Statistical Analysis and Determination of Regression Formulas for
Main Dimensions of Container Ships based on IHS Fairplay Data

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This report shows the results of the analysis of IHS Fairplay main data for container ships. All possible outliers have been left out (obvious errors in data) as described in following document:

Data Analyses – Standard Vessel Determination. Tankers, Bulk Carries and Container Vessels. Project no. 2010-56. Work Package 2, Report no. 01. University of Southern Denmark. Author: Marie Lützen

Container ships have been categorized in following 3 groups:

1. Feeder ships (TEU < 2900)
2. Panamax ships (1900 < TEU < 5300)
3. Post Panamax ships (TEU > 4000)

The equations found by regression analysis are shown for each individual ship sub type. The equations are basis for the generic ship design model for determination of main dimension and propulsion characteristics for all types of container ships – in the following called 'DTU and SDU model'.

As can be seen there is some overlap between the three sub categories. The Panamax ships have a breadth limitation of 32.2 m, an operational draught limitation of 12.0 m and a max overall length of 294.10, which define the upper limits of this group. The same is valid for Post Panamax ships with respect to a lower limit, as all ships with a breadth more than 32.2 m are categorized as Post Panamax ships.

In the coming years the Post Panamax group will be subdivided in two parts by the coming Panama Canal limitations which will be valid from 2014, when the new Panama Canal is expected to be opened. The new limitations on Panamax ships in the future will be as follows (Marine Technology 2011): Length overall: 366.00 m, breadth: 49.00 m, draught: 15.24 m
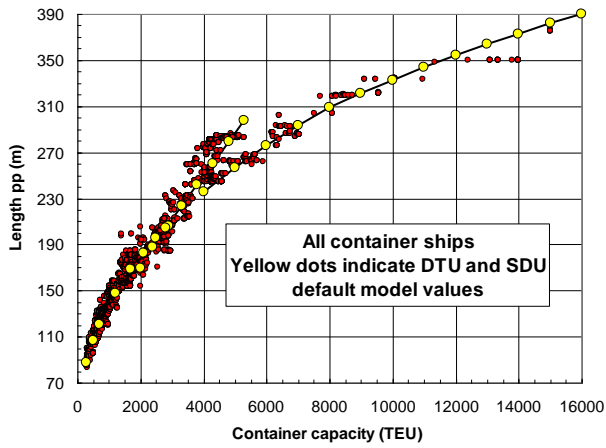
List of Appendices

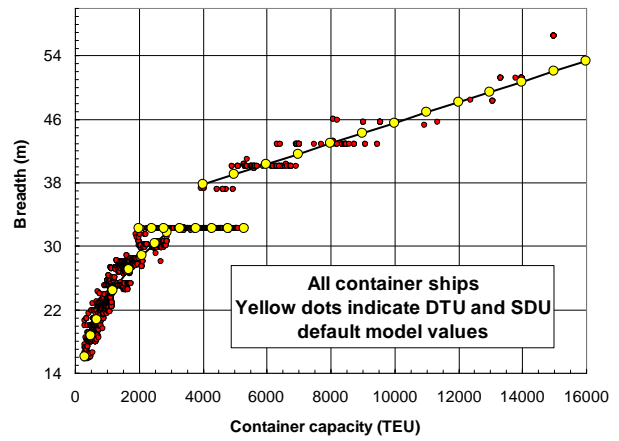Fig. 1 Length between pp as function of TEU

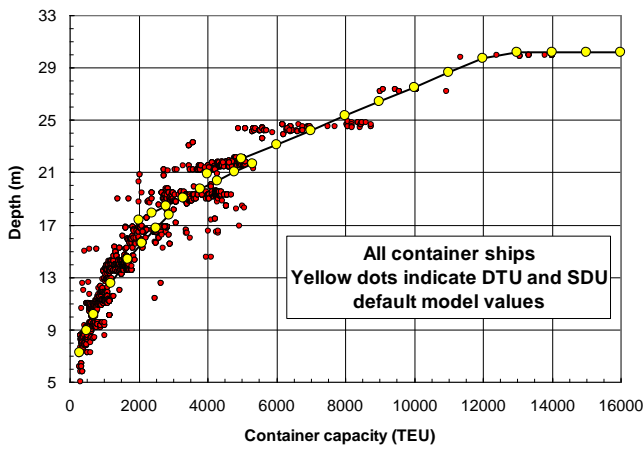Fig. 2 Breadth as function of TEU
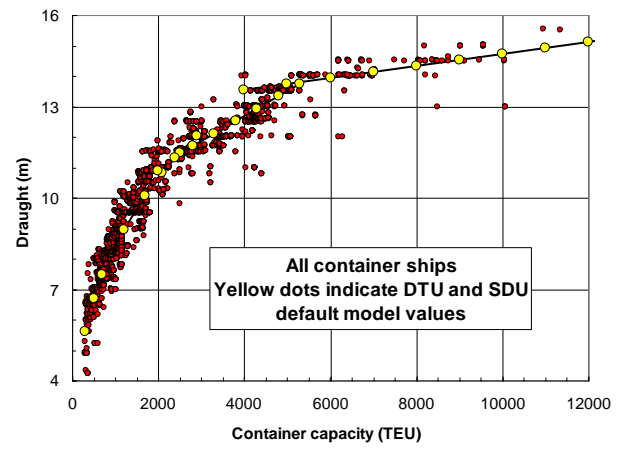

Fig. 3 Depth as function of TEU

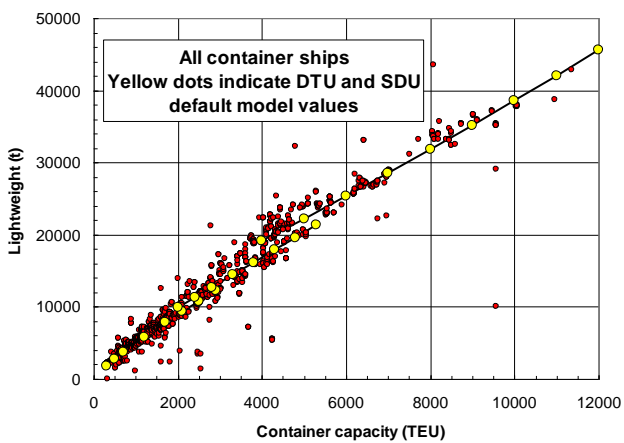Fig. 4 Maximum draught as function of TEU

