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A Linear Regression Analysis Was Conducted To Determine The Principal Dimensions of A Prospective Tourist Ship

Budianto[1]

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***Abstract*— The objective of this research is to design a catamaran tourist ship that incorporates green technology. To achieve this, the main dimensions of the ship will be determined using the linear regression method, based on existing data from similar vessels. The empirical data from existing vessels serves as the foundation for the analysis and prediction, thereby enabling the identification of relationships and patterns between the key variables, including length, width, draft, displacement, and passenger capacity. The linear regression method offers several advantages, including simplicity, ease of interpretation, and efficiency in the use of resources. As a result, it is an effective tool for initial analysis before the application of more complex methods. The R^2 value has an average result above 90 percent, so the data can be considered good and valid. The innovative aspect of the design of this tourist ship is the utilisation of data pertaining to existing vessels that have demonstrated optimal performance in their role as tourist ships. The use of existing data not only helps reduce the risk of errors in the design of new vessels but also ensures that the design is efficient and compliant with operational needs and safety regulations. This research confirms the importance of a data-driven approach in the design of environmentally friendly and efficient ships. In the context of ship design and operation, displacement represents a pivotal parameter in linear regression analysis. An understanding of the relationship between displacement and ship performance allows for more accurate predictions regarding speed, fuel consumption, stability, and draft. This allows for the design of ships that are more efficient, stable, and safe, and optimized under a variety of operational conditions.**

Keywords— ship, tourism, green technology, principle dimension, Linear Regression

I. INTRODUCTION

The maritime tourism industry has undergone substantial expansion in recent decades, which has concomitantly elevated the demand for tour boats. Catamarans, with their doub1le-hull design, have been a popular choice due to the enhanced stability, fuel efficiency, and passenger comfort they offer. However, in light of the growing awareness of environmental impacts, there is a pressing need to design a tour boat that is not only efficient but also environmentally friendly. In order to develop a catamaran tour boat that applies green technology, it is ` this process is to ascertain the optimal dimensions of the ship, including its overall length (LOA), width (beam), draft, and displacement, in order to ensure compliance with performance criteria and safety regulations. The utilisation of existing ship data in the determination of these principal dimensions can facilitate the generation of a more accurate and reliable basis. The linear regression method represents an effective tool for the analysis and prediction of the main dimensions of a ship. By employing data from existing vessels, linear regression is capable of identifying relationships and patterns between diverse technical variables, thereby facilitating more exact estimation in the design of novel vessels. The objective of this research is to determine the optimal main size for an effective and efficient tourist ship. The contribution of this research is to calculate the optimal main size for the design of tourist ships using existing data from similar comparison ships. Furthermore, this method offers simplicity and efficiency in the use of resources, making it an appropriate choice for preliminary analysis. The objective of this research is to design a small catamaran tour boat with green technology, using the linear regression method based on existing vessel data to determine the main size of the vessel. It is hoped that through this approach, an optimal and efficient vessel design can be obtained that complies with operational needs and safety regulations, while reducing negative impacts on the environment.

Catamaran stability and efficiency as existing design asserts, catamarans exhibit superior stability compared to monohulls, a quality attributed to their double-hull design [4]. Furthermore, the reduction in water resistance results in enhanced fuel efficiency. The objective of green technology innovation is to develop and implement technologies that reduce the environmental impact of processes and products. In study to examine the potential for green technology innovations to be implemented on ships. They identify several areas of interest, including electric propulsion systems, alternative fuel use, and waste management technologies [1]. The application of linear regression represents an effective statistical methodology for the analysis of relationships between variables and the prediction of the principal dimensions of ships based on historical data. The necessity of regression model validation to guarantee precise and dependable forecasts in the context of ship design. It is imperative that the requirements for the construction of tourist ships be preceded by rigorous

Budianto. Department of shipbuilding engineering, Politeknik Perkapalan Negeri Surabaya, Surabaya, Postal Code 60111, Indonesia. E-mail:budianto@ppns.ac.id.

scientific studies in order to ensure the attainment of effective and efficient design outcomes.

A. Design Review.

The following illustrates the stages involved in the feasibility study process, among others.

