# Evaluation Models of Effectiveness and Efficiency of Pioneer Ship Services: Case Study of West Papua Region

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Abstract: The pioneer ship program is one of the programs provided by the Government of Indonesia to connect areas that have not been commercially profitable by providing subsidies from national funds (APBN). Therefore, the Government continues to evaluate pioneer ship services so that the subsidy is on target. This study aims to give recommendation models for measuring the effectiveness and efficiency of pioneer ship services and to evaluate pioneer ship services operated in route R-95 by using Multivariate Analysis and Data Envelopment Analysis (DEA). There are five criteria to measure effectiveness, frequency and operational time of ship, demand of passengers and goods, and load factor of ship. Measurement of efficiency is based on total costs and fares of passengers and goods. It is obtained from the models that 7 routes are not effective and 1 route is efficient. In order to increase effectiveness, vessel must carry at least 15% from capacity of ship. While to increase efficiency, operator of ship must reduce operating costs at least 30%.

## 1 INTRODUCTION

The province of West Papua includes 598 small islands that are around it. Being a province with a large number of islands, there is an imbalance in regional, economic and social development. Such conditions make the welfare of the people in West Papua unequal between the people who live in cities and in the islands. One of the Government's efforts to connect the islands in West Papua is by providing a pioneer ship facility, where the routes served have been determined by the Government. Based on the Decree of the Directorate General of Sea Transportation in 2018, 113 pioneer sea transportation routes have been established, with a total of 41 stopover ports. One of the pioneer ship routes serving West Papua is R-95 with a shipping distance of 1670 nm. Route R-95 has a base port in Sorong City with 9 transit ports. Under these conditions, making the R-95 route has a longer vessel operating time, which is 14 days.

The length of time the ship sails affect the operational costs of the ship. Cost is one of the most important things in the operation of the ship. Operating costs incurred are not proportional to the income earned. To reduce the burden of costs incurred, the Government provides assistance in the form of subsidies to pioneer ship operators. However, the Government does not yet know whether the existing pioneer ship services are effective and efficient. The effectiveness and efficiency of pioneer ship services are important things that need to be reviewed and considered. This is because the operation of the pioneer ships is related to subsidies provided by the Government to operators, where these subsidies are obtained from the state budget (APBN).

In this study, the authors determine the measurement model for the effectiveness and efficiency of pioneer ship services. The object of research is pioneer ships operating in West Papua, precisely on the R-95 route which has a base port in Sorong City. The City of Sorong was chosen as the focus of research because in meeting the daily needs of people in the islands dependent on the City of Sorong. In addition, the condition of the R-95 pioneer ship route with the base port of Sorong City has 9 transit ports so the vessel's travel time is relatively long. This makes the route needs to be re- evaluated, both in terms of effectiveness and efficiency of pioneer ship services. So that with this research, it is expected to be able to solve the existing problems through a model of measuring the effectiveness and efficiency of the pioneering ship services produced.



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## 2 RESEARCH METHODOLOGY

The analysis phase in this study uses 2 (two) methods of adjusting to the model to be made, namely Multivariate Analysis for the effectiveness model and Data Envelopment Analysis for the efficiency model. To determine the effectiveness measurement model, it is necessary to identify the criteria used as a measurement tool. There are five criteria for measuring the effectiveness of pioneer ship services, that is, (i) frequency of ships (each year), (ii) time of operation of the ship (hours), (iii) number of passengers (people/year), (iv) number of goods (tons/year), and (v) ship load factor (%). Meanwhile, to determine the efficiency model, the author integrates input (total cost) and output (tariff) that applies to passengers (Rp./ person.nm) and goods (Rp./ ton.nm).

In addition, at this stage a sensitivity analysis phase is carried out on the criteria that most influence the effectiveness, level of effectiveness and efficiency of pioneer vessel services on the R-95 route, and the relationship between effectiveness and efficiency.

## 3 GENERAL DESCRIPTION

### 3.1 Current Condition Analysis

West Papua is one of the provinces located in eastern Indonesia. West Papua Province is located on the island of Papua and is bordered by the State of Papua New Guinea. West Papua Province is the result of division from Irian Jaya Province and was legally recognized by the state as West Papua Province in 2007. In the beginning, Papua Island only had one province, namely Irian Jaya Province. After experiencing regional division, Papua Island now has two provinces, namely West Papua and Papua. Regional expansion is carried out by the Government aimed to facilitate the Government in developing and advancing the area on the island of Papua.

West Papua Province is located west of the island of Papua, where the province includes the bird's head region of the island of Papua and the surrounding islands. This province is bordered directly by the Pacific Ocean in the north, bordering North Maluku and Maluku Provinces in the west, Cenderawasih Bay in the east, and Seram Sea in the south.

