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THE RELATIONSHIP BETWEEN THE BOONE INDICATOR AND THE HERFINDAHL-HIRSCHMAN INDEX: EVIDENCE FOR THE CONTAINER LINER SHIPPING INDUSTRY

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ABSTRACT

The present paper focuses on the relation between the Boone indicator and the Herfindahl-Hirschman Index. Both measures of competition are employed for the container liner shipping industry. First, the paper examines a new model-based measure of competition. This measure of competition based on Boone's theoretical work quantifies the impact of marginal costs on performance, measured in terms of profits or market shares. Boone (2000 and 2004) shows that when profit differences are increasingly determined by marginal cost differences, this indicates increased competition. The evolution of competition will be calculated using a pooled data set of 20 liner operators. Data availability limits the analysis to industry level for the period 2000-2008. The problem setting is that unlike other sectors, the container liner shipping industry is characterized by limited data availability. Operating expenses for the business segment container shipping are not readily available; and this is exacerbated by the economic crisis. Therefore, the paper examines whether the Herfindahl-Hirschman Index (HHI) is a good alternative measure. Based on the 2000-2008 dataset, the findings suggest that the indicators do not agree on the direction of change in competition and that the Boone indicator is the preferred tool to establish it.

Keywords: Competition, Boone indicator, Herfindahl-Hirschman Index, Container liner shipping Industry

INTRODUCTION

The container liner shipping industry[1] (hereafter CLSI) has been facing comprehensive restructuring, particularly over the past decade. It has been a period of significant merger and acquisition transactions. Successive waves of such consolidation are likely to have had an impact on the degree of competition in the industry. In addition, the industry has undergone fundamental changes (e.g. deployment of ultra large container vessels, increased containerisation and integration, and the growing importance of integrated logistic concepts) that may have affected competition. In the wake of these developments, the liner carriers have found themselves challenged to offer a worldwide container service network in order to meet the rising customer expectations, and to do so under competitive conditions. Next to operational issues, hence, liner carriers face economic uncertainties (i.e. weak Far East-Europe cargo demand, a fragile state of European consumer confidence) and financial difficulties. It is therefore of great interest to assess the degree of competition prevailing at the market level.

Generally, the literature distinguishes a structural and a non-structural approach to assess the degree of competition. A review of the (container) liner shipping literature[2] reveals that the assessment of competition in the container liner shipping industry has remained insufficiently explored, in contrast with that in other newly liberalised service sectors. In the literature of other liberalised industries, the financial sector in particular, it is found that a new methodology to measure competition has been introduced. The evolution of Industrial Organisation theory (structural approach) towards the New Empirical Industrial Organisation modelling (non-structural approach) is an extra incentive for investigating the extent of competition in the CLSI. Moreover, Clerides *et al.* (2013) state that estimation of competition (inverse of market power) is heavily influenced by the New Empirical Industrial Organisation (NEIO) literature.

The Boone indicator, a non-structural approach seems well-designed to investigate the change in competition over time in a certain industry by taking into account the effects of competition based on profits. The basic idea of the Boone indicator is that the (cost) advantage of each firm to its competitors in terms of lower marginal costs translates into (relatively) higher profitability (Boone, 2000 and 2004; Boone and Weigand, 2000). This indicator allows one to measure how competition in the CLSI evolves over time and helps to understand the effects of competition and efficiency on the liner operators' behaviour (Sys 2011).

Using this indicator, first, the present study considers the degree of competition over time before the abolishment of the block exemption from 18th October, 2008, a policy change with the objective of intensifying competition, and the global downturn. To do this, an empirical specification will be estimated to explain profits through market structure variables and

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[1] The container liner shipping industry is defined as "…*a major segment of the liner shipping industry, is a maritime industry, international if not global in scope. This industry operates vessels transporting containers with various but standardised dimensions/sizes, regardless of the contents. Whether filled or not, these (container) vessels are put into service on a regular basis and often according to a fixed sailing schedule, loading and discharging at specified ports." (Sys 2009).*

[2] For an overview: see Sys 2010.

measures of efficiency using firm-level panel data. Currently, little information on the degree of competition and its evolution after 2008 is readily available. The problem setting is that unlike other sectors, the CLSI is characterized by limited data availability. Operating expenses for the business segment container shipping are not ready available; and this is exacerbated by the economic crisis. Therefore, the paper examines whether the Herfindahl-Hirschman Index (HHI) is a good alternative measure.

The main emphasis of the present study is twofold. First, the question is addressed if both indicators agree on the direction of change in competition. The second question explores whether the Boone indicator is the preferred tool to establish it.

The remainder of this paper is structured as follows. The section 'Methodology' documents and discusses the theory behind the Boone indicator. This section also contains a brief survey of the literature on this particular methodology, the data and the empirical results. Successively, the Herfindahl-Hirschman Index is calculated and discussed. The next to last section elaborates upon the relation between both indicators. Finally, the last section ends with concluding remarks, sets a few challenges for further economic research and derives implications for policy makers.

METHODOLOGY

Theory behind the Boone indicator

Boone (2000) has developed an indicator to measure the effects of competition based on firms' profits. Two effects can be distinguished in which competition can be intensified within a market. The first effect is a fall in entry barriers. Consequently, increased entry leads to more intense competition. Secondly, competition can be intensified by more aggressive behaviour by incumbents. This forces inefficient firms out of the market and increases concentration. The Boone indicator captures both effects. To do so, Boone parameterises competition in terms of a negative relationship between relative efficiency and relative profits. (Boone 2000 and 2004; Griffith et al. 2005). The relative profits measure or the Boone indicator relies on the notion that competition enhances the performance of efficient firms (i.e. with lower marginal costs) and impairs the performance of inefficient firms, which is reflected in lower profits or smaller market shares (van Leuvensteijn et al. 2007). This effect of efficiency on profits or market shares will be greater in a more competitive environment, since firms are punished more harshly for being inefficient (Boone 2004)[3].