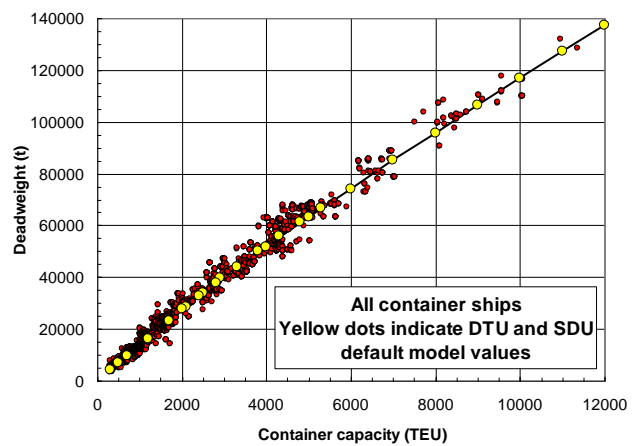Fig. 5 Lightweight as function of TEU
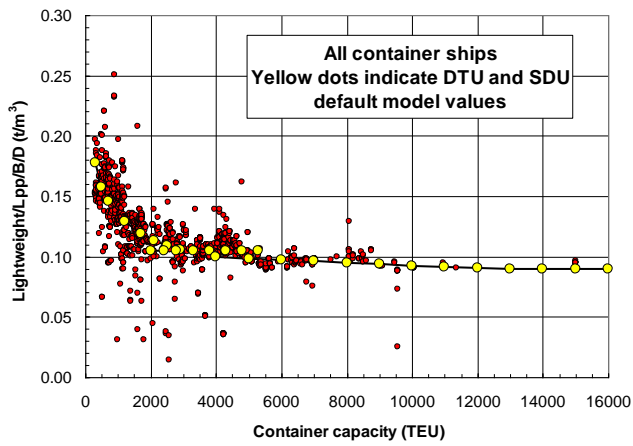

Fig. 6 Deadweight as function of TEU

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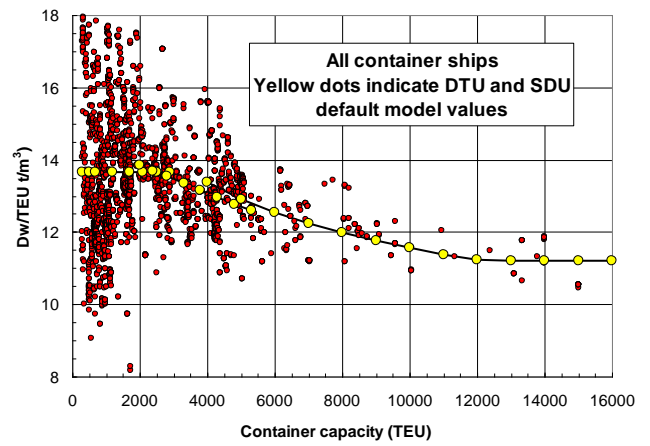Fig. 7 Lightweight coefficient as function of TEU

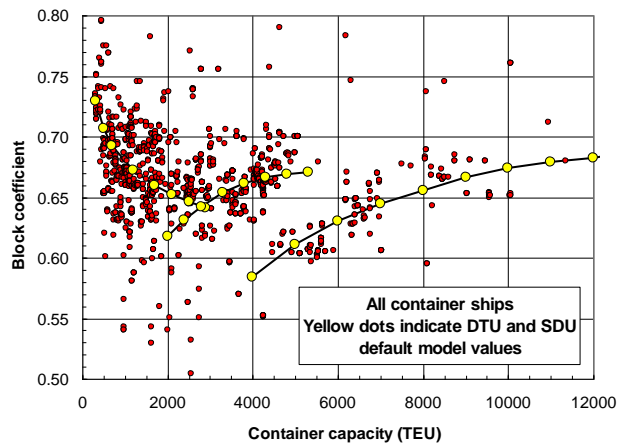

Fig. 8 Deadweight/TEU as function of TEU
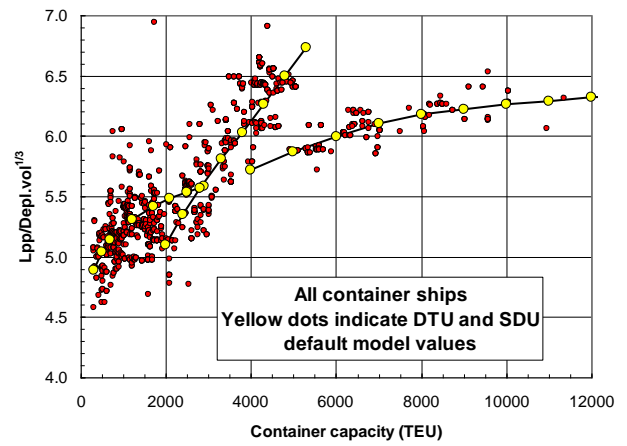

Fig. 9 Block coefficient as function of TEU

Fig. 10 Length displacement ratio as function of TEU

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Appendix A - Small container ships (< 2900 TEU)

Length pp $= 10.14 * TEU^{0.378}$

Breadth $= 2.9 * TEU^{0.3}$

Depth $= 0.767 * TEU^{0.394}$

Draught $= 0.827 * TEU^{0.336}$

Lightweight/Lpp/B/D $= 0.659 * TEU^{-0.23}$
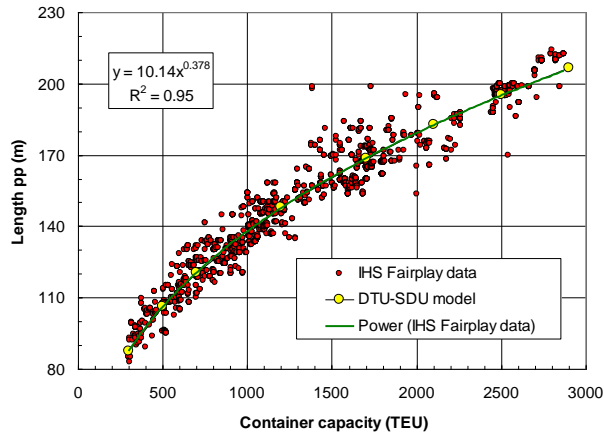
Deadweight/TEU $= 13.65$

