regression*

The three principal components subsequently used as independent variables in a multiple regression model. Furthermore, three dummies are included to examine the impact of the dry bulk carrier's vessel type. Since all dummies have to be jointly included or exclude in the model, 'enter' regression method is chosen for the dummy group and 'stepwise' method is chosen for the component group. The PCR result is summarized in Table 2.

Table 2. Result of Principal Component Regression

	Coefficients	Std. Error	T	Sig.	Tolerance	VIF
(Constant)	-0.593	.032	-18.680	.000		
C1	.049	.012	3.936	.000	.991	1.009
C2	.502	.015	33.855	.006	.694	1.441
C3	.087	.013	6.924	.000	.962	1.040
D1	1.645	.048	33.934	.000	.414	2.415
D2	0.646	.039	16.403	.000	.472	2.120
D3	0.246	.037	6.584	.000	.487	2.055
R Square	0.871					
Adjusted R Square	0.871					
F(sig.)	953.486(.000)					

a. Dependent Variable: Zscore(p).

The F statistics shows that variables have significant impacts on the price of dry bulk carrier. The model can explain 87.1% of total variance and it indicates that the regression line fits the observation well. The coefficients of variables are all statistically significant. Then we apply the principal component equations (4) - (6) into the PCR model (2). The final model with five original independent variables can be present as follows:

$$
\begin{aligned}
Z(P_i) = -0.593 + 0.049 * Z(CAPA_i) + 0.16 * Z(C_i) + 0.407 * Z(TRATE_i) + 0.048 * Z(CRATE_i) \\
+ 0.123 * Z(PCM_i) + 1.645 D_{i1} + 0.646 D_{i2} + 0.246 D_{i3}
\end{aligned} \quad (7)
$$

And the unstandardized coefficients model can be specified as,

$$
\begin{aligned}
P_i = 1.111 + 4.082 * (CAPA_i) + 8.552 * (C_i) + 0.284 * (TRATE_i) + 0.377 * (CRATE_i) \\
+ 11.109 * (PCM_i) + 19.969 D_{i1} + 7.841 D_{i2} + 2.986 D_{i3}
\end{aligned} \quad (8)
$$

The hypotheses are confirmed by the significantly positive signs of five coefficients. According to the standardized coefficient model, it indicates the most important role time charter rate plays in determining the dry bulk carrier prices, followed by shipbuilding cost index, price-cost margin, shipbuilding capacity utilization and credit rate in decreasing importance. For example, a 10% increase in time charter rate will make price of dry bulk carrier rise by 4.07%. This is in accordance with the reality that shipbuilding and shipping markets are tightly connected. For dry bulk carrier in particular, values of cargo transportation are lower than those of tankers and containers. Therefore, it is assumed that higher the time charter rate for dry bulk carrier, the higher return on investment for ship owners, and as a result, ship owners will be more willing to invest in dry bulk carrier with higher prices. For large shipyards that are able to switch their production from one vessel type to another, the building of a dry bulk carrier is cheaper and hence is a shipyard's last resort in its strive to maximize revenue (Haralambides *et al*. 2005). The prices of dry bulk carrier may be able to depend on the market demand to a greater degree.

Shipbuilding cost index, constructed by three major cost components in the Chinese shipbuilding industry, is found to be the second most important factor in determining the prices of dry bulk carrier. This result is the further proof of the fact that world shipbuilding centers have always been relocated to the lower cost countries.

The price cost margin impact on the price level of dry bulk carrier to a moderate degree. The answer could be that China is becoming a major shipbuilding nation for dry bulk carrier in recent years and has held more than 37% market share in terms of new orders since 2006. With regard to China's big market power in dry bulk sector, market competitions from other shipbuilding nations have a certain degree of influence on the Chinese prices.

The shipbuilding capacity utilization is found to have a significant but smaller effect on price in our study. One reason is that capacity utilization has been keeping as high as 93% to 100% since the start of modern Chinese shipbuilding industry. Another reason is due to the limitation of our dataset mentioned before. Most of the data concentrate on year 2006-2008 during which was the market prosperity and therefore capacity utilization kept extremely high, even 100%. The fluctuation of ship export credit rate has a significant but the least effect. It confirms that the Chinese shipbuilding industry has less relied on the government subsidies after transforming from a central planning system to a free market launched by the COSTIND (State Commission of Science and Technology for National Defense Industry) in 1999. Major shipyards are prompted to be more market-oriented and to take part in the world competition by improving technology and quality. At the same time, all coefficients of dummy variables are significant and prove the systematically different prices of four types of dry bulk carrier. The bigger ship has a higher price level and the intercept for Capesize, Panamax, Handymax and Handysize in unstandardized coefficient models are 21.08, 8.952, 4.097 and 1.111 respectively.