West Papua Province has 13 districts/cities, namely: Manokwari Regency, South Manokwari Regency, Maybrat Regency, Arfak Mountain Regency, Raja Ampat Regency, Sorong Regency, South Sorong Regency, Tambrauw Regency, Bintuni Regency, Teluk Wondama Regency, Fakfak Regency, Kaimana Regency, and Sorong City. The central government of West Papua Province is located in Manokwari Regency, where the regency is located as the Capital of the Province. The West Papua region also has small islands which are spread across regencies / cities. The small islands that are owned by this province are the main attraction for tourists. One of the islands that has become a tourist attraction is the Raja Ampat Islands in Raja Ampat Regency (See Figure 1).

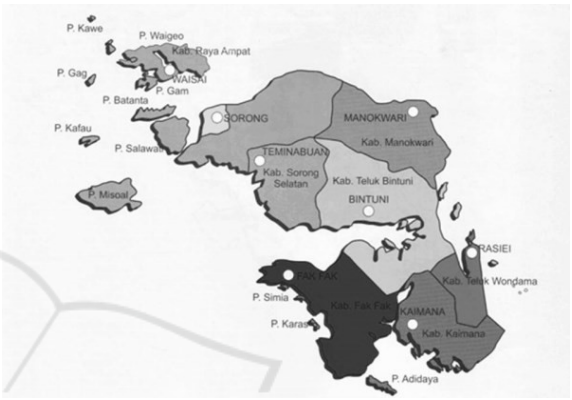


Figure 1: Map of West Papua.

Regional conditions and uneven population distribution in the province of West Papua have become separate obstacles for the Government in terms of regional development and development. This causes the underdevelopment of regional infrastructure, especially in the field of transportation. Considering the condition of the land that is less supportive for the intensification of road construction, the Government provides an alternative to the community in the form of procurement of sea transportation. One of the sea transportation facilities provided by the Government is a pioneer ship.

Pioneer ships are ships that have the task of connecting remote areas or still lagging behind. Pioneer ships operate on routes established by the Government, where the area included in the route is an area that has not been served or not served commercially by sea transportation. West Papua is one of the areas served by pioneer ships. This can be seen from 22 pioneer ships that visited West Papua. The following are 22 pioneer ship routes that stop in West Papua such as R-51, R-57, R-58, R-65, R-69, R-72, R-75, R-77, R-78, R-79, R-84, R-87, R-88, R-89, R-90, R-91, R-92, R-93, R-94, R-95, R-96, and R-113.

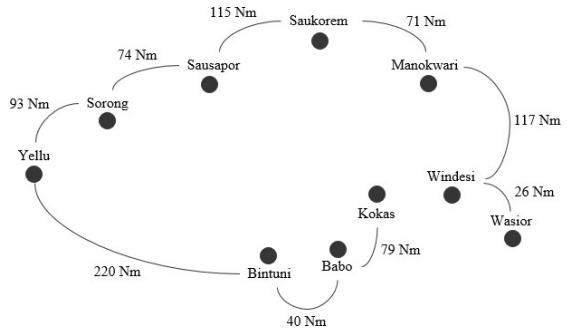


Figure 2: R-95 Route.

## 3.2 Research Location

This study choses the R-95 route as a case study, where the R-95 route is served by KM Sabuk Nusantara 42. The R-95 Route is one of the pioneer routes serving West Papua, where the area served by this route is Sorong - Sausapor - Saukorem - Manokwari - Windesi - Wasior - Windesi - Manokwari - Saukorem - Sausapor - Sorong – Yellu - Bintuni - Babo - Coke - Babo - Bintuni - Yellu - Sorong. The regions visited on the R-95 route have been determined by the Government in the Decree of the Sea Transportation General (see Figure 2).

Table 1: R-95 Route Distance Matrix (nm).

| | Sorong | Sausapor | Saukorem |
|---|---|---|---|
| **Sorong** | | 74 | 189 |
| **Sausapor** | 74 | | 115 |
| **Saukorem** | 189 | 115 | |
| **Manokwari** | 260 | 186 | 71 |
| **Windesi** | 377 | 303 | 188 |
| **Wasior** | 403 | 329 | 214 |
| | **Manokwari** | **Windesi** | **Wasior** |
| **Sorong** | 260 | 377 | 403 |
| **Sausapor** | 186 | 303 | 329 |
| **Saukorem** | 71 | 188 | 214 |
| **Manokwari** | | 117 | 143 |
| **Windesi** | 117 | | 26 |
| **Wasior** | 143 | 26 | |
| | **Sorong** | **Yellu** | **Bintuni** |
| **Sorong** | | 93 | 313 |
| **Yellu** | 93 | | 220 |
| **Bintuni** | 313 | 220 | |
| **Babo** | 353 | 260 | 40 |
| **Kokas** | 432 | 339 | 119 |
| | **Babo** | **Kokas** | |
| **Sorong** | 353 | 432 | |
| **Yellu** | 260 | 339 | |
| **Bintuni** | 40 | 119 | |
| **Babo** | | 79 | |
| **Kokas** | 79 | | |