The advantages of the Boone indicator are threefold. First, the Boone indicator is shown to be more robust theoretically than the price cost margin (Boone 2004). Secondly, the Boone indicator is able to measure competition at disaggregated level. Thirdly, as mentioned in van Leuvensteijn *et al.* (2007), the indicator requires relatively little data compared to many other approaches (e.g. the Bresnahan model) which are very data intensive. The Boone indicator does not require having data for all firms in the market all years.

The indicator relies on two key assumptions. First, Boone (2000) assumes that firms generally pass on at least part of their efficiency gains to their clients (read: shippers). Secondly, the Boone indicator ignores differences in product quality and design across firms,

[3] Measuring efficiency using a production/cost frontier analysis was impossible due to a lack of data.

as well as the attractiveness of innovations (van Leuvensteijn et al. 2007). This might be a caveat with regard to the Boone indicator.

MODEL

Following Boone *et al.* (2004), van Leuvensteijn *et al.* (2007) and van Leuvensteijn (2008), the mathematical derivation starts from the assumption that firm *i* faces a demand curve of the form

$$p(q_i, q_{j\neq i}) = a - bq_i - d\sum_{j\neq i} q_j \quad (1)$$

whereby each firm has a constant marginal cost, mc_i. To maximise profits, firm *i* chooses the optimal output level q_i to solve

$$\pi_i = (p_i - mc_i)q_i \quad (2)$$

or

$$\max\left\{(a - bq_i - d\sum_{j\neq i} q_j - mc_i)q_i\right\} \quad (3)$$

Two key assumptions are imposed. First, the intercept *a* has to exceed the marginal cost ($a > mc_i > 0$). Secondly, the parameter *d* which can be interpreted as the measurement of the degree of substitution of this product between firms is positive and less than or equal to the parameter *b* ($0 < d \leq b$). The first order condition for a Cournot-Nash equilibrium is then given by

$$a - 2bq_i - d\sum_{j\neq i} q_j - mc_i = 0 \quad (4)$$

Let there be N firms producing positive output levels, one can solve the N first order condition yielding

$$q_i(mc_i) = \frac{(2\,b/d - 1)a - (2\,b/d + N - 1)mc_i + \sum_j mc_j}{(2b + d(N-1))(2\,b/d - 1)} \quad (5)$$

If profits, π_i are defined as variable profits excluding entry costs, *E* a firm with marginal costs mc_i enters the market if, and only if, $\pi_i(mc_i) \geq E$ in equilibrium. Combining the profit function (Eq. 2) with Eq. 5 which relates output with marginal costs, it can be shown that profits depend on marginal costs in a quadratic way

$$\pi_i(mc_i) = b\left[q(mc_i)\right]^2 \quad (6)$$

Based on these properties, Boone *et al.* (2004) considered two ways in which competition in a market can be intensified through (i) an increase of *d* (keeping d below b) and/or (ii) the effect of a reduction in the entry cost, *E*. In the former regime, the products offered by different firms become closer substitutes. In the second regime, the lower the entry barriers, the more firms should enter and the more competitive the industry should be. The Boone indicator picks up both forms of changes in competition correctly (Boone *et al.* 2004).

In order to calculate the Boone indicator, Boone (2004), Griffith *et al.* (2005), Boone *et al.* (2007), van Leuvensteijn *et al.* (2007) postulate the following linear specification between

profits ($ln\ \pi_{i,t}$) and marginal costs ($ln\ mc_{i,t}$) which can be viewed as a first order Taylor approximation

$$ln\ \pi_{i,t} = \alpha + \beta\ ln\ mc_{i,t} + \mu_{i,t} \qquad (7)^4$$

The notation is as follows: the subscript *i* and *t* values represent firm *i* at time *t*. The parameter of interest is the absolute value of the slope coefficient, β. The Boone indicator or β is expected to have a negative sign. It represents the percentage decrease (increase) in profits of firm *i* as a result of one percentage point increase (decrease) in marginal costs. The larger β, the more intense the competition. The parameter α is the constant term and $\mu_{i,t}$ is an error term following the classical assumption, namely, $E(\mu_{i,t}) \sim N(0,\sigma^2)$. In order to deal with heteroskedasticity, Eq. (7) has been specified in log-linear terms.

As data on marginal costs cannot be observed directly, most studies used a proxy. In the next subsection, the Boone literature will be reviewed in order to inventarise the used proxies used.

LITERATURE REVIEW

Appendix 1 gives a brief review of the growing literature that has applied the Boone indicator and elaborates on the choice of the dependent and independent variables. Appendix 1 lists the papers according to the year of publication. The next two columns report the sample period and the industries studied. The fourth column provides an overview of the chosen dependent variable while the last column summarizes the independent variable used.

In the first study, Boone (2000) investigates the conceptual differences between competition measures for a broad set of economic models and proves that intensifying competition entails more emphasis on rewarding efficiency advantages. After developing the theoretical framework, Boone and Weigand (2000) and Boone (2004)[5] have tested their model using data from different manufacturing industries. As dependent variable, Boone and Weigand (2000) used the relative values of profits where Boone (2004) selected the absolute values of profits. Given that the marginal costs cannot be observed directly, both papers approximated the independent variable by the ratio of variable costs and revenues.

Since then, several articles have applied the Boone indicator for different industries. Following Boone and Weigand (2004), Creusen *et al.* (2006a) apply the Boone indicator to measure the intensity of competition for a number of sectors of the Dutch economy (i.e. manufacturing industry, construction sector and service sector). Griffith *et al.* (2005) concentrated on the UK market whereas Creusen *et al.* (2006b) investigated the Dutch market sector using four competition indicators (i.e. price-cost margin, Herfindahl-Hirschman Index, labour-income ratio and the Boone indicator). Covering the 1993-2001 period, Creusen *et al.* (2006b) found elasticities between average variable costs and profits of about -5.7 and -2.5 respectively.

