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GUIDE TO ONLINE CALCULATION TOOL – LINER SHIPPING ON THE NSR

CBS MARITIME

CROSS DISCIPLINARY PROBLEM-FOCUSED RESEARCH AND EDUCATION IN THE MARITIME INDUSTRY CONTEXT

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In the context of the CBS Maritime mapping project on the commercial opportunities and challenges for the maritime industry following the opening in the Arctic, an online calculation tool was developed. This calculation tool allows researchers and industry professionals to insert the specifications of a given vessel, along with environmental and economic parameters in order to obtain information on the feasibility of transporting containerized cargo along the NSR. Specifically, the model allows the user to determine the year when the investment in an ice reinforced containership operating along the NSR during the navigation (and the SCR at other times), will become favorable compared to an ordinary container ship solely operating on the SCR. This is done by calculating the total and annual costs per TEU of each vessel. These values are compared resulting in a ratio, which allows for the estimation of the critical point at which the costs per TEU of the ice reinforced vessel becomes advantageous compared to the open water vessel that solely operates on the SCR. Based on this, the creation of detailed scenarios can help to understand how different factors influence the feasibility of transport using the NSR. Integrated into the calculation tool is the ship calculation tool made by Hans Otto Kristensen which allows for the determination of vessel fuel consumption given user determined values of speed, vessel engine size, engine type, capacity utilization and hull specifications. This gives the calculation tool a high degree of prediction power while still maintaining significant customization options. The calculation tool is available for download free of charge on the CBS Maritime homepage (http://www.cbs.dk/viden-samfundet/business-in-society/cbs-maritime/downloads).

The following is a guide on how to successfully utilize the program. It includes a detailed explanation of the results, layout and cells in which data can be entered. The user interface is divided into three sheets with the first being the front page, the second page containing the major input as well as illustrating the results, and the third allowing for the alterations of specific cost and time variables.

1.1 FRONT PAGE

The front page serves as a brief introduction to the calculation tool and lists the economic and environmental assumptions creating the framework of the calculations behind the model, along with a short description of the incorporated fuel price projections.

The user initiates the calculation by clicking on the picture located in the left side columns. The program will automatically redirect the user to the input and result section after clicking on the picture.

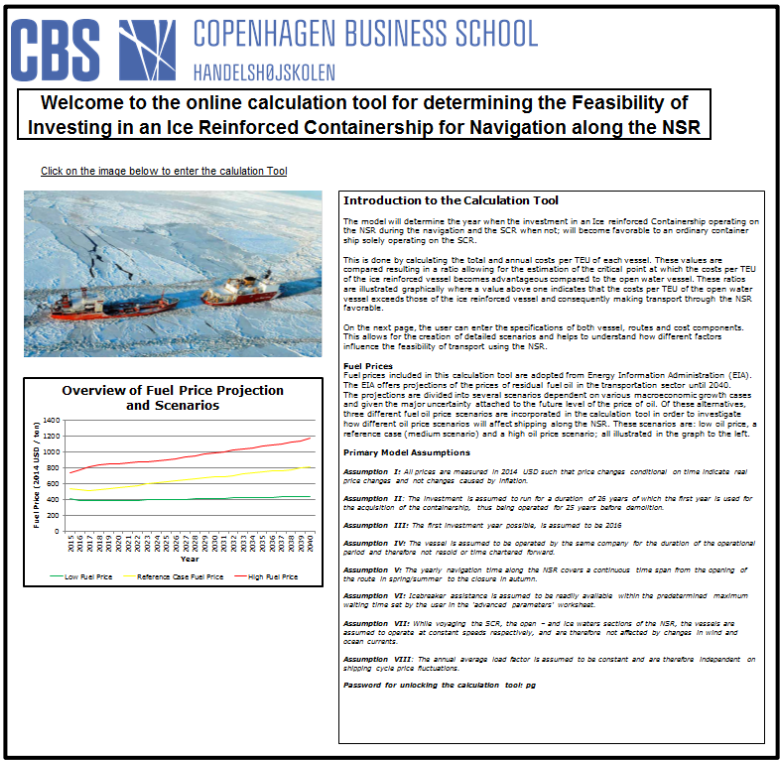

Figure 1: Calculation tool front page

1.2 RESULTS PAGE

The "*Results*" page allows the user to insert the primary variables and presents the results of the calculations. The left side column labelled "*Input*" contains the input cells where the user can specify the primary inputs of the vessels and routes, as well as financial valuations.

