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An empirical study of fleet expansion and growth of ship size in container liner shipping

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ABSTRACT

The world fleet capacity has been continuously enlarged in container liner shipping. In line with the enlargement, new ship generations have been launched, especially since the 1990s.The paper concentrates on the two major issues of capacity expansion and growth of ship size in the industry. Multiple regression models are built to measure the effects of fleet capacity and ship size as well as slot utilisation level, market freight rate and oil price on revenue and cost of shipping lines in the period 1997–2012. Investing in new capacity will lead to higher total revenue of operators whereas lower unit revenue. Its positive effect on total and unit cost can be noted. No statistical evidence is found to indicate the relationship between ship size and financial indicators. Additionally, it is possible to evaluate positive influence of slot utilisation level and market freight rate, and negative influence of oil price on financial results of liner carriers.

1. Introduction

The world container ship fleet has experienced profound development since the 1990s. The carrying capacity increased by a factor of 6, from 3.17 m TEUs (4772 ships) in 1990 to 18.9 m TEUs (8337 ships) in 2014. A substantial portion of the growth was thanks to the container shipping lines (CSLs) in the top 20. Their capacity share in the global fleet was from 39% to around 75%. The fleet capacity of Maersk Line advanced nearly 28 times whereas that of MSC went up about 90 times. In tandem with such strong growth of the world fleet, it has been the trend of ever-increasing vessel capacity. As stated by Ashar (2002), the evolution in liner shipping refers to the growth of ship size. The maximum size was 4300 TEUs in 1988, up to 7100 TEUs in 1996, then 15,500 TEUs in 2006, and is 18,000 TEUs now. The influx of mega ships has been obviously among the major breakthroughs in the shipping industry.

The paper concentrates on the two major issues of ship deployment, capacity expansion and growth of ship size. The central research question is how these factors influence on financial results of CSLs. To answer it, multiple regression models are built to measure the relationships between variations of their revenue and cost (total and unit) and those of their carrying capacity, average ship size and other such factors as slot utilisation level, oil price and market freight rate during the period 1997–2012. Results from the regression models, together with in-depth analysis based on practices from the industry, provide some insights into scale economies of firm capacity and ship size.

The paper is structured as follows. Section 2 reviews literature regarding economy of ship deployment in container liner shipping. Section 3 summarises the expansion of global fleet as well as major eras in the development of container ships. Section 4 presents models to evaluate influence of capacity expansion and ship size growth on CSLs' financial results. Section 5 provides in-depth analysis regarding the two issues. Section 6 includes some conclusions.

2. Literature review

Ship deployment has been attracted much attention in the domain of maritime logistics. Basic understanding of ship operation can be found in some textbooks (Alderton, 2008; Jansson and Shneerson, 1987; Stopford, 2004; Wijnolst and Wergeland, 2009; Talley, 2009). Different strategies of CSLs to develop their ship fleet are completely analysed by Notteboom (2004) and Cariou (2008). Drewry (2009) and Notteboom (2012) pay attention to operational strategies of CSLs to tackle over-capacity in the market. Many papers concentrate on tackling optimisation problems concerning ship deployment (Qi and Song, 2012; Verny and Grigentin, 2009). They are comprehensively reviewed and classified by Christiansen et al. (2013), Meng et al. (2014) and Tran and Haasis (2014).

The relationship between carrying capacity and firm performance has been studied in several researches. Lam et al. (2007)

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use the structure–conduct–performance paradigm to evaluate the situation of liner shipping on the Trans-Pacific, Far East-Europe and Trans-Atlantic trades between 1998 and 2002. The analysis indicates that there is no conclusive evidence that the increased concentration of fleet capacity leads to better financial results. Lun et al. (2010) examine the positive correlation between firm scale and profit. Lun and Marlow (2011) apply a data envelopment analysis (DEA) to evaluate the impact of CSLs' fleet capacity on their profit and revenue. DEA is also employed by Bang et al. (2012) to point out positive contribution of firm size and ship size to firm performance. Yip et al. (2012) build an S-curve to formulate the association between firm capacity and revenue. The curve can describe well both scale economy and diseconomy of carrying capacity.

Cost saving is an important driving force to deploy bigger and bigger ships. Scale economies of ship size have been quantified so as to assess the viability of large ships. Gilman (1980, 1983) provide cost estimation of several ship sizes in correspondence with different operating speeds and handling rates. The model takes account of capital cost, operating cost and fuel cost. Veldman (1993) incorporate shippers' cost into shipping cost to evaluate optimum ship size. Lim (1994) investigates efficiency of large ships not only in terms of cost but also in terms of income. Drewry (1996) compares total cost of a Super post-panamax ship (6000 TEUs) and that of an optimised panamax one (4000 TEUs) with 21% saving of the former over the latter. Tozer (2003) and Tozer and Penfold (2002) present cost difference between ultra-large container ships and smaller ones under various operating speeds. Sys et al. (2008) quantify cost advantage of ship size up to 18,000 TEUs by using the liner service cash flow model of Stopford (2004) and taking into account cost distinction between single and twin propeller systems on ships. Stopford (2009) considers the variation of container ship costs with various carrying capacities on the transpacific round voyage.