- Importance of Empirical Data.
  The research demonstrates that empirical data from existing vessels is indispensable for the validation and optimisation of new vessel designs, furnishing a more precise foundation for analysis and prediction. The reliability of a database used for ship design research is contingent upon the implementation of systematic data collection methods and rigorous data validation.
- Tourist Ship Design Case Study.
  This new research presents a case study of the application of green technology to the design of a tourist vessel. It discusses the challenges and solutions encountered in the design and implementation process, with particular reference to the implementation of green technology [13].
- Sustainable Maritime Design.
  Case Studies in Green Ship Technology, This case study examines the application of green technology to the design of a tourist vessel, elucidating the challenges and solutions encountered during the design and implementation process [5].
- Ship Design Simulation and Validation.
  The Simulation Methodology section delineates the diverse simulation techniques employed to assess and corroborate the feasibility of ship designs. These techniques encompass analyses of stability, hydrodynamic performance, and fuel efficiency. Computational Fluid Dynamics (CFD) testing, CFD simulations are a crucial tool for predicting the hydrodynamic performance of ships and identifying potential issues before the production stage [16].
- Safety and Environmental Regulations.
  The following section outlines the safety and environmental standards that must be adhered to. In order to ensure the safety and environmental compliance of tourist vessels, Lloyd's Register provides guidance on the safety standards and environmental regulations that must be adhered to in the design and operation of such vessels. The international regulations pertaining to emissions and safety have a profound influence on the design process and technological innovation of ships [3].
- Regression Model Development Method.
  This comprehensive guide provides an in-depth examination of the development and evaluation of linear regression models, encompassing a range of techniques, including validation methods and residual analysis [6]. The objective of this study is to present a comprehensive overview of regression analysis as it is employed in the field of engineering research. Montgomery presents a detailed account of the application of regression methods in engineering research, encompassing the development of models and the interpretation of results [17].

B. Research Process.

This research was conducted in several main stages, which involved data collection, data analysis, and the application of the linear regression method to determine the main size of a small catamaran tour boat. The objective of the data collection process is to obtain information regarding the existing ship. The following section is dedicated to the identification of the data source. The collection of technical data is conducted from a variety of reliable sources, including journals, technical reports, and ship databases. The data set comprises the vessel's principal dimensions (length, breadth, draught, displacement), passenger capacity, and maximum speed. The process of ensuring the accuracy and relevance of the data collected for analysis is referred to as data validation. The objective is to ensure that the data collected is accurate and pertinent to the analysis. Incomplete or inconsistent data will be excluded from the analysis.

A statistical description should be conducted in order to gain an understanding of the distribution and characteristics of the existing ship data. The mean, median, and standard deviation are examples of descriptive statistics that can be employed in order to provide an overview of the data [7]. The objective of this study is to identify the key variables that will be used in the analysis. It is necessary to determine which variables are to be used in the linear regression model. These may include overall length (LOA), beam, draft, displacement, passenger capacity, and maximum speed. Application of Linear Regression Method, The objective of this study is to develop a regression model [18] [19] [20]. A model is developed using linear regression techniques to relate key variables to the main size of the ship. The model will facilitate the prediction of the vessel's primary dimensions based on the available input data. Model Evaluation It is essential to evaluate the performance of the regression model using appropriate validation techniques, such as cross-validation and residual analysis, in order to ascertain its accuracy and reliability.

II. Method

The research method stage delineates the procedures to be followed in order to obtain optimal results, which can then be employed as a framework for elucidating the specifics of the research. A review of the literature on ship design reveals the potential of the linear regression method as an alternative means of determining the principal dimensions of a ship. The method has been applied to a variety of ship designs, offering a promising avenue for further investigation. In order to produce a detailed account of the research process, the following steps were undertaken such as :

A. Catamaran Tour Boat Design

The following section will present the application of a regression model. The objective of this study is to determine the optimal main size for a small catamaran tour boat design incorporating green technology, using a regression model developed for this purpose [21]. The objective of Green Technology Integration is to: The

objective is to identify the most suitable green technologies for incorporation into the ship design, including electric propulsion systems, solar panels, and waste management systems [10].