Table 2: Specification of KM Sabuk Nusantara 42.

| **Dimensions** | | **Capacity** | | |
|---|---|---|---|---|
| Loa | 62.8 m | Passanger | 400 | person |
| Lpp | 57.36 m | Cargo | 50 | ton |
| B | 12 m | | | |
| H | 4 m | **Machinery** | | |
| T | 2.7 m | Main Engine | 1,100 | HP |
| GT | 1206 | | 2 | unit |
| DWT | 499 ton | Auxiliary Engine | 210 | HP |
| Vs | 12 knot | | 2 | unit |
| ABK | 12 person | | | |

The R-95 route has a total distance of 1607 nm. The distance that must be sailed by a pioneer ship has been listed in the Decree of the Sea Transportation General. To serve the entire area on the R-95 route, KM Sabuk Nusantara 42 requires a 14-day voyage to arrive at the point of origin. Table 1 shows distance between regions on the R-95 route.

Route R-95 is served by KM Sabuk Nusantara 42. KM Sabuk Nusantara 42 is a pioneering ship designated by the Government to serve areas on the R-95 route. KM Sabuk Nusantara 42 is operated by PT. Indonesian National Shipping (PELNI). Table 2 shows the specifications of KM Sabuk Nusantara 42.

People who use KM Sabuk Nusantara 42 services are required to pay the applicable tariff. Payment of tariffs is made for the people who deliver goods and the people who are passengers. The rates that apply to KM Sabuk Nusantara 42 are shown in Table 3.

Table 3: Tariff of KM Nusantara 42.

| O | D | Dist | Tariff | |
|---|---|---|---|---|
| | | | Pass. Rp/pax.nm | Goods Rp/ton.nm |
| Sorong | Sausapor | 74 | 9,400 | 8,100 |
| Sausapor | Saukorem | 115 | 13,400 | 11,400 |
| Saukorem | Manokwari | 71 | 9,100 | 7,800 |
| Manok-wari | Windesi | 117 | 13,600 | 11,500 |
| Windesi | Wasior | 26 | 4,700 | 4,000 |
| Sorong | Yellu | 93 | 11,600 | 9,700 |
| Yellu | Bintuni | 220 | 21,600 | 18,700 |
| Bintuni | Babo | 40 | 6,200 | 5,200 |
| Babo | Kokas | 79 | 9,800 | 8,500 |

O: Origin, D: Destination, Dist: Distance, Pass.: Passenger

## 3.3 Demand of Passengers and Goods of R-95 Route

As explained earlier, KM Sabuk Nusantara 42 is a pioneer ship carrying two types of cargo, namely passengers and goods. In this study, data on the number of passengers and goods using data in 2018 were obtained when the authors conducted a direct field review. Figure 3 and Figure 4 shows the flow of passengers and goods on the R-95 route.

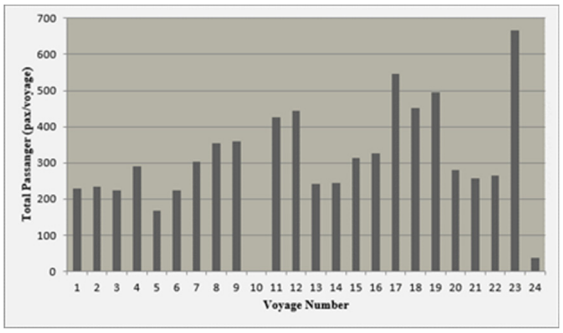


Figure 3: Demand of Passengers -KM Sabuk Nusantara 42.

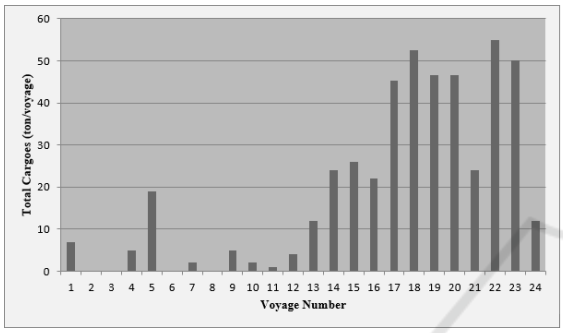


Figure 4: Demand of Goods - KM Sabuk Nusantara 42.