Maliranta *et al.* (2007) tested various relatively well-known competitiveness indicators across the Finnish manufacturing and service sectors at a relatively disaggregated level. Out of nine different indicators, these authors state that the Boone indicator is preferred for both

[4] Boone and Weigand (2000) made several transformations and adjustments to the basic equation (i.e. control for firm-specific effects, control for time-specific effects, etc.) (see Creusen *et al.* 2006a). Sys (2011) also tested some of these transformations and adjustments for the CLSI.

[5] In the meantime, this study has been published in Economic Journal, 188, pp. 1245-1261. In the literature review, here, Boone (2008) is not mentioned as it concerns a revised version of Boone (2004).

analytical/theoretical and empirical reasons. All the above-mentioned studies estimated the firm's marginal cost by the ratio of variables costs and revenues. Maliranta *et al.* (2007) used different functional forms.

van Leuvensteijn *et al.* (2007) is the first to apply the Boone indicator to the banking sector covering the 1994-2004 period. For six major EU countries and two non-EU countries (i.e. the US and Japan), van Leuvensteijn *et al.* (2007 and 2010) measures the level of competition in the lending markets, a separate product market as well as among specific types of banks. In contrast to previous studies, van Leuvensteijn *et al.* (2007) measures the impact of marginal cost on performance in terms of market shares and calculates the marginal cost (i.e. employing a translog function) instead of using average variable costs as a proxy for marginal cost. Whereas most studies estimate the cross-sectional relationship between marginal costs and profits of different firms at a given time, van Leuvensteijn (2008) and Boone and van Leuvensteijn (2010) applied the Boone indicator to identify different regimes of competition for one firm, viz. the American Sugar Refining Company during different periods of time (1890-1914). In both studies, the authors again use information on market shares as a proxy for the profits. Another study of Bikker and van Leuvensteijn (2008) applies the Boone model to the Dutch life insurance industry over 1995–2003. The Boone indicator of this industry is around -0.45. They estimated the Boone indicator in three ways. First, Bikker and van Leuvensteijn consider marginal cost derived from a translog cost function (TCF). Second, they test the model using an adjusted marginal cost (i.e. marginal costs adjusted for scale economies). Last, marginal costs are represented by average variable cost. Bikker and van Leuvensteijn (2008) found that average variable costs and model-based marginal costs result in similar estimates.

Tarryn (2008) regresses absolute values of profit on marginal cost to determine the effectiveness of measuring the degree of competition within the electricity markets. According to Tarryn (2008), the Boone Indicator may not be an adequate measure to use within the electricity sector due to intricacies of the electricity market (e.g. hourly fluctuating demand).

Maslovyck (2009) adopts the Boone indicator approach in estimating the level of competition in the Ukrainian loan market. This study estimated the Boone indicator, using both the average cost and the translog cost function approach. The author found that the translog cost function approach is more robust and reliable in estimating the level of competition.

Schaeck and Cihák (2010) estimate a modified version of the Boone model. To estimate the Boone indicator, these authors opt for a lin-log specification and use return on assets (ROA) as a dependent variable instead of lnROA. The independent variable is proxied by average variable costs.

Applying a similar concept as van Leuvensteijn *et al.* (2007), Roengpitya (2010) measures the level of competition in the loan market of the Thai and U.S. banks. In contrast to the study of van Leuvensteijn *et al.* (2007), this author estimated the translog cost function including the states' fixed effects and calculated the marginal cost differently. In 2013, van Leuvensteijn *et al.* analyses the impact of loan market competition on the interest rates applied by euro area banks to loans during the period 1994–2004. The authors estimate a translog cost function for each separate country and take the first derivative of loans to obtain the marginal costs of lending.

Braila *et al.* (2010) estimate the Boone indicator from firm-level data to describe product market competition in the Belgian economy covering the 1997-2004 period. Here, the dependent variable is defined as the difference between a firm's revenue and its variable

cost. The marginal cost is approximated by the ratio of variable cost and operating revenue (or turnover).

The study of Schiersch and Schmidt-Ehmcke (2010) is the first to question the applicability of the Boone indicator. These authors conclude that "*the Boone-Indicator, although theoretically superior, is, at least at this stage, not an empirically robust indicator. The Lerner-Index on the other hand indicates changes in competition as expected. However, the results of the RPD (Relative Profit Differences) based Boone-Indicator are promising*".

The study of Devine *et al.* (2011) applies the Boone indicator across a range of industries in New Zealand using firm level data. Next, the authors compare and discuss several measures of competition, including the Price-Cost Margin (PCM) or Lerner Index. Doan (2012) investigates the evolution of competition in Vietnam during the economic transition using the Boone indicator and the price-cost margin (PCM). Also Clerdes *et al.* (2013) compares three measures of competition.

Summing up, this compilation of articles does not seem to offer a consensus regarding the choice of dependent and independent variables. Furthermore, this body of literature can be applied to all kind of industries except for network industries (i.e. media, electronic communication, railways), ICT-industries as well as very knowledge-intensive industries (i.e. pharmacy) (see Creusen *et al.*, 2006a). This paper adds to this literature by using the Boone-indicator for the CLSI.

VARIABLES/DATA USED

First, the key variables to calculate the Boone indicator are measures of efficiency and profitability. Following van Leuvensteijn (2008) and Bikker and van Leuvensteijn (2008), as a left-hand variable in Eq. 7, market share ($s_{i,t}$) is used instead of profits or relative profits. For the purpose of this study, market share is defined as $s_{i,t} = \frac{x_{i,t}}{X_{i,t}}$ where $x_{i,t}$ equals the market share of liner operator i for year t and $X_{i,t} = \sum_{i=1}^{100} x_{i,t}$ for Top 100 liner operators[6]. van Leuvensteijn *et al.* 2007 and Bikker and van Leuvensteijn (2008) state that working with market share has two advantages. The first advantage is the fact that a market share model will be more precise since the impact of efficiency on market share and its relation with competition is theoretically known. Another advantage of working with market share is the ever positive value of this variable. Given that logarithms of negative values do not exist, observations with negative values (read: negative profits) would be dropped. Consequently, the estimation results would be distorted by sample bias as it would ignore inefficient, loss-making liner carriers.