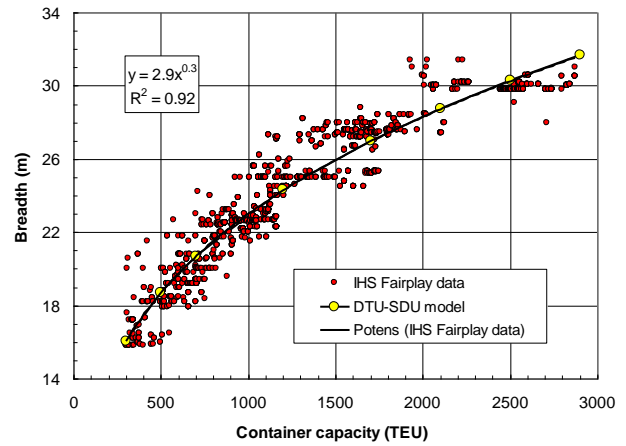Fig. A1 Length between pp as function of TEU
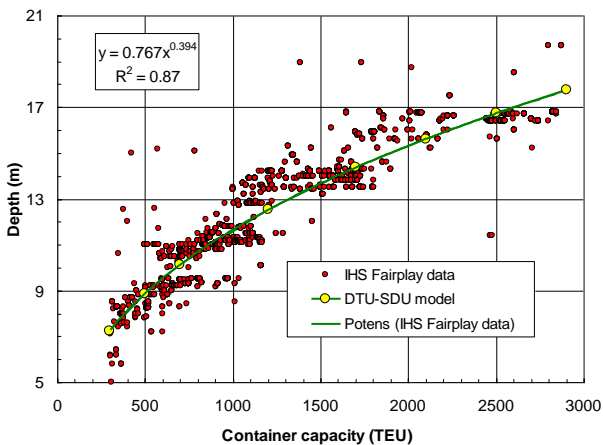

Fig. A2 Breadth as function of TEU

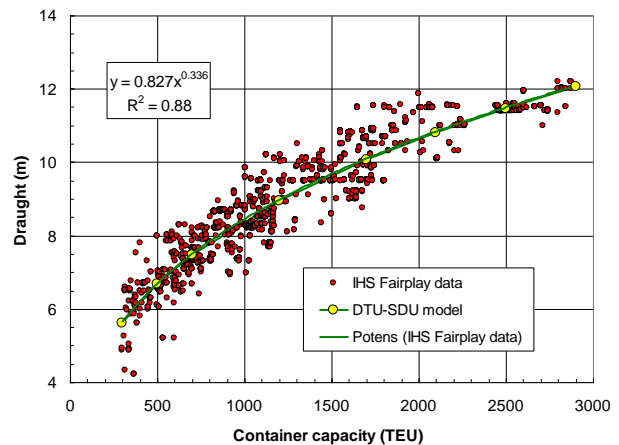Fig. A3 Depth as function of TEU

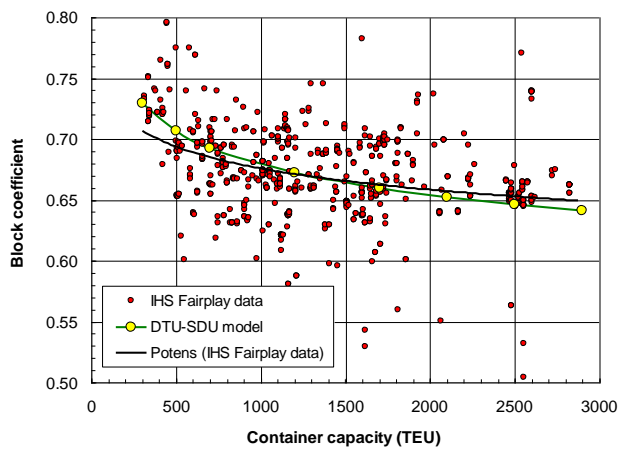
Fig. A4 Maximum draught as function of TEU

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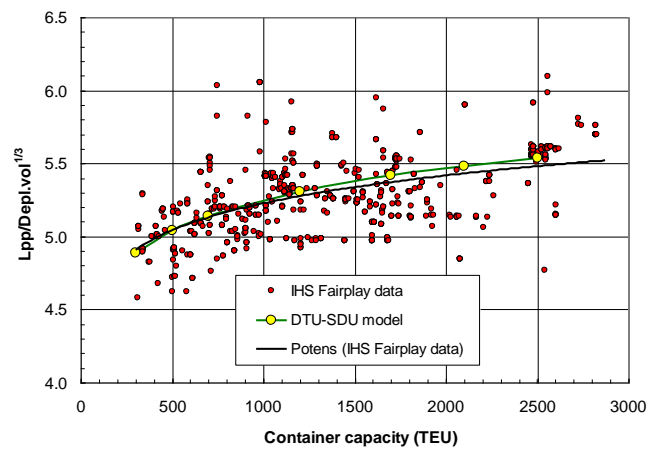Fig. A5 Block coefficient as function of TEU