The results in the middle columns are divided into two sections. The top section of the middle columns are the "*Total cost per TEU*", listing the first year where the investment in the ice reinforced containership will become advantageous to that of an ordinary open water vessel, measured in total costs per TEU. The lower section labelled "*Annual costs per TEU*" lists the first year where the annual operation costs per TEU of the ordinary containership exceeds those of the ice reinforced vessel. The third section labelled "*Illustration*" on the right side columns graphically depicts the results achieved from the middle section by listing both the ratios of the total and annual costs per TEU depending on the year, of the two containerships examined.

Finally, this page features two buttons; the orange button takes the user back to the Front-page, allowing for the selection of a ship in another segment. The green button titled "*Advanced Parameters*" redirects the user to the advanced settings page where the user can change the values of different cost components for each of the vessels examined.

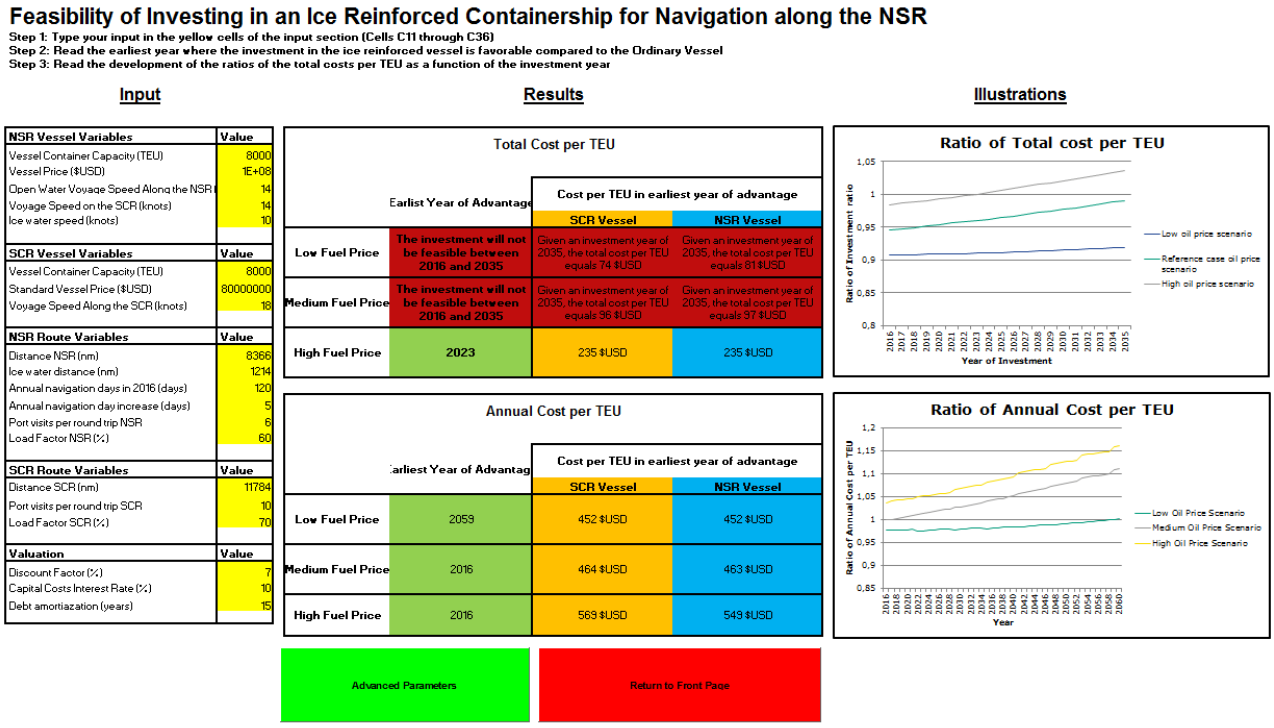

Figure 1: Calculation tool results page

1.2.1 Input section

The input section lists the values of the most vital primary and secondary variables required to calculate the optimal fuel strategies. The cells in which the user is encouraged to enter specific values are marked by the colour yellow.

The input cells require the following input:

NSR vessel variables:

- **C10:** Enter the maximum TEU capacity of the ice reinforced vessel, measured in number of TEU.
- **C11:** Enter the new building price of the ice reinforced vessel, measured in $USD.
- **C12:** Enter the average sailing speed in the open water sections of the NSR measured in knots.
- **C13:** Enter the average sailing speed of the ice reinforced vessel when voyaging the SCR, measured in knots.
- **C14:** Enter the average sailing speed in the ice water section of the NSR, measured in knots.

SCR vessel variables:

- **C17:** Enter the maximum TEU capacity of the ordinary (i.e. non-ice reinforced) vessel, measured in TEU.
- **C18:** Enter the new building price of the ordinary vessel, measured in $USD.
- **C19:** Enter the average sailing speed of the ordinary vessel, measured in knots.

