SESO STUDIECENTRUM VOOR ECONOMISCH EN SOCIAAL ONDERZOEK

Some empirical relations between tonnage, dimensions and cargo capacity for a sample of modern ships

Walter NONNEMAN

werknota 7215/764

december 1972

Universitaire Faculteiten St.-Ignatius
Prinsstraat 13 - 2000 Antwerpen

D/1972/1169/11

In this paper we derive some empirical relations for moderns ships between their tonnage, dimensions and cargocapacity. Such relations can be used for estimating the maximal accesibility of port structures such as locks, quays, etc. in terms of t.d.w. (1), or to built a ship dimension generator in order to facilitate port planning (2). Also in estimating a technical capacity index for ports (3), these relationships can be used.

1. THE SAMPLE

From Fairplay (4) we draw a sample of 301 different ships under construction. Within the sample different groups are distinguished. For each ship the following data are gathered:

1. deadweight tonnage;
2. overall length in meters;
3. extreme beam in meters;
4. draught in meters;
5. cargo capacity (see further).

The following vessel groups are distinguished.

1.1. Dry cargo vessels: This group consists of 134 open and closed shelterdeck vessels. Bulk carriers i.e. ships defined as single-deck vessels of 12.000 tdw and over, with machinery aft, are excluded here. They form a distinct group (see 1.3). Within this category containerships with a cargo capacity of less than 300 containers are included. The smallest vessel in the sample measures 1.400 tdw; the largest 17.700 tdw.

---

(1) See E. HUNTER and T.B. WILSON, The increasing size of tankers, bulkcarriers and containerships with some implication for port facilities, National Ports Council, Research and Technical Bulletin, 1969, nr.5, p. 187-224.

(2) See A.W. DEAZELY, Basic features of a ship dimension simulator, Dock and Harbour Authority, December 1971, p. 339-340.

(3) See A.S. SVENDSEN, Sea Transport and Shipping Economics, Weltschiffahrtsarchiv, Heft 5, Bremen 1958, p. 83-87.

(4) World Ships on Order, Supplement to Fairplay, 26th August 1971.

Three different cargo capacity measurements are available. For 56 ships grain space, for 51 bale space and for 27 container capacity (1) are given. Table 1.1 gives the vessel types within this category.

Table 1.1. Dry cargo vessels: types

Types	Numbers of vessels with cargo capacity in terms of			Total
	grainspace	bale space	containers	
dry cargo vessel	36	9	-	45
cargo liner	3	15	-	18
part container ship	12	19	-	31
part refrigerated	3	6	-	9
heavy lift vessel	1	-	-	1
ore carrier(<12.000t)	1	-	-	1
limber carrier	-	2	-	2
container/trailer	-	-	15	15
container/part refrigerated	-	-	4	4
container ship	-	-	8	8
Total	56	51	27	134

1.2. Container ships: In this group 47 vessels with a container-capacity of 300 or more ISO-20 ft. containers are included. The tonnages in the sample range from 8.000 tdw till 50.000 tdw. Table 1.2. summarizes the different types.

Table 1.2. Containerships: types

Types	Number of vessels
container/part refrigerated	17
container/trailer	7
container/liner	23
Total	47

(1) Grain space and bale space are in cubic metres. Container capacity is in numbers of 20 ft. ISO-containers.

1.3. Bulk carriers: 75 ships defined as single-deck vessels of 12.000 tdw and over, with machinery aft are in this group. Their capacity is measured in terms of grain space. The smallest carrier is 13.200 tdw; the largest 79.500 tdw. Table 1.3. indicates the types included.

Table 1.3. Bulk carriers

Types	Number of vessels
bulk carrier	29
ore carrier	31
bauxite carrier	1
bulk carrier, self unloading	1
vehicle carrier	5
container carrier	4
timber carrier	2
wood-pulp/sulphuric acid carrier	1
sulphur carrier	1
Total	75

1.4. Tankers: Miscellaneous tanker types - total number 45 - with sizes from 1.500 to 120.000 tdw are included in this group. For the types see table 1.4.