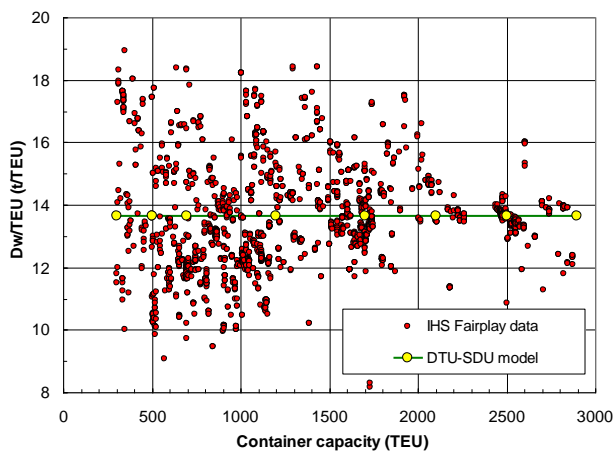Fig. A6 Length displacement ratio as function of TEU
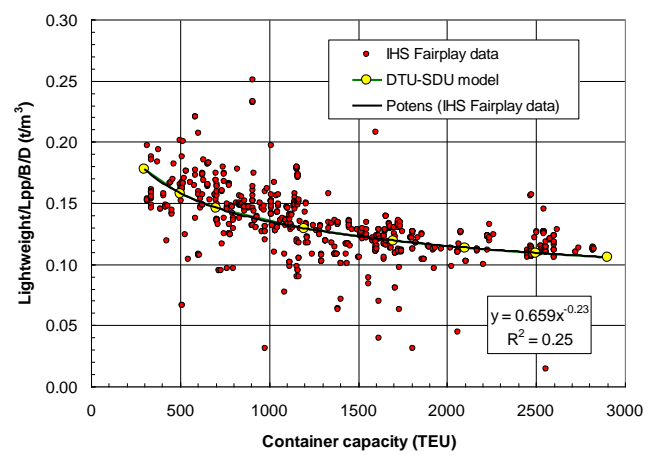

Fig. A7 Deadweight/TEU as function of TEU

Fig. A8 Lightweight coefficient as function of TEU

Appendix B – Panamax container ships (1900 – 5300 TEU)

Length pp	$= 2.494 * TEU^{0.555}$ (< = 3800 TEU)
Length pp	$= 241.92 + (TEU – 3800) * 0.037$ (>3800 TEU)
Breadth	$= 32.22$ m
Depth	$= 14.77 + 0.0013 * TEU$
Draught	$= 2.19 * TEU^{0.211}$ (<= 3300 TEU)
Draught	$= 12.1 + (TEU – 3300) * 0.00082$ (> 3300 TEU)
Lightweight/Lpp/B/D	$= 0.105$
Deadweight/TEU	$= 14.6 – 0.00038 * TEU$

The regression formulas for the length and the draught have been split into two formulas respectively, in order to obtain the best possible curve fit, for length and draught. These adjustments were also carried out to obtain the best fitted values for the block coefficient and the length displacement ratio, which are calculated indirectly on basis of all the regression formulas, for the main dimensions and the weights.
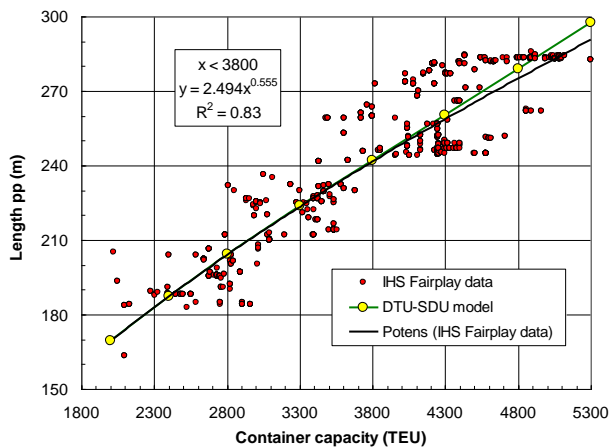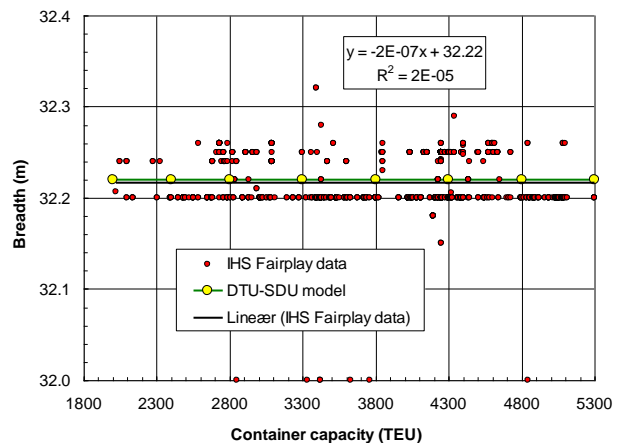

Fig. B1 Length between pp as function of TEU
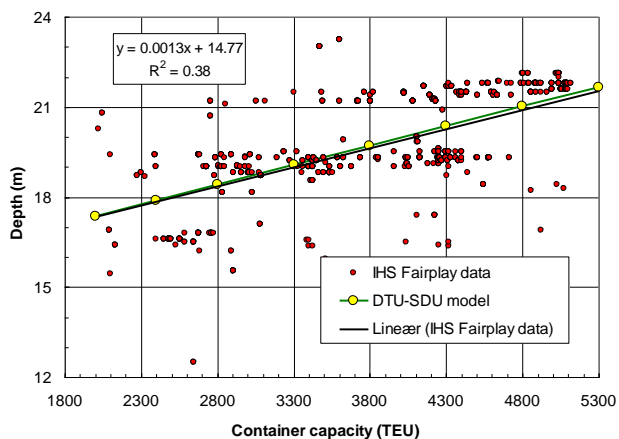

Fig. B2 Breadth as function of TEU

Fig. B3 Depth as function of TEU

$y = 0.0013x + 14.77$
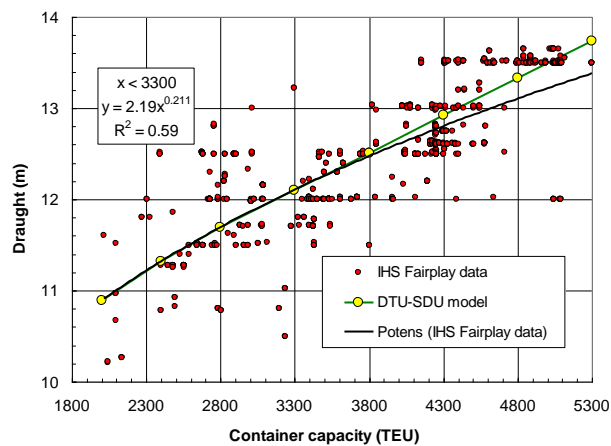$R^2 = 0.38$

- IHS Fairplay data
- DTU-SDU model
- Lineær (IHS Fairplay data)