Overall, the time charter rate and shipbuilding cost have the greatest effect of all variables on the determination of dry bulk carrier price. It is argued in the previous studies (Haralambides *et al.* 2005; Jin 1993) that shipbuilding is a supply- and cost-driven industry instead of demand driven and cost is a decisive factor of world newbuilding prices. Our results indicate that time charter rate has a higher impact on China's dry bulk prices than the shipbuilding cost. A reason behind this may be the 'China Factor'. Under the strong economy growth, China becomes one of the world's largest energy consumers and has greatest influence on the bulk trade. The demand for iron ore promotes the dry bulk shipping market dramatically. In the meanwhile, China has become a net coal importer since 2009. This not only increases the seaborne trade for Chinese domestic use, but also forces Japan and South Korea, who imported coal from China before, to turn to farther distance Australia to quest for resources. On a global scale, 'China Factor' gives a great push to the freight rate boost in bulk shipping market, and consequently stimulates ship owner's desire to expand the dry bulk fleet and brings up the prices of dry bulk carrier. Therefore time charter rate plays a greater role than shipbuilding cost in determining the prices of Chinese dry bulk carrier. What else can be implied from model is that international competition in shipbuilding industry is more closely tied to the dry bulk carrier prices than other two domestic factors. Therefore, changes of nationally industrial policy or capacity utilization may not affect the price of Chinese dry bulk carrier as much as it would in the case of competition degree in world shipbuilding.

6.3. Simulations and Discussions

Previously we test the price formation of dry bulk carrier. In this section, the model is used to carry out few simulations in order to understand the likely price behaviour under various exogenous variable changes. Here we choose time charter rate and shipbuilding cost index as the impact variables and fix all other variables in simulations. It is because time charter rate is the most important price determinant and shipbuilding cost is the core competence of the Chinese shipyards. The reference year chosen is 2009 and twelve scenarios are tested against the baseline scenario in Table 3. Because of the American financial crisis, the time charter rate in year 2009 was already at historically low level. We now assume that time charter rate will change at four different levels, namely -50%, 50%, 100% and 150%, compared to 2009. Chinese shipbuilding industry is facing with heavy pressure about rising cost, for this reason cost index will change at 0, 50%,100% levels compared to 2009. Numbers given below are percentage changes over year 2009 for time charter rate, cost index and prices.

Table 3. Simulation Results of Price Changes

Variables	Baseline	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
TRATE	0	-50%	-50%	-50%	50%	50%	50%	100%	100%	100%	150%	150%	150%
C	0	0	50%	100%	0	50%	100%	0	50%	100%	0	50%	100%
CAPESIZE	0	-0.09	0.07	0.22	0.09	0.24	0.40	0.17	0.33	0.48	0.26	0.41	0.57
PANAMAX	0	-0.06	0.19	0.45	0.06	0.31	0.57	0.12	0.38	0.63	0.18	0.44	0.69
HANDYMAX	0	-0.07	0.25	0.57	0.07	0.39	0.71	0.14	0.46	0.78	0.21	0.53	0.84
HANDYSIZE	0	-0.07	0.31	0.68	0.07	0.45	0.83	0.15	0.53	0.91	0.22	0.60	0.98

There is clearly a large increase in prices for all types under S2 to S12 when compared to baseline scenario. In S1 to S3, time charter rate levels are the same but different levels of cost increase makes significant changes to prices. The higher the cost is, the higher the price change is. All price changes in S4 to S6, S7 to S9 and S10 to S12 share the same characteristics. Under the same cost increase, for example S2, S5, S8 and S11, shipbuilding prices will continue to rise if there are favourable conditions in time charter rate. In most of scenarios, expect for four, smaller ships will have larger price changes. But there is hardly any difference of price changes for all types in S1, S4, S7 and S10 under which only time charter rate changes compared to baseline scenario. We also notice that there is a big price gap between S3 and S4, S6 and S7, and S9 and S10 for all types. It means lower time charter rates combined with higher costs can also lead to higher prices.

7. Conclusions

In this study, we propose a price formation model for dry bulk carrier in the Chinese shipbuilding industry, thus filling a gap in the literature of world shipbuilding prices. We utilize the actual vessel prices quoted by major Chinese shipyards and propose a new approach PCR for price modelling. In particular, the theoretical relationship between price and determinants is discussed by including generic market factors as well as Chinese elements. Several conclusions have been drawn. First, time charter rate is the most important determinants. While increase in shipbuilding cost, price-cost margins, shipbuilding capacity utilization and credit rate have positive effects in decreasing importance. Despite the common perception that shipbuilding industry is cost driven, we conclude the highest impact of time charter rate on the Chinese price of dry bulk carrier attributes to the 'China Factor'. The competitive indicator we constructed also influences the price moderately. The dynamic price simulations indicate that there is a likely big increase in the prices as a result of growth in time charter rate and shipbuilding cost. Particularly, smaller vessels tend to have larger price increase under same condition. Second, PCR approach is proved to be a good way of overcoming the problem of multicollinearity in maritime economic field. Dummies in the model successfully serve to distinguish the systematic difference of vessel types. Third, investors and policy makers in shipbuilding industry can benefit from applying the model when making decisions. It also has implications for emerging shipbuilding nations who start development from dry bulk carrier sector and will enter the arena of major shipbuilding nations.

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