Based on the flow of passengers and goods, it can be seen that the shipping of goods using the pioneer ship KM Sabuk Nusantara 42 is fluctuating. Not infrequently the ship experiences a cargo emptiness. Such conditions did not cause the operation of the pioneer ships to be stopped. Pioneer ships still have to serve routes even though there is no demand for shipping goods from the public.

# 4 ANALYSIS AND DISCUSSION

## 4.1 Measurement Criteria of Effectiveness

In this study there are several criteria used to measure effectiveness, namely: frequency and operational time of ship, demand of passengers and goods, and load factor of ship. These criteria will be arranged into an index that can be used to measure the effectiveness of pioneer ship services.

### 4.1.1 Frequency of Ship

Pioneer ships have annual target operating frequency of the ship that has been determined by the Government. The target frequency of operation of pioneer vessels is stated in the Decree of the Director General of Sea Transportation regarding the Pioneer Sea Transportation Route Network. Pioneer ships that operate must meet the targets set by the Government in order to achieve the objective of conducting pioneer ship transportation. Each pioneer ship that operates has a different frequency target. The difference in frequency of the ship is influenced by the distance and time of the ship's voyage. Frequency of KM Sabuk Nusantara 42 are 23-24 each year.

### 4.1.2 Operational Time of Ship (Hour)

The operating time of the ship affects the effectiveness of the pioneer ship services. This is because, inappropriate operation time of ships can hamper community activities and productivity considering that people in eastern Indonesia rely heavily on ships as a means of transportation. Table 4 summarise operating time of KM Sabuk Nusantara 42, which serves the R-95 route.

Table 4: Operational Time of KM Sabuk Nusantara 42.

| O | D | Dist | Time (Hour) | | Freq |
|---|---|---|---|---|---|
| | | nm | Sea | Port | RT/year |
| Sorong | Sausapor | 74 | 6.2 | 6 | 24 |
| Sausapor | Saukorem | 115 | 9.6 | 6 | 24 |
| Saukorem | Manokwari | 71 | 5.9 | 6 | 24 |
| Manokwari | Windesi | 117 | 9.8 | 6 | 24 |
| Windesi | Wasior | 26 | 2.2 | 6 | 24 |
| Wasior | Windesi | 26 | 2.2 | 6 | 24 |
| Windesi | Manokwari | 117 | 9.8 | 6 | 24 |
| Manokwari | Saukorem | 71 | 5.9 | 6 | 24 |
| Saukorem | Sausapor | 115 | 9.6 | 6 | 24 |
| Sausapor | Sorong | 74 | 6.2 | 6 | 24 |
| Sorong | Yellu | 93 | 7.8 | 6 | 24 |
| Yellu | Bintuni | 220 | 18.3 | 6 | 24 |
| Bintuni | Babo | 40 | 3.3 | 6 | 24 |
| Babo | Kokas | 79 | 6.6 | 6 | 24 |
| Kokas | Babo | 79 | 6.6 | 6 | 24 |
| Babo | Bintuni | 40 | 3.3 | 6 | 24 |
| Bintuni | Yellu | 220 | 18.3 | 6 | 24 |
| Yellu | Sorong | 93 | 7.8 | 6 | 23 |

O: Origin, D: Destination, Dist: Distance
Freq: Frequency, RT: Round Trip

### 4.1.3 Load Factor of Ship (%)

Load factor of ship is the most important thing in measuring the effectiveness of pioneer ship services. The ship load factor is a value that shows the usefulness of the load capacity available on the ship. Through the load factor value, it can be seen what percentage of vessel capacity is fulfilled. Pioneer ships carry two types of cargo, namely passengers and goods. Table 5 shows load factors of KM Sabuk Nusantara 42.

Table 5: Load Factor of KM Sabuk Nusantara 42.

| Origin | Destination | Load Factor |
|---|---|---|
| Sorong | Sausapor | 12% |
| Sausapor | Saukorem | 4% |
| Saukorem | Manokwari | 0% |
| Manokwari | Windesi | 5% |
| Windesi | Wasior | 5% |
| Wasior | Windesi | 7% |
| Windesi | Manokwari | 3% |
| Manokwari | Saukorem | 8% |
| Saukorem | Sausapor | 0% |
| Sausapor | Sorong | 2% |
| Sorong | Yellu | 0% |
| Yellu | Bintuni | 0% |
| Bintuni | Babo | 2% |
| Babo | Kokas | 3% |
| Kokas | Babo | 4% |
| Babo | Bintuni | 1% |
| Bintuni | Yellu | 1% |
| Yellu | Sorong | 0% |

## 4.2 Sea Transportation Costs

Sea transportation costs consist of capital costs, operating costs, voyage costs, loading and unloading costs. This also applies to the operation of pioneer ships, but the loading and unloading costs are not charged because the loading and unloading vessels use crane-owned equipment owned by the ship. In this study, the components that exist in the cost of sea transportation refer to the Ministerial Regulation No. 15 of 2017 which regulates the components of income and costs that are calculated in the implementation of pioneering sea transportation activities through the assignment mechanism. Table 6 recapitulates transportation costs of KM Sabuk Nusantara 42.