Depth (m)

Container capacity (TEU)

Fig. B4 Maximum draught as function of TEU

$x < 3300$
$y = 2.19x^{0.211}$
$R^2 = 0.59$

- IHS Fairplay data
- DTU-SDU model
- Potens (IHS Fairplay data)

Draught (m)

Container capacity (TEU)

Fig. B5 Block coefficient as function of TEU

- IHS Fairplay data
- DTU-SDU model
- Potens (IHS Fairplay data)
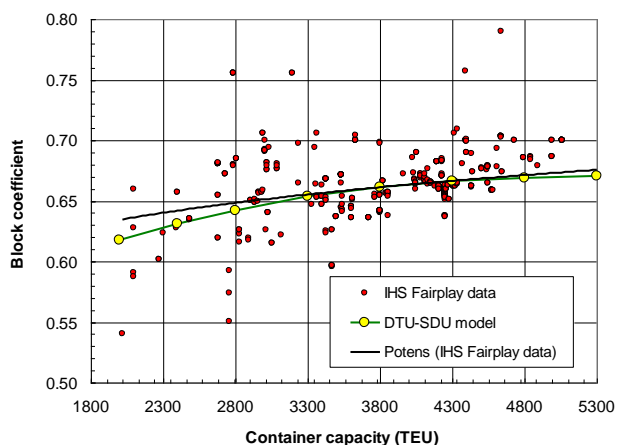
Block coefficient

Container capacity (TEU)

Fig. B6 Length displacement ratio as function of TEU

- IHS Fairplay data
- DTU-SDU model
- Potens (IHS Fairplay data)

$Lpp/Depl.vol^{1/3}$
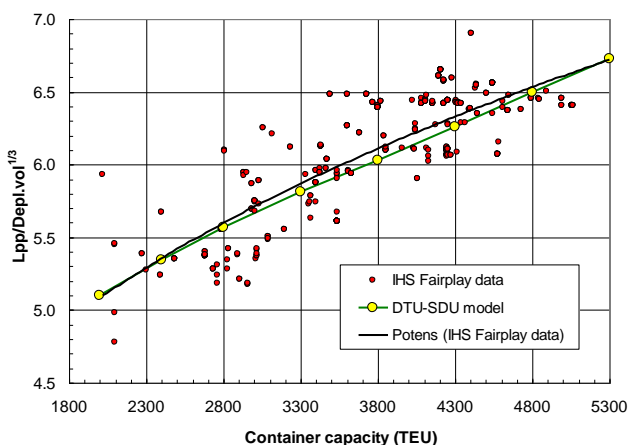
Container capacity (TEU)

Fig. B7 Lightweight coefficient as function of TEU

$y = 2E-06x + 0.0999$
$R^2 = 0.005$

- IHS Fairplay data
- DTU-SDU model
- Lineær (IHS Fairplay data)

$Lightweight/Lpp/B/D$ (t/m³)
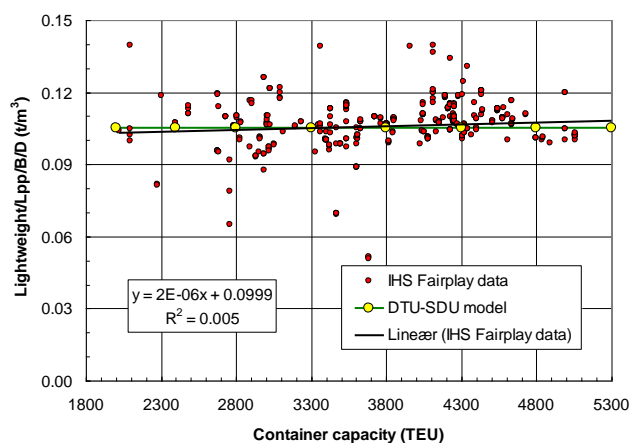
Container capacity (TEU)

Fig, B8 Deadweight/TEU as function of TEU

$y = -0.00038x + 14.6$
$R^2 = 0.06$

- IHS Fairplay data
- DTU-SDU model
- Lineær (IHS Fairplay data)

Dw/TEU (t/TEU)

Container capacity (TEU)

Appendix C – Post Panamax container ships (> 4000 TEU)

Length pp $= 131.31 + 0.03012 * TEU - 0.00000099556 * TEU^2$ (<= 8000 TEU)

Length pp $= 14.66 * TEU^{0.339}$ (> 8000 TEU)

Breadth $= 32.51 + 0.0013 * TEU$

Depth $= MIN(30.2, 16.5 + 0.0011 * TEU)$

Draught $= 12.73 + 0.0002 * TEU$

Lightweight/Lpp/B/D $= MAX(0.09, 0.104 - 0.00000115 * TEU)$

Dw/TEU $= MAX(11.2; 50.43 * TEU^{-0.16})$

The regression formula for the length has been split into two formulas, in order to obtain the best possible curve fit, for the length. This adjustment was also carried out to obtain the best fitted values for the block coefficient and the length displacement ratio, which are calculated indirectly on basis of all the regression formulas, for the main dimensions and the weights.