NSR Route Variables:

- **C22:** Enter the average distance of the NSR, measured in nautical miles per voyage.
- **C23:** Enter the average distance of ice covered waters[1] along the NSR, measured in nautical miles per voyage.
- **C24**: Enter the amount of navigation days along the NSR in year 2016, measured in days.
- **C25:** Enter the annual increase in navigation days along the NSR after year 2016, measured in days (example: entering the value "3" will result in an annual increase in navigation days of 3).
- **C26:** Enter the amount of port visits of a round trip when navigating the NSR.
- **C27:** Enter the average capacity utilization of the ice reinforced vessel when navigating the NSR, indicated by a number from 0 to 100, where 100 indicates full utilization.

SCR Route variables:

- **C30:** Enter the average distance of the SCR, measured in nautical miles per voyage.
- **C31:** Enter the amount of port visits of a round trip when navigating the SCR regardless of the vessel type.
- **C32:** Enter the average capacity utilization when navigating the SCR regardless of the vessel type (see C27).

Valuation:

- **C35:** Enter the annual discount factor used for the calculations of the total cost per TEU as a function of investment year, measured in percentages (example: for 8 percent insert the value "8").
- **C36:** Enter the annual interest rate used for determining the annual debt payments of the investment in each of the two vessels, measured in percentages (example: for 10 percent insert the value "10").
- **C37:** Enter the number of years over which the vessel investment costs are amortized, measured in years.

[1] Ice covered waters means, in this case, parts of the NSR where the vessels has reduced speed due to ice, whether it is fast ice, pack ice, or small floes.

1.2.2 Results Section: Total Cost per TEU

The upper middle section in the range E9:H22 calculates the point in time when the total costs per TEU of the investment in the ice strengthened vessel is favorable to the total costs per TEU of the investment in an open water vessel that solely navigates the SCR. The earliest year where such an investment is advantageous is presented in column F, given the three different fuel price scenarios, while the corresponding total costs per TEU for the ordinary and ice reinforced vessels are listed in columns G and H, respectively. If the investment does not become feasible prior to year 2036, the calculation tool will report so and list the total costs per TEU for each vessel given an investment year of 2035; the latest investment year possible given the timespan of this study.

A colour code is attached to each strategy in order to easily recognize how different input variables may change the strategy rankings. The colour codes are as follows:

- Investment is favourable before 2036 (green).
- Investment will not be favourable prior to 2036 (red).
- Total investment costs per TEU for the open water vessel (orange).
- Total investment costs per TEU for the ice reinforced vessel (blue).

1.2.3 Results Section: Annual Cost per TEU

The lower middle section in the range E25:H39 calculates when the annual costs per TEU of the ice strengthened vessel will become favorable to those of the open water vessel that solely navigates the SCR. The earliest year where the annual costs per TEU if the ordinary vessel exceeds those of the ice reinforced vessel is presented in column F, given the three different fuel price scenarios, while the corresponding annual costs per TEU for the two vessels are presented in the columns G and H, respectively. If the annual costs per TEU of the ice reinforced vessel will not be lower than those of the ordinary vessel prior to year 2060, the calculation tool will report so and list the total costs per TEU for each vessel in the year of 2060; the latest operational year given the timespan of this study.

A colour code is attached to each of the cells in the middle columns, in order to easily recognize how different input variables may change the feasibility of operating the ice reinforced vessel. These colour codes are as follows:

- Annual cost per TEU is favourable before 2060 (green).
- Annual cost per TEU will not be favourable before 2060 (red).
- Annual cost per TEU for the open water vessel (orange).
- Annual costs per TEU for the ice reinforced vessel (blue).

1.2.4 Graphical Illustrations

The results presented in the middle section are derived from the two graphs on the right side columns which illustrates the total and annual costs per TEU of the ice reinforced vessel relative to the open water vessel. More specifically, the upper and lower graphs illustrate the ratios of the cost per TEU comparisons (vertical axis) as a function of vessel investment year and annual operational costs, respectively (horizontal axis), given the three different oil price scenarios incorporated

into the analysis. These ratios are calculated by dividing the costs per TEU of the ordinary open water vessel with the costs per TEU of the ice reinforced vessel. A ratio above one therefore indicates that the costs per TEU of the ice reinforced vessel are lower than those of the ordinary vessel and vice versa. Consequently, the point where the value of the curves exceeds values of one determines the first year where the investment or operation of the ice reinforced vessel results in a lower cost per TEU.

1.3 ADVANCED SETTINGS

The "*Advanced Settings*" page allows for the customization of the values of different fixed and variable cost components of the two vessels examined. Additionally, the advanced settings allow for the alteration of values determining the average wait time when transiting the Suez Canal and the NSR. The input cells are all marked with yellow and located in the left side column which is divided into three subsections labelled "*Speed Variables*", "*Ordinary Vessel Costs*" and "*Ice reinforced Vessel Costs*".