Table 6: Costs of KM Sabuk Nusantara 42.

| **Type** | **Amount (Rp/year)** |
|---|---|
| Capital | 4,932,991,495 |
| Operational | 2,538,938,749 |
| Voyage | 7,115,317,476 |
| **Total** | **14,587,247,720** |

Based on the calculation of sea transportation costs, unit costs for each route can be obtained as shown in Table 7.

Table 7: Unit Costs of R-95.

| Origin | Destination | Unit Cost | |
|---|---|---|---|
| | | Passenger (Rp/ pax.nm) | Cargo (Rp/ ton.nm) |
| Sorong | Sausapor | 47,177 | 42,459 |
| Sausapor | Saukorem | 73,316 | 65,984 |
| Saukorem | Manokwari | 45,264 | 40,738 |
| Manokwari | Windesi | 74,591 | 67,132 |
| Windesi | Wasior | 16,576 | 14,918 |
| Wasior | Windesi | 16,576 | 14,918 |
| Windesi | Manokwari | 74,591 | 67,132 |
| Manokwari | Saukorem | 45,264 | 40,738 |
| Saukorem | Sausapor | 73,316 | 65,984 |
| Sausapor | Sorong | 47,177 | 42,459 |
| Sorong | Yellu | 59,290 | 53,361 |
| Yellu | Bintuni | 140,256 | 126,230 |
| Bintuni | Babo | 25,501 | 22,951 |
| Babo | Kokas | 50,365 | 45,328 |
| Kokas | Babo | 50,365 | 45,328 |
| Babo | Bintuni | 25,501 | 22,951 |
| Bintuni | Yellu | 140,256 | 126,230 |
| Yellu | Sorong | 59,290 | 53,361 |

## 4.3 Effectiveness of Pioneer Ship

Effectiveness shows success in terms of whether or not the goals / objectives have been set. This also applies to pioneer ships, where a pioneer ship is said to be effective if it can reach its destination. In this study, the effectiveness model was prepared using Multivariate Analysis-Factor Analysis method, with data processing tools using SPSS 22 software. The subsequent subsections are the process of determining the effectiveness model.

### 4.3.1 Kolmogorov Smirnov Test

Kolmogorov Smirnov Test is a stage that aims to test the normality of data by comparing the distribution of data that will be tested for normality with the standard normal distribution. Table 8 shows the results of Kolmogorov Smirnov's test on five effectiveness measurement criteria.

Table 8: Result of Kolmogorov Smirnov test.

| Criteria | KS-0 | KS-1 | Result |
|---|---|---|---|
| $x_1$ | 0.24 | 0.32 | Normal |
| $x_2$ | 0.17 | 0.32 | Normal |
| $x_3$ | 0.16 | 0.32 | Normal |
| $x_4$ | 0.29 | 0.32 | Normal |
| $x_5$ | 0.10 | 0.32 | Normal |

Based on the KS test results, it appears that the data used in this study are included in normally distributed data.

Table 9: Result of Matric Correlation.

| | Ship_Frequency | Time_ship | Total_Passenger | Total_Cargo | Load Factor_Ship |
|---|---|---|---|---|---|
| Ship_Frequency | 1,000 | -0,039 | 0,587 | 0,264 | 0,369 |
| Time_ship | -0,039 | 1,000 | 0,397 | -0,312 | -0,388 |
| Total_Passenger | 0,587 | -0,397 | 1,000 | 0,683 | 0,844 |
| Total_Cargo | 0,264 | -0,312 | 0,683 | 1,000 | 0,916 |
| Load Factor_Ship | 0,369 | -0,388 | 0,844 | 0,916 | 1,000 |

Determinant = 0,018

### 4.3.2 Matrix Correlation Test

This matrix correlation test aims to determine the relationship between variables. Correlation values between variables can be seen from the determinant value of the matrix. Variables are said to be unrelated when the determinant value approaches the value 0. Based on calculations, a determinant value of 0.018 is obtained. The determinant value obtained is less than 1, so this indicates that multicollinearity is not significant.

Table 10: Result of KMO – Bartlett's test.

| **KMO and Bartlett's Test** | | |
|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | .626 |
| Bartlett's Test of Sphericity | **Approx. Chi-Square** | **58.190** |
| | **df** | **10** |
| | **Sig.** | **.000** |

The results of the measurement of the effectiveness and efficiency of pioneer ship services on the R-95 route show that there are 7 route segments that are classified as ineffective and there are 2 route routes that are classified as efficient (see Table 9).