Table 1.4. Tankers

Types	Number of vessels
asphalt tanker	2
chemical tanker	2
sulphuric acid tanker	1
LPG tanker	1
solvents carrier	1
bunkering tanker	1
tanker	9
crude oil tanker	6
chemical/oil tanker	2
products tanker	16
vegetable oil tanker	1
wine tanker	3
Total	45

2. REGRESSIONS

2.1. Dimensions vs. tonnage

For each group of vessels the following equations are estimated

$$\lg Y = \alpha + \beta \lg T + \varepsilon$$

with Y = length (L), beam (B) and draught (D) in meters
T = tonnage in dwt
lg = natural logarithm
α, β = constants
ε = disturbance.

The estimates are summarized in table 2.1. As we can see all estimates are highly significant. From these equations we can derive following conclusions:

1. the effect of a one percent increase in tonnage on the length of a containervessel is greater(viz. 0.442%) than for other vessels (ca. 0.32%).
2. the effect of a one percent increase in tonnage on the beam of dry cargo vessels is smaller(viz. 0.25%)than for other vessels (viz. ca. 0.30%).
3. the effect of one percent increase in tonnage on draught is greatest for dry cargo vessels (viz. 0.35%)and smallest for tankers (viz. 0.25%).

Table 1.1. Summary of regressions on dimensions

	vessel types	regression	corr. coef.	standard error of estimate
1. Length	dry cargo vessels	lgL=1.935+0.327 lgT (0.014)	0.90	0.114
	containerships	lgL=0.976+0.442 lgT (0.028)	0.92	0.076
	bulk carriers	lgL=1.986+0.313 lgT (0.015)	0.92	0.055
	tankers	lgL=1.928+0.313 lgT (0.077)	0.98	0.064
	all vessels	lgL=1.955+0.324 lgT (0.007)	0.93	0.131
2. Beam	dry cargo vessels	lgB=0.709+0.248 lgT (0.014)	0.90	0.114
	containerships	lgB=0.408+0.295 lgT (0.027)	0.86	0.072
	bulk carriers	lgB=0.160+0.297 lgT (0.014)	0.93	0.049
	tankers	lgB=0.130+0.306lgT (0.007)	0.99	0.058
	all vessels	lgB=0.496+0.272lgT (0.006)	0.93	0.110
3. Draught	dry cargo vessels	lgD=-1.149+0.352 lgT (0.092)	0.96	0.076
	containerships	lgD=-0.908+0.320 lgT (0.015)	0.96	0.041
	bulk carriers	lgD=-0.454+0.274 lgT (0.010)	0.96	0.035
	tankers	lgD=-0.296+0.248 lgT (0.026)	0.83	0.212
	all vessels	lgD=-0.671+0.295 lgT (0.006)	0.95	0.106

2.2. Capacity vs. tonnage

The estimated regressions are of the following type

$$\lg Y = \alpha + \beta \lg T + \varepsilon$$

where Y = grainspace (GC), bale space (BC), container capacity (CC), and liquid capacity (LC);
T = tonnage in dwt.;
lg = natural logarithm;
α,β = constants;
ε = disturbance

Table 2.2. gives the estimations

Tabel 2.2. Summary of regressions on cargo capacity

	vessel type	regression	corr. coef.	standard error of estimate
1. Grain space	dry cargo vessels	lgGC=0.215+1.015 lgT (0.042)	0.96	0.213
	bulk carriers	lgGC=1.026+0.924 lgT (0.016)	0.99	0.058
	both	lgGC=0.743+0.952 lgT (0.013)	0.99	0.159
2. Bale space	dry cargo vessels	lgBC=0.092+1.033 lgT (0.051)	0.94	0.194
3. Container capacity	dry cargo vessels	lgCC=-0.307+0.671 lgT (0.167)	0.63	0.366
	containerships	lgCC=-2.370+0.951 lgT (0.068)	0.90	0.184
	both	lgCC=-2.951+1.007 lgT (0.030)	0.97	0.276
4. Liquid capacity	tankers	lgLC=-0.388+1.061 lgT (0.020)	0.99	0.162

The following conclusions can be drawn.

1° Grain space varies approximately proportional (1.015) with dw tonnage in case of dry cargo vessels (0.924).
An F-test was performed for testing the hypothesis of equality between the coefficients of the regressions, but it does not lead to a decisive answer.

2° Bale space varies approximately proportional (1.033) with dwt tonnage.

3° Container capacity varies significantly less with tonnage for dry cargo vessels (0.671) than for containerships (0.951).
An F-test indicates a significant difference between the two regressions.

4° Liquid capacity varies approximately proportional with the tanker dwt.