[6] In liner shipping, several Commission decisions and Court judgments identify volume and/or capacity data as the basis for calculating market shares. Most studies in container liner shipping literature (Hoffman, 1998, Notteboom, 2004) use the available data of AXS-Alphaliner, more specifically the Top 100. AXS-Alphaliner deduct the market shares from the existing on board TEU (twenty equivalent unit) capacities of liner operators, compared to the fleet effectively deployed by each operator deployed on liner trades (www.alphaliner.com).

A lack of data prohibits the estimation of a translog function in order to determine the marginal costs. So, as an explanatory variable, average variable cost ($avc_{i,t}$)[7] is used as an approximation of the marginal costs (the relationship is in fact exact, if the marginal cost is constant). The choice for the right-hand variable is based upon the study of Bikker and van Leuvensteijn (2008). These authors found that average variable costs and model-based marginal costs result in similar estimates. Here, the average cost is calculated as the ratio of operating expenses to transported twenty feet equivalent unit (TEU).

The Boone indicator measures to which extent the market maps efficiency differences into profit differences. Marginal costs and profits are not directly observable. Mis-measurement within these variables and/or working with proxies – a common practice - may bias the result (Boone 2000; van Leuvensteijn *et al.* 2007). Boone and Weigand (2000) note that approximating marginal costs with average variable costs is only correct if production is characterised by constant returns to scale technology[8]. The latter holds for the containerized liner shipping industry.

Rank	Liner operator	Webpage	TEU	Ships	Number of services	Market share	Alliances
4	APL/NOL	www.nol.com.sg	549,508	139	70	4.41%	☑
29	CCNI	www.ccni.cl	36,712	16	10	0.30%	
8	China Shg C.L. (CSCL)	www.cscl.com.cn	453,009	125	46	3.64%	
3	CMA CGM	www.cma-cgm.com	1,031,327	353	91	8.29%	
7	COSCO Container L.	www.coscon.com	453,204	134	88	3.64%	☑
13	CSAV	www.csav.com	328,721	96	22	2.64%	
9	Hanjin Shipping	www.hanjin.com	440,299	99	52	3.54%	☑
6	Hapag Lloyd	www.hapag-lloyd.com	462,288	113	68	3.72%	☑
11	K-Line	www.kline.com	342,043	90	66	2.75%	☑
1	Maersk Line	www.maerskline.com	2,044,981	538	104	16.44%	
36	Matson	www.matson.com	29,074	15	5	0.23%	
21	MISC Berhad	www.misc.com.my	125,101	39	22	1.01%	
12	Mitsui-OSK L. (MOL)	www.mol.co.jp	341,820	91	85	2.75%	☑
10	NYK	www.nykline.com	407,300	106	41	3.27%	☑
14	OOCL	www.oocl.com	324,209	71	69	2.61%	☑
25	RCL	www.rclgroup.com	53,435	39	36	0.43%	
19	UASC	www.uasc.net	196,237	49	15	1.58%	
22	Wan Hai Lines	www.wanhai.com	125,060	66	34	1.01%	
15	Yang Ming Line	www.yml.com.tw	312,962	77	51	2.52%	☑
17	ZIM	www.zim.co.il	305,523	94	47	2.46%	

Figure 1: Sample of liner operators

[7] Bikker and van Leuvensteijn (2008) state that *"[A]verage variable costs have the advantage of being less complex, since they are not model-based, but they are less accurate because we cannot distinguish between variable and fixed costs*". Boone (2004, p. 18) discusses the definitions of fixed and variable costs and states that only variable costs and no fixed costs should enter the calculation.

[8] Boone and Weigand (2000) discuss in detail the limitations of the Boone indicator with respect to an unobservability of marginal costs, an (unobserved) unlevel playing field and problems with defining the relevant market. These authors use excellent examples to illustrate the limitations.

To estimate the Boone model, data was obtained from investor/annual reports. It resulted in an unbalanced firm-level panel of data[9] for a sample of 20 liner operators. Figure 1 lists the sample of liner operators and shows the market share as well as other variables (number of TEU capacity, ships and offered services) to explain competition. The paper focuses on the 2000-2008 period. The next section discusses and analyses the estimates of the Boone indicator.

EMPIRICAL RESULTS[10]

As stated earlier, the Boone indicator is based on two assumptions. Most studies accept the assumption regarding the ignorance of the differences in product quality and design across firms. However, Boone and Weigand (2000) state that *"[P]roducing higher quality products is usually more expensive in terms of inputs, but clearly these higher costs (as such) do not indicate a lack of efficiency. To take this into account, a firm's costs should be corrected for the quality of its goods*."

To test whether a liner operator's costs should be corrected for the quality of its products, firstly, the product should be defined. The product or service can be defined as the transportation of a box/container between A and B (door to door, port to port, etc.). Liner carriers are assumed to be single product firms. Does the container liner shipping industry produce higher quality products? In other words, is there a quality difference between the transportation of a box/container by liner operator x and y both offering – for instance - a door-to-door service? From the viewpoint of the shipper, the answer is positive. Transit time, schedule reliability, etc. differs from liner carrier to liner carrier. Assuming a quality difference, another question arises namely whether it is more expensive in terms of inputs for the liner operator? Due to a lack of data at trade level, the latter is unobservable.

Is it possible that long hauls are both more expensive and more profitable than short hauls? Put differently, should one take the portfolio of services into account? Due to the practices of "double/triple dipping"[11] as well as transhipment combinations on long hauls, it is very difficult to get insight in costs and revenues per trade lane and to conclude that long hauls are both more expensive and more profitable. But then, these practise are introduced to cut costs and wring greater efficiencies from their networks. The Boone indicator should turn out to attain the appropriate sign.