### 4.3.3 Variable Feasibility Test

Variable feasibility test is performed to find out which variables are feasible to be used in factor analysis. Before conducting the variable feasibility test, a Kaiser Meyer Olkin and Bartlett test was carried out. The Meyer Olkin and Bartlett Keizer Test aims to find out whether the factor analysis method in this study can be continued or not. The requirements for a study can use the factor analysis method if the KMO value> 0.5 and the Sig. on Bartlett's Test <0.05 (See Table 10).

The next step in factor analysis is the variable feasibility test. The feasibility of a variable can be seen in the value of Measure of Sampling Adequacy (MSA). Table 11 displays the results of the MSA test.



Table 11: Result of MSA's test.

| **Anti-Image Matrices** | | | | | |
|---|---|---|---|---|---|
| | Ship_Frequency | Time_ship | Total_Passenger | Total_Cargo | Load Factor_Ship |
| Ship_Frequency | 0.587[a] | -0.240 | -0.551 | -0.026 | 0.163 |
| Time_ship | -0.240 | 0.785[a] | 0.216 | -0.055 | 0.065 |
| Total_Passenger | -0.551 | 0.216 | 0.640[a] | 0.352 | -0.686 |
| Total_Cargo | -0.026 | -0.055 | 0.352 | 0.630[a] | -0.858 |
| Load Factor_Ship | 0.163 | 0.065 | -0.686 | -0.858 | 0.598[a] |

a = Measures of Sampling Adequancy (MSA)

The MSA values in the above table are shown in numbers with the sign "a". Based on the resulting MSA value, the five variables that act as criteria for measuring the effectiveness of pioneer ship services have an MSA value > 0.5. Therefore, the five variables are feasible to be used in measuring the effectiveness of pioneer ship services.

Table 12 summarises communalities and total variance explained, which explain the percentage of the ability of each variable to explain an object.

Table 12: Communalities and Total Variance Explained.

| | **Communalities** | | **Initial Eigenvalues** | | |
|---|---|---|---|---|---|
| | Initial | Extraction* | Total | % Of Variance | Cumulative % |
| Ship_Frequency | 1.000 | 0.304 | 3.073 | 61.461 | 61.461 |
| Time_ship | 1.000 | 0.247 | 0.986 | 19.713 | 81.173 |
| Total_Passenger | 1.000 | 0.857 | 0.701 | 14.015 | 95.188 |
| Total_Cargo | 1.000 | 0.758 | 0.197 | 3.949 | 99.137 |
| Load Factor_Ship | 1.000 | 0.907 | 0.043 | 0.863 | 100.000 |

*Extraction method: Principal Component Analysis

Table 13: Table of Component Matrix.

| Component Matrix[a] | |
|---|---|
| | Component |
| | 1 |
| Ship_Frequency | .552 |
| Time_ship | -.497 |
| Total_Passenger | .926 |
| Total_Cargo | .870 |
| Load Factor_Ship | .952 |

Extraction Method: Principal Component Analysis.
a. 1 components extracted.

The component column produces a loading factor matrix whose value will be the coefficient of the variable in explaining the object, where the object described by the formed variable is the effectiveness of the pioneer ship service. Degree of effectiveness of pioneer ship is shown by the following equation.

$$y = 0{,}552x_1 - 0{,}497x_2 + 0{,}926x_3 + 0{,}87x_4 + 0{,}952x_5 \quad (1)$$

Where:

$y$ : effectiveness of pioneer ship
$x_1$ : frequency of ship (each year)
$x_2$ : operational time of ship (hour)
$x_3$ : demand of passengers (person/year)
$x_4$ : demand of goods (tons/year)
$x_5$ : load factor of ship (%)

### 4.3.4 Effectiveness Scale

The effectiveness scale contains a range of values for the level of effectiveness of a route (see Table 14).

Table 14: Effectiveness scale.

| Nilai | Effective Level |
|---|---|
| < 1.9 | Very Not Effective |
| 1 - 2.9 | Not Effective |
| 2 - 3.9 | Effective Enough |
| 3 - 4.9 | Effective |
| > 5 | Very Effective |

## 4.4 Efficiency of Pioneer Ship Service

Table 15: Input and output.

| Input Variable | | Output Variable | |
|---|---|---|---|
| Passenger Cost | $x_1$ | Passenger Tariff | $y_1$ |
| Cargo Cost | $x_2$ | Cargo Tariff | $y_2$ |

Efficiency of pioneer ship service measurement model was prepared using the Data Envelopment Analysis (DEA) method and processed using a solver in a spreadsheet application. The following section describes how to determine pioneer ship service efficiency model.