Fig. C1 Length between pp as function of TEU

Fig. C2 Breadth as function of TEU

Fig. C3 Depth as function of TEU

Fig. C4 Maximum draught as function of TEU

Fig. C5 Block coefficient as function of TEU

Fig. C6 Length displacement ratio as function of TEU
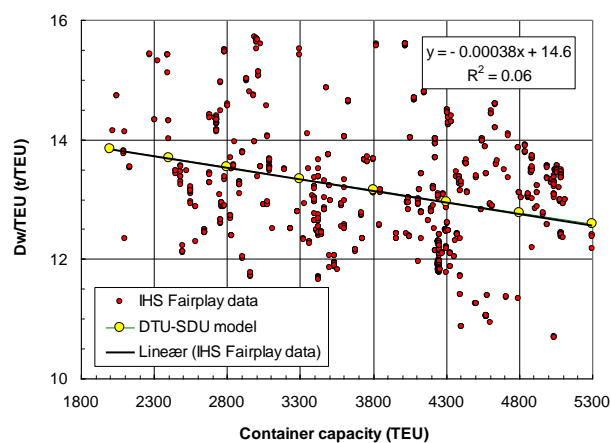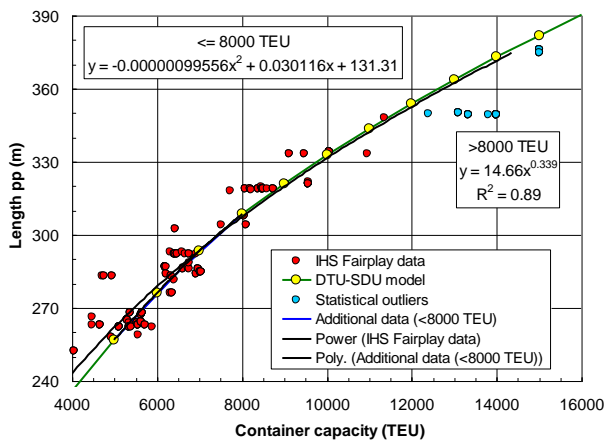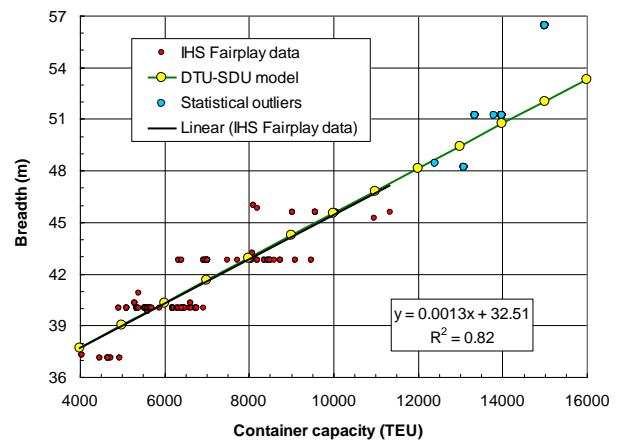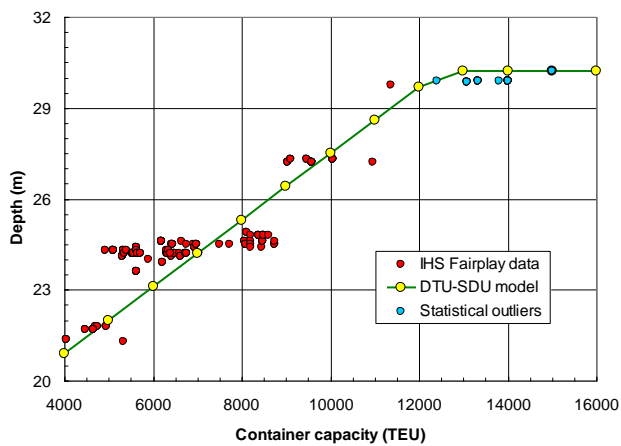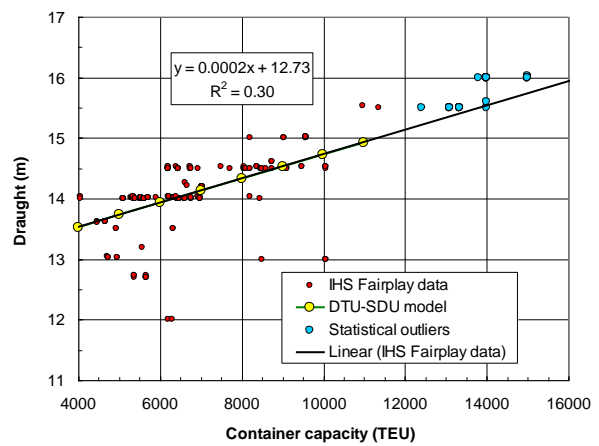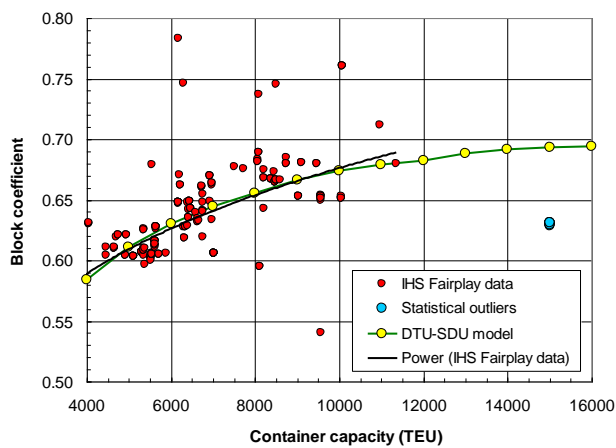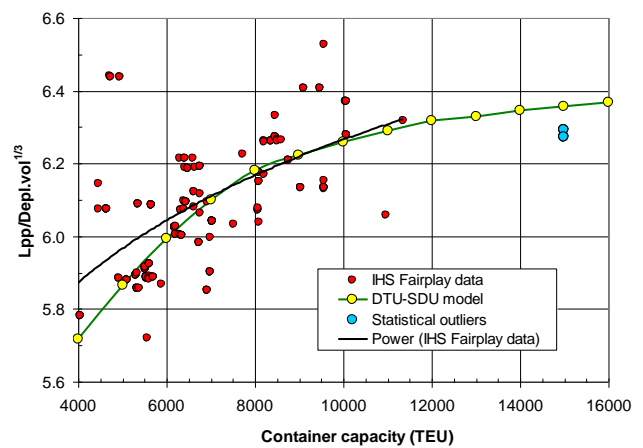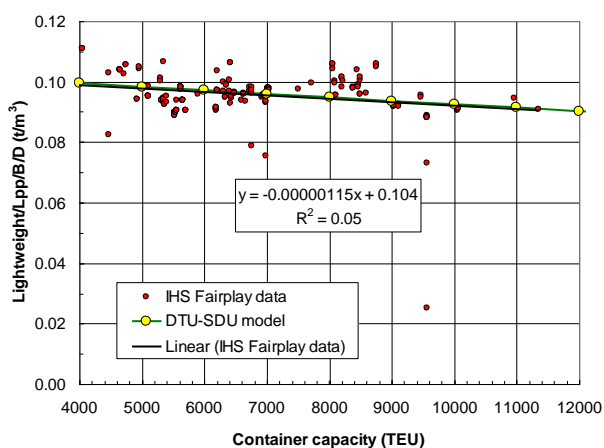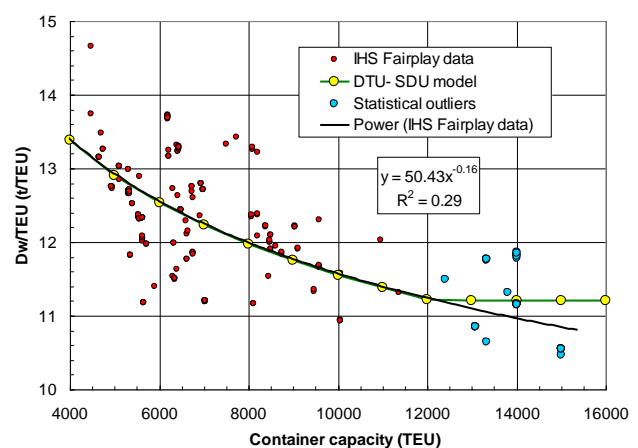