Creusen *et al.* (2006a) suggest adjusting the basis equation for industry-specific effects. For the CLSI, industry-specific effects might be like differences in technology (ship size), the wide range of services, being a member of an alliance, etc. A look at Figure 1 shows that the dataset is very heterogeneous regarding the number of services offered and the average

[9] The Boone indicator requires data of fairly homogeneous products (Creusen et al., 2005; van Leuvensteijn et al. 2007). Although some heterogeneity (i.e. service, transit time, etc.) exists, the product is assumed highly homogeneous (read: transport of a container/box) in the containerised liner shipping industry.

[10] The empirical evidence in the present paper is based on the container liner shipping industry. The Boone indicator can also be used for separate submarkets (read trade lines), in other segments of the (liner) shipping industry as well as in other transport modes. Due to a lack of detailed information, the present study cannot take into account that liner operators compete at trade level and neglect the possible interrelationship between trade lanes.

[11] The practice of double/triple dipping is often used on long-haul routes. It means that other vessels also load containers for other trade lanes using intermediate wayports or hubs along the route to unload them. This logistic pattern ensures that, wherever is practical, empty slots are filled and/or that a slot is used more than once on a given leg, which produces opportunities to earn additional revenue.

ship size (TEU capacity divided by number of ships). Given this observation on the one hand and the suggestion of Creusen *et al.* (2006a) on the other hand, the year-by-year Boone indicator is estimated based on

$$ln\, s_{i,t} = \alpha + \sum_{t=1,\ldots T-1} \gamma_t d_t + \sum_{t=1,\ldots,T} \beta_t d_t ln\, avc_t + service_{i,t} + avteu_{i,t} + \mu_{i,t} \quad (8)$$

where d_t is the year t dummy variables and t = 2000…2008. In order to estimate the Boone indicator more accurately, the variables number of services ($service_{i,t}$) and average TEU ($avteu_{i,t}$) were added as explaining variables to the basic equation. A wider range of services and the deployment of larger ship sizes might affect profit. The parameters α, γ and β can be estimated by ordinary least squares (OLS)[12].

Table 1: Time fixed effects estimates of the Boone model[13]

Extended model		
Variable	Coefficient	t-Statistic
SERVICE?	0.018289	19.1554 **
AVTEU?	0.000412	4.9372 **
C	-5.609487	-28.8473 **
LNAVC?--2000	0.233333	210.3799 **
LNAVC?--2001	-0.135650	-1.8942 *
LNAVC?--2002	0.192068	2.5820 *
LNAVC?--2003	0.160307	2.9221 **
LNAVC?--2004	-0.166424	-3.4781 **
LNAVC?--2005	-0.200081	-7.9306 **
LNAVC?--2006	-0.159378	-5.6320 **
LNAVC?--2007	-0.110895	-3.5568 **
LNAVC?--2008	-0.166986	-12.0238 **
Adjusted R^2	0.530435	

Table 1 presents the heteroskedasticity-robust OLS estimates of the Boone indicator based on Eq. 8 with market shares and average variable costs in logarithms. The middle column shows the annual estimates of beta while the last column shows the t-statistics. An estimated β of – 0.166986 for 2008 would suggest that a liner carrier with one percentage point higher average costs than another (more efficient) liner carrier would have 16.70 percent lower profit (proxied by market shares) than the more efficient liner carriers (Griffith et al. 2005).

[12] van Leuvensteijn *et al.* 2007; Schaeck and Cihák 2010 and Roengpitya 2010 have applied a Generalised Method of Moments (GMM) estimator whereby one-year lagged values of the explanatory variables are used as instruments. Statistical tests (for overidentification of the instruments, Hansen J-test and for relevance of excluded instruments, Anderson canonical correlation likelihood ratio) and variance estimation (kernel-based heteroskedastic and autocorrelation consistent) are performed in these studies. The GMM-style estimator with as instruments the one-year lagged values of the explanatory variable, average cost (in logarithms) is also tested for the containerised liner shipping industry. When fitting a model by GMM, one should check whether the instruments used are uncorrelated with the errors. The test statistic has a χ2 distribution under the null hypothesis that the instruments are valid. The significant statistic (557.2609; Hansen J-test p value: 0) indicates a decisive rejection of the null hypothesis that the model is correctly specified.

[13] The asterisks indicate the statistical significance at 1 percent (**) and 5 percent (*) respectively.

Year dummy coefficients are not reported separately since the key parameter of interest is the slope coefficient, *β*. From the regression results obtained, the slope coefficients are significant in all years and fluctuate between 0.23 and -0.20. The annual estimates of beta are negative in the years 2001, 2004 to 2008. The impact of the announcement of the takeover of Royal P&O Nedlloyd is again observable in the negative peak in beta in 2005. Subsequently, competition weakens till the year 2008. During that year the container liner shipping industry was under the spell of the question whether the block exemption would be abolished. As from October 18th, 2008 this abolishment is a fact (EEC Regulation n°4056/86) (see Sys *et al.* 2011). This might explain the further increase in competition.

Turning to the added variables, both the number of services and the average ship size are positive and significant. Incorporating these explanatory variables impacts profits.

The Herhindahl hirschman index

Another measure of competition is the **Herfindahl-Hirschman Index** (HHI). HHI is a structural approach to map the competition in the container liner shipping industry. This approach explains profits by means of market share variables. This index is high if a few firms have large market shares and dominate the market. HHI takes into account both the number of liner operators and the inequality of market shares. The HHI is a concentration measure based on the sum of squares of all liner operators' percentage of market shares, according to the existing on board TEU (twenty equivalent unit) capacities of liner operators, and ranges from 0 (a perfectly competitive industry) to 10,000 (a monopoly). Shepherd (1999) gives the following formula for the Herfindahl-Hirschman Index:

$$H = \sum_{i=1}^{n} s_i^2 \text{ x } 10.000 \qquad (9)$$

where n = the number of carriers and si = the share of the ith carrier. It gives added weight to the biggest operators. The principle is: the higher the index, the more concentration and (within limits) the less open market competition. As a benchmark, a market with an HHI below 1,000 is considered to be unconcentrated and unlikely to be subject to any adverse competitive effects. A value between 1,000 and 1,800 generally indicates moderate concentration. Any value over 1,800 indicates a highly concentrated market (Shepherd, 1999).