B. Design Testing and Validation

The objective of the simulation and performance analysis is to: A series of simulations should be conducted to assess the performance of the ship design, based on the primary dimensions derived from the regression model. This analysis encompasses an evaluation of the ship's stability, fuel efficiency, and environmental impact. A design revision and optimization process was undertaken. In light of the test results [11] [12], it is imperative to undertake a comprehensive revision and optimization of the vessel design, with the objective of ensuring that the vessel meets all performance, safety, and environmental efficiency criter.

C. Documentation and Reporting

The preparation of the research report is a crucial step in the research process [22] [23]. A research report should be prepared, in which all stages and results of the research are documented. This report includes a comprehensive analysis of the data, regression models, a detailed account of the ship design, and a thorough examination of the test results. The results will be published in due course. It is recommended that research results be published in relevant journals or conferences in order to facilitate the sharing of findings and scientific contributions with the maritime and academic communities.

The primary objective is to ascertain the optimal dimensions of a catamaran tour boat incorporating green technology [3]. This is achieved by a comprehensive analysis of operational requirements, including passenger capacity, cargo space, route type, and design speed. In order to ascertain the most recent design trends and technologies, a process of benchmarking with similar vessels is undertaken. In the preliminary design phase, the overall length (LOA), width (beam), draft, and height of the ship are calculated in accordance with the requisite operational and stability requirements. The utilisation of ship design software and computational fluid dynamics (CFD) analysis for simulation and calculation facilitates the optimisation of hull form and hydrodynamic performance. It is essential to evaluate the scale model in a test pool to ascertain its stability and functionality. Based on the trial outcomes, the design should be refined [14]. The utilisation of environmentally benign propulsion systems, such as electric motors, solar panels, or hybrid engines, in conjunction with the incorporation of energy-efficient construction materials, constitutes an integral aspect of the implementation of green technology. It is imperative that the vessel design is in compliance with the requisite safety regulations.

In order to ascertain the principal dimensions of a ship, it is necessary to employ a process of linear regression, which entails a series of systematic steps. The initial step is to collate historical data on the dimensions of analogous vessels, including the overall length (LOA), width (beam), draft, and displacement. Additionally, related variables such as passenger capacity and design speed should be recorded. It is essential to identify all independent and dependent variables that are pertinent to the analysis. A preliminary correlation analysis should be performed in order to ascertain the relationship between the variables. Subsequently, the least squares method should be employed to estimate the model parameters, including the intercept and regression coefficients. To ensure that the model adequately explains the observed variation in the data, it is essential to evaluate the model using statistical techniques such as the coefficient of determination (R^2) and residual analysis. To prevent overfitting, additional data or cross-validation methods are employed for model validation. Once the model has been validated, the linear regression model may be employed to predict the dimensions of the ship to be constructed based on the aforementioned variables.

In addition to the use of linear regression, there are a number of alternative methods that can be employed to determine the optimal size of a catamaran tour boat in accordance with the principles of green technology. Empirical methods entail the utilisation of historical data and the comparison with analogous vessels, with a view to ascertaining the optimal size. Analytical methods, such as hydrostatic calculations and the use of technical equations, facilitate the calculation of the optimal size based on the principles of balance, stability, and displacement. The utilisation of numerical simulations, such as Computational Fluid Dynamics (CFD) and Finite Element Analysis (FEA), facilitates an in-depth examination of the water flow and the strength of the ship structures, thereby enabling the design to be optimised [9]. Optimization methods employ algorithms such as genetic optimization or particle swarm optimization to identify the optimal size based on fuel efficiency, stability, and construction cost criteria. Modular and iterative approaches, including modular design and prototype testing in test pools, facilitate the evaluation of design performance prior to determining the final size. Heuristic methods, which rely on the expertise and experience of the design team and an exploration of the design space, also play an important role in this process. By integrating these methodologies, ship designers can guarantee that the final vessel size not only fulfills operational and regulatory criteria but also exhibits optimal efficiency and environmental responsibility.