### 4.4.1 Input and Output

In this study, there are input and output variables to measure efficiency. The following variables are used in the preparation of efficiency models (see Table 15).

### 4.4.2 Efficiency Measurement

The efficiency measurement that will be carried out is oriented towards the input, without changing the output produced. After determining the input and output variables of the model, the next step is to determine the UPK (Decision Making Unit). In this study there were 18 UPKs, where the determination of the UPK was based on the route of the route to be measured for efficiency. Table 16 shows UPK for each segment in R-95 route.

Table 16: Decision Making Unit of R-95 route.

| Origin | Destination | UPK |
|---|---|---|
| Sorong | Sausapor | 1 |
| Sausapor | Saukorem | 2 |
| Saukorem | Manokwari | 3 |
| Manokwari | Windesi | 4 |
| Windesi | Wasior | 5 |
| Wasior | Windesi | 6 |
| Windesi | Manokwari | 7 |
| Manokwari | Saukorem | 8 |
| Saukorem | Sausapor | 9 |
| Sausapor | Sorong | 10 |
| Sorong | Yellu | 11 |
| Yellu | Bintuni | 12 |
| Bintuni | Babo | 13 |
| Babo | Kokas | 14 |
| Kokas | Babo | 15 |
| Babo | Bintuni | 16 |
| Bintuni | Yellu | 17 |
| Yellu | Sorong | 18 |

Next is to construct efficiency measurement model which is then used to calculate level of efficiency using MS Solver. The following equations are the model for measuring the efficiency of pioneer ship services.

$$\sum_{k=1}^{18} x_{ik}\lambda_k \le x_{ik}\theta_k, \begin{cases} i = 1,2 \\ k = 1 \end{cases}$$
$$\sum_{k=1}^{18} y_{ik}\lambda_k) \ge y_{ik}\theta_k, \begin{cases} i = 1,2 \\ k = 1 \end{cases} \quad (2)$$

$$\forall \lambda_k \ge 0 \quad (3)$$

Where :

$\theta_k$ : efficiency of DMU
$\lambda_k$ : coefficient of input and output
$x_{ik}$ : input (cost)
$y_{jk}$ : output (tariff)
$i$ : varian of input (cost); $i$: 1, 2
$j$ : varian of output (tariff); $j$: 1, 2
$k$ : varian of DMU (route); $k$: 1, 2, ..., 18

## 4.5 Sensitivity Analysis Effectiveness Criteria

This analysis aims to find out which criteria have the most significant influence on changes in the value of effectiveness. Criteria that have a significant effect on changes in the value of effectiveness will be seen on the graph of the results of the analysis. Figure 5 shows results of the sensitivity analysis of the criteria for effectiveness.

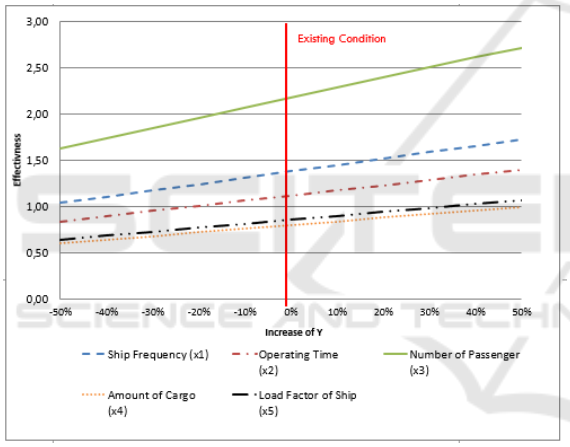


Figure 5: Sensitivity Analysis Effectiveness Criteria.

Criteria for the number of passenger requests has a very significant effect on the value of effectiveness than the other four criteria. The second criterion that influences the effectiveness of pioneer ship services is the ship load factor. This ship load factor criteria is currently only used by the Government in evaluating pioneer ship services.

## 4.6 Effectiveness and Efficiency of R-95

In this research, the model (Equation 2 and 3) is used to obtained level of effectiveness and efficiency of R-95. The results are shown in Table 17.

The measurement shows that 7 (seven) route segments are classified ineffective, while only 2 (two) route routes are categorised efficient. In total, the combination of effectiveness and efficiency gives that only 2 (two) segments have adequate performance.