VARIABLES/DATA USED

The HHI is computed over the period 1999-2012 using the available market share data of AXS-Alphaliner (various editions), more specifically the TOP 100. AXS-Alphaliner deduct the market shares from the existing on board teu (twenty equivalent unit) capacities of liner operators, compared to the fleet effectively deployed by each operator deployed on liner trades (www.alphaliner.com).

Although there are about 400 liner operators, an omission of the lower-ranked carriers will have no significant impact on the conclusions, as the smallest operators have a market share of less than 1 % each. When these very small market shares are squared, the contribution each carrier makes to the HHI is less than 1/1,000 (in other words, the HHI is affected at most in the fourth decimal place). As a result, where the container shipping industry is concerned, the liner operators ranked in the segment 101 - 400 can be safely omitted without affecting the picture of industry competition (Sys, 2009).

Table 2: Evolution of the HHI

Herfindahl-Hirschman Index			
1999	336.20	2006	665.93
2000	415.34	2007	646.22
2001	427.54	2008	640.00
2002	427.37	2009	644.07
2003	451.34	2010	647.26
2004	462.24	2011	643.03
2005	473.91	2012	706.91

RESULTS

Table 1 summarises the calculations of the HHI value for the container shipping industry. The second consolidation round (2006) is quite observable by a remarkably higher HHI (+ 35%). No HHI value exceeds the value of 1,000. According to the theory, the latter suggests a competitive market.

Over the studied period, the HHI clearly increases, indicating a trend of growing concentration in the container shipping industry. The increase in the HHI generally indicates a gain of market power and an decrease in competition. In detail, the decrease in the HHI, noticeable from the year 2006 to 2008 then again suggests an increase in competition. (Sys, 2009).

THE COHERENCE BETWEEN THE HHI AND THE BOONE INDICATOR

This section focuses on the relation between the Boone indicator and the HHI. It also briefly elaborates on the differences in underlying economic determinants (Boone, 2000 and 2004, and Creusen *et al.,* 2006).

The analysis of the relationship between the both measures allows to answer the questions if the measures agree on the direction of change in competition and whether the Boone indicator is preferred to establish how competition involves over time[14].

Regarding the first question, the relation between the Boone indicator (right-hand axis) and the HHI (left-hand axis) is plotted in Figure 2. In the bilateral comparison, the graphical representation suggests that the HHI and the Boone indicator contradict each other on the direction of change in competition at the industry level. On the one hand, the Boone indicator suggests intensified competition over the 2000-2008 sample period. On the other hand, following the traditional interpretation, the HHI increased over the same period. In general, increases in the HHI indicate a gain of market power and a decrease in competition, while decreases imply the opposite.

[14] Since the study could benefit from longer time-series, the coherence between the different indicators should be interpreted with caution.

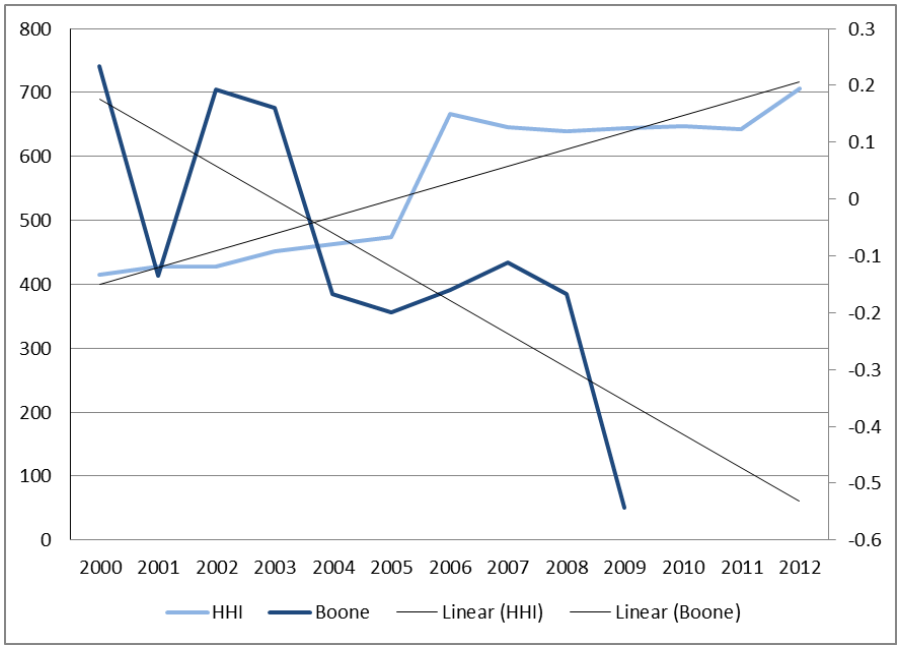

Figure 2: Relationship HHI – Boone indicator

However, according to the theory, a negative relationship between the Boone indicator and the HHI is expected. Two analyses test the relationship between both variables. Given the sample period, one must remain cautious about strong inferences from the correlation coefficient and results of the simple regression.

First, the correlation between both variables is calculated. The two indicators should be negatively correlated in order to agree on the direction of the change of competition. Comparing the change of the estimates of the Boone indicator with the change of the HHI statistic (in terms of percentage), both variables are correlated (Pearson correlation) with a coefficient of 0.1828, which is statistically insignificant.

Second, Figure 3 relates the change of the estimates of the Boone indicator to the change of the HHI statistic (both in terms of percentage) over the period 2000-2008. The plot indicates a weakly positive relationship. The outlier corresponds with the year 2006. Again the impact of the merger of Royal P&O Nedlloyd and Maersk Sealand is observable. Discarding the observation of 2006, the relationship between both variables turns negative.