III. Results and Discussion

In the estimation of a vessel's principal dimensions, the application of linear regression offers a number of benefits. First, linear regression employs a relatively straightforward and accessible methodology for modeling the relationship between independent and dependent variables. The equation allows for a clear representation of the relationship between the independent and dependent variables, while the coefficient indicates the predicted change in the dependent variable for each unit change in the independent variable. The results of a linear regression are readily understandable. In comparison to more

intricate methodologies, it is also efficacious with smaller datasets and necessitates minimal computational resources. The application of multiple linear regression enables the simultaneous analysis of the influence of multiple independent variables. It is frequently employed as an initial step to provide an overview before applying more complex methods. Moreover, an understanding of linear regression provides a robust foundation for statistical analysis methods. Moreover, an understanding of linear regression provides a robust foundation for more intricate statistical analysis and machine learning techniques. However, it should be noted that linear regression has certain limitations, particularly in cases where the relationship between variables is not linear or where there are complex interactions. In such instances, it may be necessary to employ alternative methods in order to obtain more accurate results. The following data on catamaran vessels and the application of green technology is presented in Table 1.

TABLE 1
EXISTING SHIP DATA

Ship Name	Loa (m)	B (m)	T (m)	H (m)	Displ. (ton)	Passenger (Pax.)	Vmax (kn)
Breeze	7.0	3.0	0.8	1.9	10.0	6.0	10.0
Horizon	9.0	4.0	1.2	2.8	15.0	10.0	12.0
Sea Star	10.0	4.5	1.3	2.5	18.0	12.0	11.0
Ocean Wave	12.0	5.0	1.5	3.5	22.0	15.0	10.0
Coral Reef	14.0	5.5	1.7	4.1	25.0	18.0	12.0
Wave Rider	16.0	6.0	1.8	4.9	30.0	20.0	10.0
Sea Breeze	18.0	7.0	1.9	4.9	35.0	25.0	10.0
Blue Horizon	20.0	8.0	2.0	4.0	40.0	30.0	12.0

To conduct a linear regression analysis, it is essential to adhere to a series of fundamental steps. The following section provides a general overview of the methodology to be employed when utilising existing data [23] [24] [25] [1].

Step 1: collect data
The initial step is to collect the data. From the data set provided, select the variables that will be subjected to analysis. To illustrate, should one wish to analyse the relationship between ship length (LOA) and displacement, the following steps must be taken:

- The independent variable is represented by the letter X. Overall Length (LOA)
- Variable Y (dependent): The dependent variable is displacement.

Step 2: Plot the Data
A scatter plot graph should be created in order to display the data. Each data point on the graph will represent a single vessel of a specified length and displacement.

Step 3: Calculate Linear Regression
The linear regression method should be employed in order to ascertain the optimal line that fits the data. The linear regression can be calculated using the following formula:

$$Y = aX+b \quad (1)$$

Where:

- Y is displacement
- X is the overall length (LOA)
- a is slope
- b is the intercept (intersection point with the Y axis)

In order to calculate the values of a and b, the following formulas should be employed

$$a = \frac{n(\sum XY)-(\sum X)(\sum Y)}{n(\sum X^2)-(\sum X)^2} \quad (2)$$

$$b = \frac{(\sum Y)-a(\sum X)}{n} \quad (3)$$

Step 4: Construct the Regression Curve
The linear regression line should be plotted on a scatter plot graph in order to ascertain its suitability for representing the data.

Step 5: Interpret Results
Determine how well the linear regression model describes the relationship between the analyzed variables by looking at the coefficient of determination R2 value if required. To calculate the *R*2 (coefficient of determination) value of a linear regression, it is necessary to follow several steps. R2 measures how well the linear regression model explains the variability of the data. With the linear regression model Y= aX + b, calculate the predicted value of Ẏ for each value of X is Ẏi = aXi +b Then calculate the residuals for each data point.

$$\text{Residuals i} = Yi-\dot{Y}i \quad (4)$$

The SST and SSR are employed to quantify the overall variability of the data set.

$$SST= \sum(Yi-\dot{Y})^2 \quad (5)$$

$$SSR = \sum(Yi-\dot{Y})^2 \quad (6)$$

In order to achieve the aforementioned objective, it is necessary to

$$R2 = SSR/SST \quad (7)$$

Ship displacement is a crucial input parameter in linear regression, as it is directly correlated with the total weight of the vessel, encompassing the structure, cargo, fuel, and equipment. The weight of the ship affects its performance in terms of stability, draft, buoyancy, speed, and fuel consumption. Incorporating displacement into a

linear regression analysis enables the investigation of the relationship between ship weight and other performance variables, such as speed and fuel efficiency. Moreover, displacement impacts the stability and balance of the vessel, as well as draft, which determines the ability to operate in shallow waters. The data provided by the comparator ship offers a historical context and an understanding of trends that can be used to comprehend the evolution of ship technology, design, and performance over time. Such knowledge can prove useful in facilitating more accurate predictions and in providing a basis for informed decision-making. A comprehensive recapitulation of the data pertaining to the comparison vessels will be conducted, encompassing information on their respective lengths, widths, and speeds. The aforementioned data will allow for the following to be obtained.