Fig. C7 Lightweight coefficient as function of TEU

Fig. C8 Deadweight/TEU as unction of TEU

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Appendix D – Water plane area coefficient and draught change

The water plane area coefficient, Cw, at maximum draught, for container ships is shown in Fig. D1 for ships in the IHS Fairplay data base.

Cw depends on the block coefficient, Cb, as follows:

Cw = 0.55 + 0.45 Cb

where Cw and Cb are calculated on basis of the length between pp.
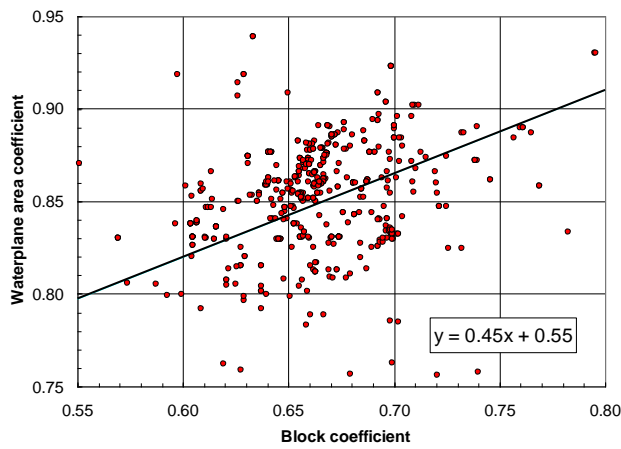

Fig. D1 Water plane area coefficient as function of the block coefficient for container ships (IHS Fairplay)
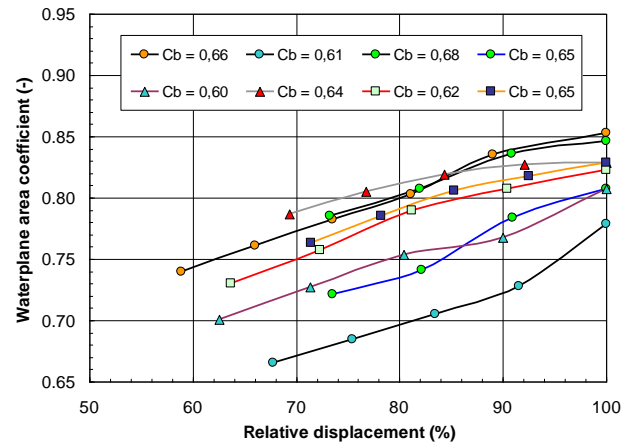

Fig. D2 Water plane area coefficient as function the relative displacement

In Fig. D2 is shown the water plane area coefficient as function of the relative displacement for some container ships, for which more detailed information has been available. Based on the results in Fig. D2, the water plane area coefficient at a displacement Δ2 can be approximated as follows:

$$Cw(\Delta 2) = Cw(\Delta 1) - 0.28 \cdot \left(1 - \frac{\Delta 2}{\Delta 1}\right) = [0.55 + 0.45 \cdot Cb(\Delta 1)] - 0.28 \cdot (1 - \frac{\Delta 2}{\Delta 1})$$

It is important to know the how the water plane area coefficient depends on the displacement as it is used to calculate the draught change due to change of the displacement.

Maximum/scantling draught and design draught

All data presented in this report are presented as function of the maximum deadweight.

Normally two draughts are specified for container ships, namely the design draught and the scantling draught. The design draught is the draught at which the ship is expected to operate normally, while the scantling draught is the maximum permissible draught according to the class rules. Comparison of scantling draught data (Significant Ships, 1990 – 2010) with summer load line draught data (denoted maximum draught in this report and in the IHS Fairplay data base) shows

that the summer load line draught is nearly identical with the scantling draught (Fig. D3). The summer load line is the maximum permitted draught at which both stability and strength requirements are fulfilled, i.e. it is maximum draught approved by the Maritime Authorities.