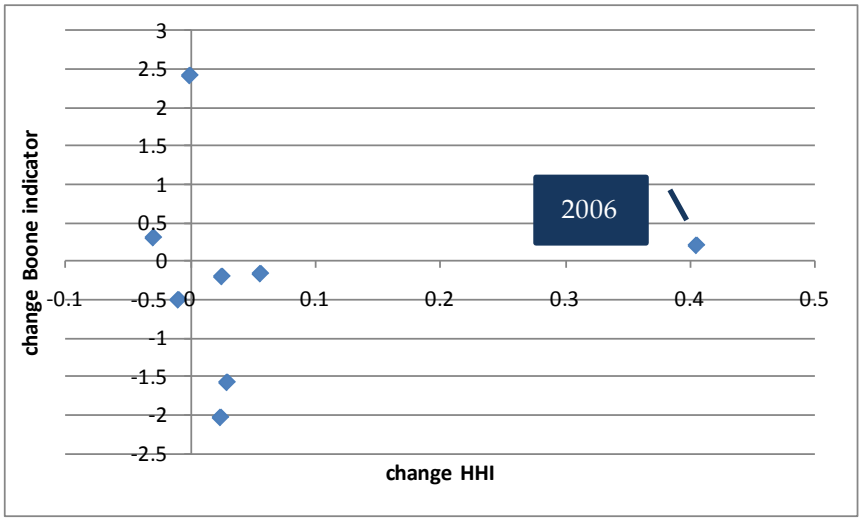

Figure 3: Change HHI versus change Boone indicator

Next, the conceptual difference between the competition measurements is analyzed from a theoretical point of view. A first explanation for the poor coherence might be found in the fact that the Boone indicator and the HHI enclose different information, which may lead to contradictory changes in competition. Also, the observed differences in competition development between the indicators at the industry level can to a degree be traced back to differences in their economic concepts. For instance, a reduction of the coherence between the indicators and the change in competition may be due to more dispersion in efficiency among firms (Creusen *et al.*, 2006). The latter might be the case in the CLSI. Another explanation for an opposite direction of change in competition might be found in the cost reducing objective of liner operators by deploying larger vessels. This objective has a non-monotone impact on the HHI, but raises the Boone indicator. Last, if aggressive conduct affects in any way the market shares of inefficient firms (reallocation effect), this effect may bias the HHI (Boone, 2000; Griffith *et al.,* 2005). At the level of the industry, aggressive conduct is not directly observable.

Given that the change in the concentration indicator for the CLSI is positive, Table 3 summarises the impact of underlying determinants across the indicators (compiled from Creusen *et al.*, 2006).

Table 3: Economic implications

Change in concentration indicator: positive		
Change in Boone indicator	Change in competition is caused by	
	positive (efficiency more rewarded)	intensifying competition is caused by - more strategic interaction - more product substitutability
	negative (efficiency less rewarded)	weakening competition is caused by - less entry, due to higher fixed costs (more emphasis on scale economies)

Figure 0-4: Economic implications

The change in the Boone indicator is positive in the 2003-2005 period. According to Creusen *et al.* (2006), the change in competition might be caused by more strategic interaction and/or more product substitutability (i.e. more liner carriers offering more services to the Far East).

In contrast, the subsequent two years point to a weakening in competition. Then, the explanation could be found in less entry.

For the year 2008, the change in the Boone indicator is again positive, while the concentration ratio is slightly decreasing. More entry is the economic implication when the change in the Boone indicator is positive (efficiency more rewarded) (see Table 3). Since end 2009, this phenomenon is observable. New competitors (e.g. MBG Shipping[15], December 2009; The Containership Company, April 2010; Cyprus-registered Rasiacon, July 2010; Hainan Pan Ocean, Aug. 2010) seek new opportunities. These new ventures are helped by the market conditions, which enable them to pick up the vessels and containers at highly competitive daily charter/rental rates. This might announce the start of a new period with more competition. If so, the policy change searched for by shippers with the objective of intensifying competition (i.e. abolishment of block exemption) will be achieved.

Further research is needed to understand the effect of the policy change, the financial and economic downturn as well as the recent new ventures.

With respect to the second question, the HHI has been increasing till the year 2007 (see Table 2). However, it never exceeded the value of 1,000. According to the theory, the latter suggests a competitive market. But, Boone (2000 and 2004), Griffith *et al.* (2005), Creusen *et al.* (2004 and 2006) and van Leuvensteijn *et al.* (2007 and 2013) state that the HHI fails as a reliable competition indicator since its relation with competition is not always straightforward. Competition can be intensified in two ways: (i) more firms in a market as a consequence of a fall in entry barriers and (ii) more aggressive conduct by incumbent firms. Analysis of the effects of both these ways of intensifying competition on the HHI explains why a widely applied measure such as the HHI is less efficient. Regarding the first way, the standard intuition of the HHI is based on a Cournot model with symmetric firms. A fall in entry barriers is an exogenous shock that intensifies competition and consequently lowers the HHI. The effect is correctly measured by the HHI. The problem with the HHI as an indicator of competition concerns the second way. More aggressive behaviour by established firms may force inefficient firms out of the market (selection effect of competition). This increase in concentration incorrectly indicates a decrease in competition. Whereas, the Boone indicator is monotone in competition both when competition becomes more intense through a fall in entry barriers and when there is more aggressive interaction between firms.

CONCLUSION

The issue of competition in the CLSI has much interest by the liner carriers and shippers in recent years, not least because of the financial and economic crisis. The present paper analyzes the degree of competition in the CLSI based on Boone's theoretical work. This indicator requires knowledge of the cost elements. Given that data on average variable cost are not ready available, the question arises whether the Herfindahl-Hirschman Index is a good alternative measure. Therefore, the paper focuses on the coherence between the Boone indicator and the Herfindahl-Hirschman Index. To do this, first, both measures are examined and discussed.

[15] January 2010, MBG Shipping failed and exited the market. The Container Ship Company went bankrupt in July 2011. Both facts are not yet visible in the dataset of the Boone indicator.

With respect to the first research question, the findings suggest that the indicators do not agree on the direction of change in competition.