- The estimated regression coefficients illustrate the relationship between the length and width of the vessel and the speed.
- The next step is to test whether the relationship is statistically significant.
- It is essential to validate the model predictions with existing ship data to ensure accuracy.

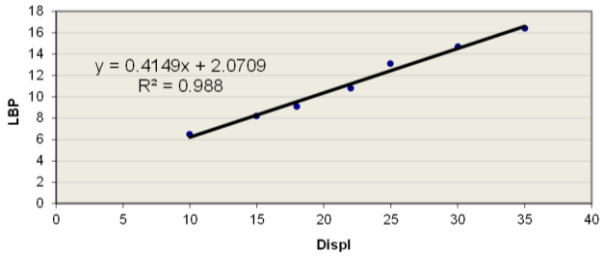

Figure 1 regression chart of displacement - LBP

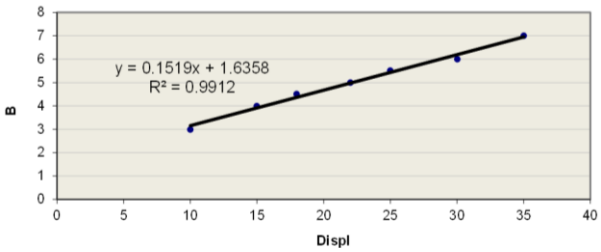

Figure 2 regression graph of displacement - B

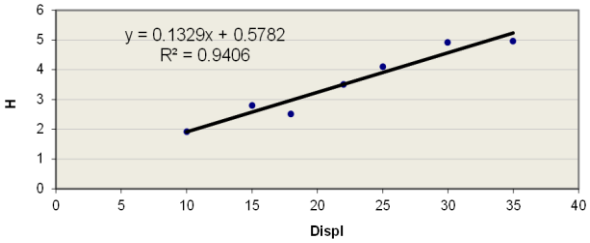

Figure 3 regression graph of displacement - H

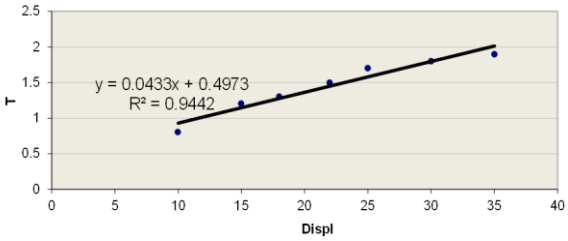

Figure 4 regression graph of displacement - T

IV. CONCLUSION

In the context of ship design and operation, displacement represents a pivotal parameter in linear regression analysis. An understanding of the relationship between displacement and ship performance allows for more accurate predictions regarding speed, fuel consumption, stability, and draft. The R^2 value has an average result above 90 percent, so the data can be considered good and valid. This allows for the design of ships that are more efficient, stable, and safe, and optimized under a variety of operational conditions.

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REFERENCES

[1] N. Manjaji Matsumoto, "Green Technologies in Ship Design and Operation," Maritime Technology and Research, vol. 2, no. 1, pp. 1-12, 2020.

[2] T. Karyono, Setiawan and Budianto, "Construction of Fishing Vessel Molding with A Case Study of Ship Objects for the Java South Sea Region," Bristol UK, 2023.

[3] Budianto, I. Sutrisno and M. B. Rahmat, "Shape Optimization of Remote Operated Vehicle Structure Using Finite Element Method," Journal of Maritime ResearchThis link is disabled., vol. 20, no. 3, pp. 57-61, 2023.

[4] Bertram, Practical Ship Hydrodinamic, Oxford: Butterwort Heinemann, 2013.