Table 17: Effectiveness dan Efficiency of R-95.

| Origin | Destination | Effective | Efficient | Result |
|---|---|---|---|---|
| Sorong | Sausapor | v | x | x |
| Sausapor | Saukorem | v | x | x |
| Saukorem | Manokwari | x | x | x |
| Manokwari | Windesi | v | x | x |
| Windesi | Wasior | v | v | v |
| Wasior | Windesi | v | v | v |
| Windesi | Manokwari | v | x | x |
| Manokwari | Saukorem | v | x | x |
| Saukorem | Sausapor | x | x | x |
| Sausapor | Sorong | v | x | x |
| Sorong | Yellu | x | x | x |
| Yellu | Bintuni | x | x | x |
| Bintuni | Babo | v | x | x |
| Babo | Kokas | v | x | x |
| Kokas | Babo | v | x | x |
| Babo | Bintuni | x | x | x |
| Bintuni | Yellu | x | x | x |
| Yellu | Sorong | x | x | x |

## 4.7 Correlation of Effectiveness and Efficiency

Sensitivity analysis is performed to determine the relationship between effectiveness and efficiency of pioneer ship services. The analysis is done by comparing the total costs incurred in the operation of the ship, with the value of effectiveness. Through this analysis, it will be known what percentage of cost reduction can be done by ship operators while still taking into account the level of effectiveness of the ship. Table 9 shows results of the analysis of the relationship of effectiveness and efficiency in pioneer ship services.

The current total cost incurred for the operation of the pioneer vessel KM Sabuk Nusantara 42 is 13 billion rupiah, of which 13 billion rupiah is assumed at 100%. Based on the graph above, operators and the Government can minimize ship costs by up to 20%.

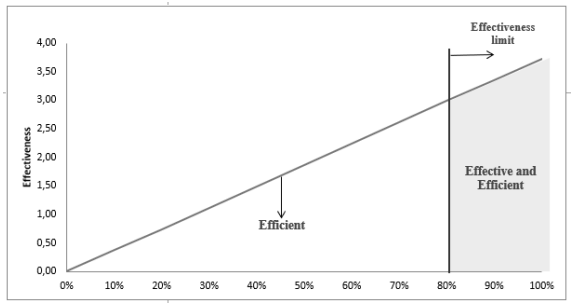


Figure 6: Correlation of Effectiveness and Efficiency.

If the cost reduction is done beyond this limit, it can reduce the effectiveness of the ship.

# 5 CONCLUSIONS

Based on research that has been done, the following conclusions are obtained:

1. The West Papua region has 22 routes served by pioneer vessels with passenger and cargo types, namely: R-51, R-57, R-58, R-75, R-65, R-69, R-72, R-77 , R-78, R-79, R-84, R-87, R-88, R-89, R-90, R-91, R-92, R-93, R-94, R-95, R -96, R- 113, where the routes are under the auspices of the Ministry of Transportation and are operated by BUMN and private companies that have won the route auction.
2. Based on the analysis done, the following results were obtained:
   - Measuring the effectiveness of pioneer ship services can be done using formulations:
     $y = 0.552x_1\text{-}0{,}497x_2 + 0.926x_3 + 0.87x_4 + 0.952x_5$
     where:
     $y$ : effectiveness of pioneer ship
     $x_1$ : frequency of ship (each year)
     $x_2$ : operational time of ship (hour)
     $x_3$ : demand of passengers (person/year)
     $x_4$ : demand of goods (tons/year)
     $x_5$ : load factor of ship (%)

     Through this formulation, the effectiveness level can be known through the effectiveness scale as follows:
     - < 1.9 : Very Ineffective
     - 2 – 2.9 : Not Effective
     - 3 – 3.9 : Effective Enough
     - 4 – 4.9 : Effective
     - > 5 : Very Effective
   - Measurement of the efficiency of pioneer ship services can be done using formulations:
     $$\theta_k = \sum x_{ik}\, \lambda_k$$
     where:
     $\theta_k$ : efficiency of DMU
     $\lambda_k$ : coefficient of input and output
     $x_{ik}$ : input (cost)
     $i$ : varian of input (cost) ; i : 1, 2
     $k$ : varian of DMU (route) ; k : 1, 2, ..., 18

     Through this formulation, it can be seen the classification of efficiency values through the following scale:
     - $\theta = 1$, efficient
     - $\theta < 1$, inefficient

3. Based on the results of measurements of the effectiveness and efficiency of the pioneer ship service on the R-95 route, it can be seen:
   - Effectiveness
     There are 11 routes classified as effective and 7 other route segments classified as ineffective. The seven ineffective route segments, i.e.:
     - Saukorem – Manokwari
     - Saukorem – Sausapor
     - Sorong – Yellu
     - Yellu – Bintuni
     - Babo – Bintuni
     - Bintuni – Yellu
     - Yellu – Sorong
   - Efficiency
     There are 2 (two) classified efficient route segments, namely the Wasior - Windesi route (and vice versa). While 16 other route segments have efficiency values below 1, so 16 route segments are classified as inefficient.

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