Finally, this page features two buttons; the green button labelled "*Return to results*" takes the user back to the results page and will include the user defined alterations to the variables. The orange button labelled "*Reset to Defaults*" resets all the variables on the sheet to their default values and formulas (this may be useful if the results show inconsistent results).
Several of the input cells include standard formulas for the calculation of the cost components that automatically approximate realistic values based on the vessel sizes. The user is encouraged to overwrite these formulas by entering predetermined values of the different cost components.

1.3.1 Speed Variables:

This section contains variables influencing the transit speed of the two routes examined by allowing the user to approximate the average waiting times encountered by the vessels when transiting the Suez Canal and the ice covered waters of the NSR. The changeable input cells require the following input:

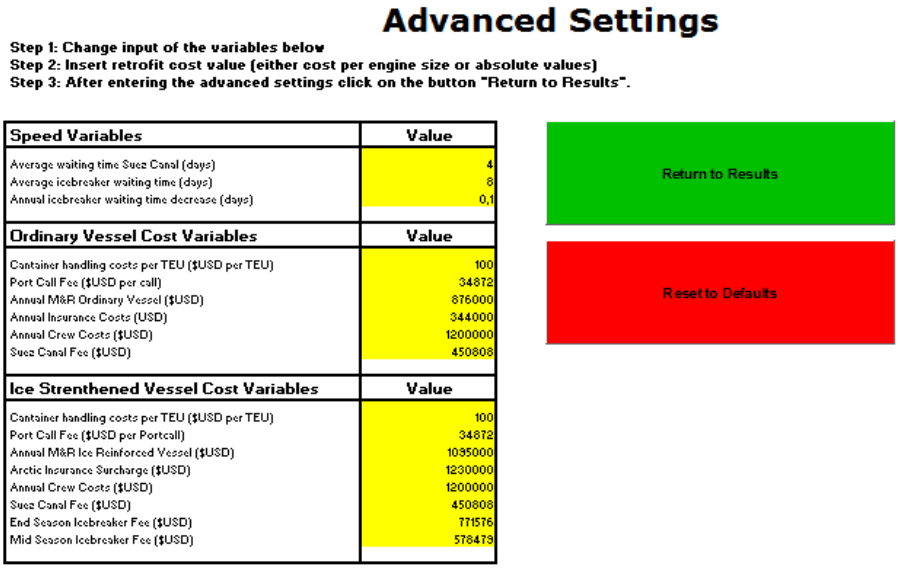

Figure 3 Calculation tool advanced settings page

- **C9:** Enter the average waiting time encountered when transiting the Suez Canal, measured in days.
- **C10:** Enter the average waiting time encountered when waiting for icebreaker assistance on the ice-covered part of the NSR, measured in days.
- **C11:** Enter the annual decrease in the average waiting time encountered when waiting for icebreaker assistance on the ice-covered part of the NSR, measured in days.

1.3.2 Ordinary Vessel Cost Components:

This section contains the default values of the variable and fixed cost components of the ordinary open water vessel, allowing the user to change these into predetermined cost estimations. The changeable input cells require the following input:

- **C14:** The total cost of handling one TEU (loading and discharging), measured in $USD.
- **C15:** Enter the costs incurred when calling at a port (berthing and towage), measured in USD per port call.
- **C16:** Enter the annual maintenance and repair costs, measured in USD.
- **C17:** Enter the annual insurance costs, measured in USD.
- **C18:** Enter the annual crew costs, measured in USD.
- **C19:** Enter the Suez Canal toll of the ordinary vessel, measured in USD.

1.3.3 Ice Reinforced Vessel Cost Components:

This section contains the default values of the variable and fixed cost components of the ice reinforced vessel, allowing the user to change these into predetermined cost estimations. The changeable input cells require the following input:

- **C22:** Enter the cost of handling one TEU (loading and discharging), measured in USD.
- **C23:** Enter the costs incurred when calling at a port (berthing and towage), measured in USD per port call.
- **C24:** Enter the annual maintenance and repair costs of the ice reinforced vessel, measured in USD.
- **C25:** Enter the annual insurance costs for the ice reinforced vessel, measured in USD.
- **C26:** Enter the annual crew costs of the ice reinforced vessel, measured in USD.
- **C27:** Enter the Suez Canal toll of the ice reinforced vessel, measured in USD.
- **C28:** Enter the icebreaker assistance fee during the first and last NSR transit, where additional icebreaker service is needed, measured in USD.
- **C29:** Enter the icebreaker assistance fee during normal transits, where the vessel only required two zones of icebreaker escort, measured in USD per gross tonnage.

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