[5] Collis and Hussey, Business Research: A Practical Guide for Undergraduate and Postgraduate Students, Palgrave Macmillan, (2009). .

[6] Draper and Smith, Applied Regression Analysis., 1998: John Wiley & Sons.

[7] Faltinsen, Hydrodynamics of High-Speed Marine Vehicles., Cambridge University Press, 2005.

[8] L. Roux, "Optimizing Yacht Design for Efficiency : A Computational Approach," Journal of Ship Research, vol. 60, no. 2, pp. 121-134., 2016.

[9] L. Register, Rules and Regulations for the Classification of Ships., Lloyd's Register., 2020.

[10] McKenna, Sustainable Maritime Design: Case Studies in Green Ship Technology, Springer, 2019.

[11] Montgomery, Peck and Vining, Introduction to Linear Regression Analysis. John Wiley & Sons., 2012.

[12] Papanikolaou, Risk-Based Ship Design: Methods, Tools and Applications., Springer., 2014.

[13] Rawson and Tupper, Basic Ship Theory, Butterworth-Heinemann, 2001.

[14] E. A. &. G. L. (. Sciberras, "Renewable Energy Sources for Maritime Vessels," Ocean Engineering, , vol. 203, p. 107231, 2020.

[15] Stern, Agdrup, Hinnenthal and Simonsen, " A Comprehensive Approach to CFD Validation for Ship Resistance, Powering, and Maneuvering.," Journal of Ship Research, vol. 50, no. 2, pp. 131-144, 2006.

[16] T. E.C., Introduction to Naval Architecture., Butterworth-Heinemann, 2018.

[17] C. J. &. M. K. Willmott, "Advantages of the Mean Absolute Error (MAE) over the Root Mean Square Error (RMSE) in Assessing Average Model Performance.," Climate Research, vol. 30, no. 1, pp. 79-82., (2005)..

[18] M. Antartika, Budianto, M. Ari and K. Suastika, "Perbandingan Hasil Analisis Metode Elemen Hingga Berbasis Software Dengan Simple Supported Calculation Pada Kapal 50 PAX Crane Barge.," Jurnal Integrasi,, vol. 12, no. 1, pp. 72-78., 2020.

[19] A. I. As, "Perancangan Kapal Pembersih Eceng Gondok di Sungai Rowo Tirto Probolinggo," Seminar Master PPNS, vol. 2, no. 1, pp. 209-215)., 2017.

[20] T. Karyono, "Perancangan Kapal Keroncong Orchestra sebagai Wahana Wisata Air Surabaya Tempo Doeloe.," MASTER PPNS, vol. 3, no. 1, p. 23, 2018..

[21] H. Saputra, D. Cahyagi, V. N. Perkasa, D. Purnama, O. Nurmannsyah, R. Saputra, R. Ferari, F. I. A. Fauzy and M. Fadillah, "Design and Fabrication of 6 Meter Fiberglass Boat for Coastal Water Tourism in Batam," International Journal of Marine Engineering Innovation and Research, vol. 9, no. 2, pp. 370-377, 2024.

[22] T. H. Yusanto, J. Julian, F. Wahyuni, A. Winarta and I. W. M. M. Managi, "Design and Performance Testing of a 3D Printed Mini DC Powered Pump for Microbubble Generator," International Journal of Marine Engineering Innovation and Research, vol. 8, no. 4, pp. 598-604, 2023.

[23] M. F. Khairi, H. W. Sugeng, P. Y. Dwi and P. Fis, "The Design of Refrigerated Portable Fish Storage Prototype for Small Scale Fisheries," International Journal of Marine Engineering Innovation and Research, vol. 9, no. 3, pp. 437-441, 2024.

[24] M. B. D. K. I. Surahman Suwardi, "Design Of a Semi-Automatic Hand Line (Hand Line) For Semi-Automatic Squid in Wangi-Wangi Selatan Sub-District, Wakatobi District," International Journal of Marine Engineering Innovation and Research, vol. 9, no. 3, pp. 547-552, 2024.

[25] E. Y. Ahmad Fasih, "Conceptual Framework for Risk Management in the Container Shipping Operations to Support Maritime Logistics in Indonesia," International Journal of Marine Engineering Innovation and Research, vol. 9, no. 3, pp. 612-623, 2024.