First, after analyzing the most important concentration measure, viz. the **HHI**, it can be concluded that the CLSI is characterized by increased concentration. According to the structural approach, then, it is implicitly accepts that a more concentrated market is less competitive.

Second, since concentration measurements are ambiguous measures of competition, a non-structural model is introduced to collect empirical evidence on the nature of competition in the container liner shipping industry by observing conduct directly. Non-structural models do not depend on concentration. The **Boone indicator** allows one to measure how competition in the CLSI evolves over time. Therefore, a firm-level panel dataset of 20 liner operators was compiled. The analysis involves the period from 2000 to 2008. The present study estimates the relation between market shares and average variable costs (both in logarithms) adding explanatory variables for industry-specific effects (the growing number of services driven by globalisation, the introduction of larger container vessels).

Several findings emerge from the empirical analysis. In terms of the degree of competition, the first finding is that competition increased over the 2000-2008 period. Over the 2002-2003 period, the leading liner operators enjoyed profits while subsequently competition has intensified. This finding corresponds with the analysis of the evolution of the profitability in the first part of the paper. Intensified competition forces the competitors to set low prices. Only efficient firms with a technological advantage (lower operating costs due to the deployment of larger vessels) as well as having a large network of services over (inefficient) competitors can attain profits. In a more competitive market, liner operators are hurt more severely for being inefficient. By theory, inefficient liner operators are forced to exit the market. Secondly, the other explanatory variables have a significantly positive impact on the profits (proxied by market shares). Finally, it is very important to check for quality differences and industry-specific effects in order to estimate the Boone indicator accurately.

In order to answer the second question, the paper also examines and discusses the coherence between the Boone indicator and the Herfindahl-Hirschman Index. The analysis of the relationship between the both measures suggest that the Boone indicator is a more preferred indicator to establish how competition involves over time.

The contribution of the present paper to the debate of competition in the container liner shipping industry is fourfold. First, it documents and estimates a new consistent indicator to measure competition over time in the CLSI. Secondly, the paper shows that the Boone indicator helps to understand the effects of competition and efficiency on the liner operators' behaviour. Thirdly, it also controls for industry-specific effects on the change in competition. Correcting for industry-specific effects appears to be very important to attain the appropriate sign. Finally, the Boone indicator is interesting for policy makers who want to enhance competition or for regulators to see whether competition indeed increases over time after a policy change.

Regarding future research, monitoring and evaluating the effect of changes in competition is a first direction for future research. In addition, further research is needed to check whether the results also stand for a longer sample period. A critical reflection might concern the short time horizon of the research. In general, the containerised liner shipping industry suffers from a lack of long time-series data.

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APPENDIX: OVERVIEW LITERATURE

Study (in chronological order)	sample characteristics	industry	dependent variable	independent variable
2000 |Boone, J.				
2000 |Boone, J. & J. Weigand	1978-1992	Manufacturing industries	relative values of profit	proxy: average variable cost/revenu
2004 |Boone, J.		Manufacturing industries	absolute values of profit	proxy: average variable cost/revenu
2004 |Creusen, H., B. Minne & H. van der Wiel	manufacturing, 1978-1999 construction, 1982-1999 market services, 1987/93-1999	Manufacturing construction market services	relative values of profit	proxy: average variable cost/revenu
2005 |Griffith, R., J. Boone & R. Harrison	UK, 1986-1999	Pharmaceutical industry supermarkets	absolute values of profit	proxy: average variable cost/revenu
2006 |Creusen, H., B. Minne & H. van der Wiel	1993-2001	Dutch manufacturing industry and service sector	absolute values of profit	proxy: average variable cost/revenu
2007 |Boone, J., J. van Ours & H. van der Wiel	1993-2002	Dutch market	absolute values of profit	average variable costs
2007 |Maliranta, M., M. Pajarinen, P. Rouvinen & P. Ylä-Anttila	1994-2004	Business sectors	operating profits (different functional form)	average variable costs (different functional forms)
2007 |van Leuvensteijn, M., J. Bikker, A. van Rixtel & C. Sørensen	EU countries + UK, US and Japan 1994-2004	Banking industry: loan markets	market share	estimate of marginal cost (MC)
2008 |van Leuvensteijn, M.	1890-1914	Sugar industry	market share	MC
2008 |Bikker, J. & M. van Leuvensteijn	1995-2003	life insurance industry	relative values of profit or market shares	estimate of MC or proxy: average cost
2008 |Roos, T.	2006-2007	Electricity sector	absolute values of profit	MC
2009 |Maslovych, M.	2005-2008	Loan market in Ukraine	market share	estimate of MC or proxy: average cost
2010 |Schaeck, K. & M. Cihák	European banks: 1995-2005 U.S. banks: 2005	Banking industry	ROA	proxy: average cost
2010 |Roengpitya, R.	1994-2004	Banking industry: loan markets	market share	estimate of MC (fixed effects)
2010 |Braila, C., G. Rayp & S. Sanyal	1997-2004	Manufacturing and non-manufacturing industries	difference between a firm's revenue and its variable cost	proxy: ratio of variable cost and operating revenue (or turnover)
2010 |Schiersch, A. & J. Schmidt-Ehmcke	1995-2006	German manufacturing firms	absolute values of profit	proxy: average variable cost/revenu
2010 |van Leuvensteijn, M., J. Bikker, A. van Rixtel & C. Sørensen	EU countries + UK, US and Japan 1994-2004	Banking industry: loan markets	market share	estimate of marginal cost (MC)
2010 |Boon, J. & M. van Leuvensteijn	1890-1914	Sugar industry	market share	MC
2011 |Devine, H., Doan, T., Iyer, K., Mok, P. & P. Stevens	2000-2009	New Zealand industries	profits	average variable costs
2012 | Doan, T.	2000-2009	Vietnam industries	profits	average variable costs
2013 | van Leuvensteijn, M., Sørensen, C., van Rixtel, A. & J. Bikker	1994-2004	Banking industry	market share	MC
2013 | Clerides, S., Delis, M. D. & S. Kokas	1997-2010	Banking sector	market share	MC