The design draught is less than the scantling draught, which is shown in Fig. D4 based on data for 255 container ships from Significant Ships (1990 – 2010). Regression formulas for determination of the design draught as function of TEU have been developed as follows (see Fig. D5):

Design draught $\qquad$ = MIN(12; 1.188 * TEU$^{0.279}$) $\qquad$ for Panamax and feeder ships

Design draught $\qquad$ = 4.83 * TEU$^{0.11}$ $\qquad$ for Post Panamax ships
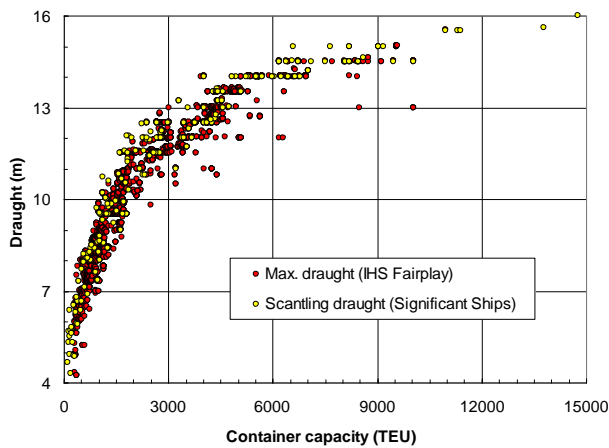

Fig. D3 Maximum draught for container ships (IHS Fairplay) compared with scantling draught according to Significant Ships (1990 – 2010)
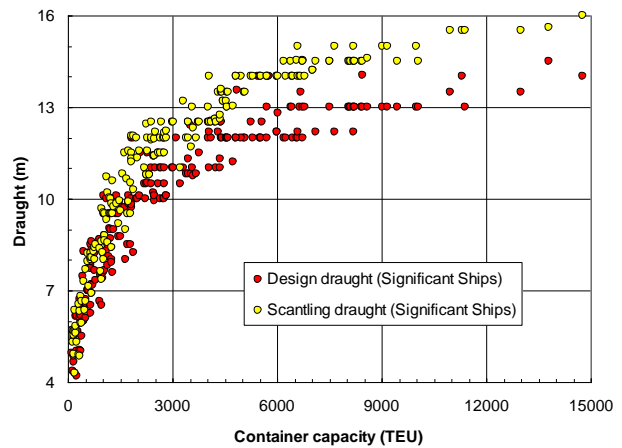

Fig. D4 Design draught versus scantling draught for container ships according to Significant Ships (1990 – 2010)
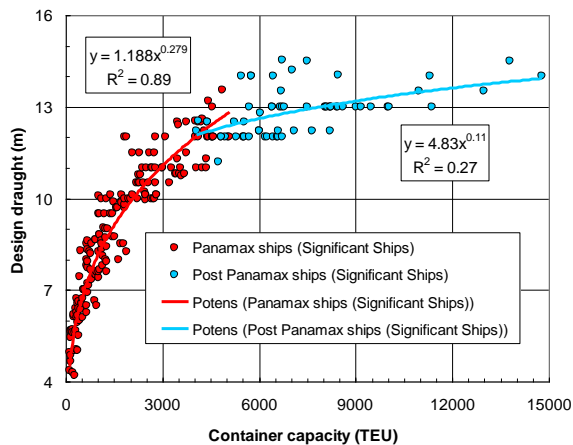

Fig. D5 Design draught for container ships according to Significant Ships (1990 – 2010)
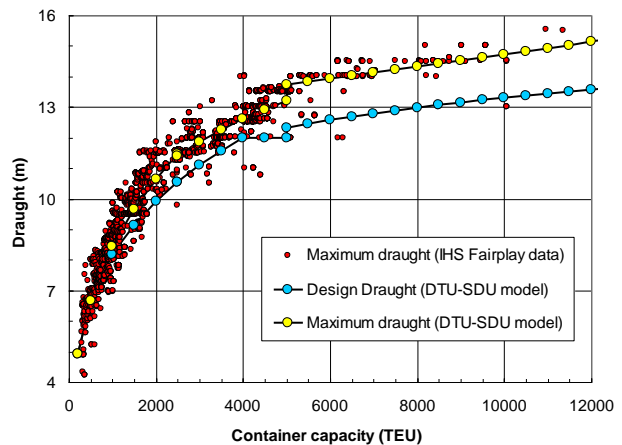

Fig. D6 Design and scantling draught according to DTU-SDU model

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For container ships, the design displacement is 85 % to 90 % of the maximum displacement which means that *Cw ~ 0.45 · Cb + 0.55.* The design deadweight can then be calculated according to this approximate formula:

$$DWT_{design} = DWT_{scantl.} - \left(T_{scantling} - T_{design}\right) \cdot Lpp \ \cdot \ B \cdot [0.45 \cdot Cb(scantling) + 0.55] \cdot \rho_{salt\,water}$$

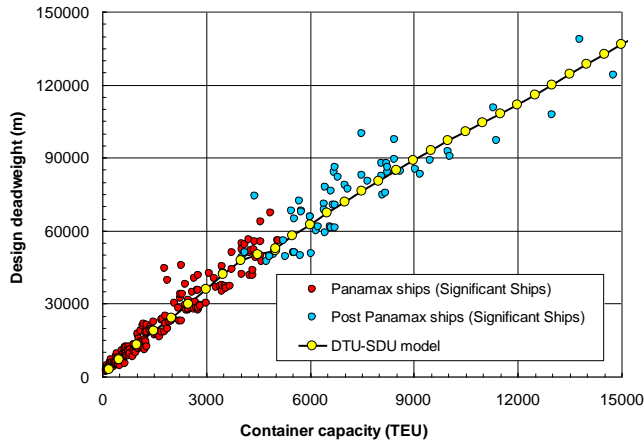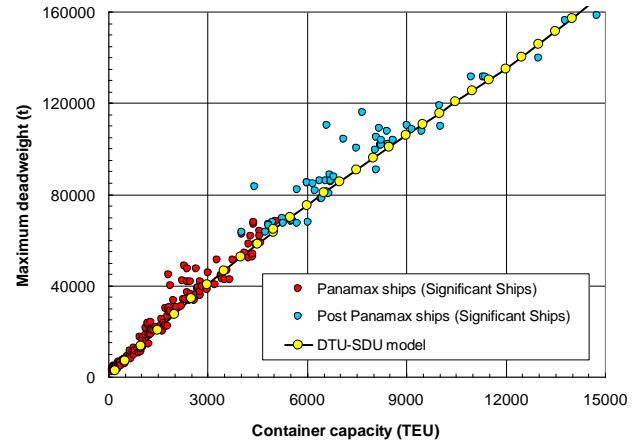The resulting design deadweight is shown in Fig. D7, where it is compared with design deadweight data from Significant Ships (1990 – 2010).

Fig. D7 Design deadweight

Fig. D8 Maximum deadweight