Some studies have established regression functions to explain the relationship between cost component per unit (DWT or TEU) and ship size by employing data of ship operation from industry consultants and CSLs. In the models of Jansson and Shneerson (1978, 1987), capital cost is estimated to conform with the two-third power rule whereas the size elasticities of operating cost and fuel cost are 0.43 and 0.72 respectively. Talley (1990) deploys regression functions to calculate operating and port cost. The outcome implies the upward trend of optimal size in case of fewer numbers of port calls, shorter port time and longer ship distance. Cullinane and Khanna (1999, 2000) exclude port cost in their estimation as the argument that it has little variation in carrying capacity. The model confirms again benefit of ship size at sea as well as advantage of large ships on long routes. Veldman (2009) takes into consideration economies of ships from 6000 to 20,000 TEUs.

Our paper contributes to literature regarding ship deployment in container liner shipping by several facets. Firstly the development of the fleet will be summarised in detail. Secondly we do empirical analyses to see effects of carrying capacity and ship size on firms' financial indicators, not only total revenue and cost but also unit revenue and cost. Thirdly economies of ship size have been often studied to evaluate their potential cost saving, our analysis takes account of their influence on financial performance of CSLs.

3. Development of container ship fleet

3.1. An overview

At the beginning of the 1970s, the world fleet included 166 ships totalling 126,267 TEUs (Gibney, 1981). After a decade, it numbered 2565 ships with the combined capacity of 1.53 m TEUs. It developed into 4772 ships (3.17 m TEUs) in 1990 and 7093 ships (6.54 m TEUs) in 2000. In April 2014, the armada consisted of 8337 ships (18.9 m TEUs). In the last 32 years, the fleet capacity increased on average by 8.3% per year, it nearly doubled every decade (Table 1).

Table 1
Fleet deployment.

	Number of vessels			Fleet capacity (mTEUs)			Average ship size (TEU)		
	FCC	NFCC	Total	FCC	NFCC	Total	FCC	NFCC	Fleet
1982	675	1890	2565	0.67	0.85	1.53	997	452	596
1985	965	3010	3975	1.01	1.36	2.37	1055	453	599
1990	1299	3473	4772	1.65	1.52	3.17	1267	438	664
1995	1723	4255	5978	2.67	1.74	4.41	1548	409	737
2000	2723	4370	7093	4.72	1.82	6.54	1732	417	922
2005	3506	4444	7950	7.85	1.91	9.76	2239	430	1228
2010	4855	3092	7895	13.97	2.14	16.11	2878	687	2026
2014	5102	3235	8337	17.32	1.49	18.9	3, 394	462	2256

Combined from Containerisation International yearbooks and monthly magazines (2002–2012) and Clarkson (2014b).

Contributing the most to the fleet development is fully cellular container (FCC) vessels. From 1982 to 2014, their capacity grew nearly 26 times in comparison with only 1.8 times of non-fully cellular container (NFCC) vessels. In 2014, FCC ships play some 92% of the total capacity; the rest includes NFCC ones such as roros, semi container and break-bulk ships. Before 1990, the world fleet had been dominated by the NFCC ships, but the FCC ones have become overwhelming since then. In the last three decades, the NFCC capacity increased on average by only 3.2% annually whilst the figure was 11% for the FCC capacity. Moreover, NFCC fleet's growth has become smaller and smaller. The average annual growth rate was 8.73% in the 1980s, down to 2.28% in the 1990s and 1.64% in the 2000s. On the contrary, FCC fleet has kept steady development with these indicators of more than 10% in each period (Fig. 1).

In harmony with the fleet scale's expansion, it has been the upturn in ship size. Average size was from 596 TEUs in 1982 to 2256 TEUs in 2014. NFCC ships have been limited in respect of size growth. The largest ships have been often under 3000 TEUs whereas the mean size has been often less than 500 TEUs. In contrast, there has been no restriction for FCC ships. Between 1980 and 2014, average FCC ship size increased from 997 TEUs to 3394 TEUs with the average growing ratio of 3.89% per year. In the 2000s, the figure was 5.23% in comparison with 3.21% in the 1980s and 2.92% in the 1990s.

The development of containerisation has witnessed the emergence of new FCC ship generations. The Handy ships (1000–1999 TEUs) had developed strongly since the end of the 1960s. The sub-panamax ships (2000–2999 TEUs) and panamax (3000–4500 TEUs) ships emerged at the beginning of the 1970s. The post-panamax generation started at the end of the 1980s and has accelerated since the mid-1990s. Since the 2000s, the fleet over 8000 TEUs has experienced substantial growth. Today, the Post-panamax armada represents 55% of the FCC capacity, in which, less than 8000 TEU ships play 21% whereas the bigger ones 34%. panamax ships account for 21.2% of the global carrying capacity and take the second place. The portions of sub-panamax and Handy are more or less the same, 9.9% and 9.7% respectively. Feeder ships (less than 1000 TEUs) are the smallest group with the share of 4.2%.

3.2. Generations of fully cellular container ships

3.2.1. Trial era

The converted T2 tanker Ideal X opened up the era of container transportation by carrying 58 containers on its flat spar deck from Port Newark to Houston on April 26, 1956. Following the pioneer