The Mundel and Objective Matrix Model of Productivity Measurement at PT Adi Perkapalan

R Yahya¹, M Mahachandra¹ and N U Handayani¹

¹Industrial Engineering Department, Faculty of Engineering, Diponegoro University, Jl. Prof. Soedarto, Tembalang, Semarang, Indonesia 50275

ramyyahya007@gmail.com

Abstract. The development of shipping sector especially in ship construction project is ship building or ship production will continue to increase from time to time. The productivity management is needed because it is important. The productivity calculation by using Mundel Model can be known from the decreasing of productivity index which is Galley part. The result of calculation by using the objective matrix (OMAX) method shown that there is an enhancement in the percentage of productivity total in 2017 but it is for the weight ratio of service which is services area and the third part. The improvement and evaluation are needed to be done to achieve a better productivity standard. There some proposals to the management to do an action to improve the productivity.

1. Introduction

The development of the ship construction model in the shipping sector especially for the ship building and the ship production will continue to increase and it is important to increase its productivity of the management. By fulfilling the company’s orientation to the increased profitability, the company has to improve its efficiency and productivity of production by fulfilling the production capacity in order to absence of waste due to additional working hours and other costs.

The shipyard industry is the most important industry in supporting sea transportation within the framework of maritime development. Shipyard industry as a provider of ships for sea transportation. In addition, the ship industry also helped repair the ship (repair). In 2015 the ASEAN free market was put in place, therefore trade in Indonesia will grow rapidly. This spurred the shipyard industry to further increase the productivity of this industry both in the fields of maintenance, repair and new shipbuilding. Therefore, it is necessary to measure productivity which aims to increase productivity that has been obtained and is the basis of planning for increasing productivity in the future.

So far, there is no particular method used to measure productivity used in the construction of new vessels. Therefore, there needs to be an appropriate productivity measurement model for the construction of new vessels, in this study the model used is the objective matrix (omax) model, which is a productivity measurement that continues to use its physical measurements without being transformed into financial measures. basic work units such as workers, time spent, material and amount of use of the machine. Then the Mundel Model method from the form of the index proposed by Marvin E. Mundel, namely by measuring input productivity is calculated according to each stated that basically the Mundel model can use one formula in the application of productivity measurements at the enteIDRrise level which can also contribute to benchmarking from the Omax model.

The formulation of the problem in this study is How to determine the productivity measurement of the construction of new ships using the mundel and omax models at PT. Adi Shipping, what factors influence the increase in productivity decline.
The purpose of this research is to identify the factors that influence the increase and decrease in productivity in the construction of new vessels, also to know the factors that cause delays in the construction of new ships.

The benefits of this study are to add insight and knowledge and understand more about increasing productivity in the construction of new ships using the Mundel and Omax models; As input or input for companies to take policies related to productivity as well as additional references related to achieving productivity in the construction of new vessels.

2. Literature Review

2.1. The meaning of productivity
Sumanth (1984) The word “productivity” appears in 1766 that means human desire and effort to improve quality of life [1]. In 1883, Litre said that productivity means an ability to produce based on the sources that have been used introduced a formal concept which is cycle productivity to be used to increase the productivity continually. There are 4 steps of the cycle concept, which are productivity of measurement, productivity of Evaluation, productivity of planning and productivity of improvement.

2.2. Mundel Model
This model is used by company to measure its productivity from the standard time to work. The strength and the weakness of this model is appropriate to be implemented to the company by seeing its output and input. The company will be measured by it productivity by having the standard time to work like job order. Productivity index (IP) is determined by the formula:

\[
IP = \left( \frac{Output \ Index}{Input \ Index} \right) \times 100\%
\]

2.3. Objective Matrix (OMAX) Method
The objective matrix (OMAX) is a partial productivity measurement system developed to monitor productivity in every part of the company with productivity criteria that are appropriate with the existence. This measurement model has a characteristic which is the performance criteria of the work group incorporated into the matrix. Each performance criterion has a target in the form of a special repair menu and it has the quality with the important level of productivity goals. The final result of this measurement is a single value for the work group. The advantages of OMAX a tool of productivity measurement, a tool to solve the productivity problems and productivity growth monitor

The performance factor is based on the productivity of objective matrix that each unit has special different dimensions. The way to measure dimension can be done by measuring its influenced factor. Objective matrix can be used to measure work units from small scale and the whole company. But, the results of measuring the performance of the units cannot be linked additively to present the performance of the big units. All of the organizations should do a process for the quality of related units.

2.4. Form and Arrangement of Objective Matrix (OMAX)
The structure of objective matrix model consists of [2]:

1. Productivity criteria; the events and factors that support the productivity of work unit that is being measured and it is known by comparison.
2. The level of achievement; it is done by measuring to monitor the amount of performance achievement for every criterion and the successful achievement is filled through the performance lines available for all criteria.
3. Matrix scale cells; before determine the standard level 3 (average), level 0 (bad performance), and level 10 (targeted achievement), matrix scale cells should be determined first.
4. Score; it is the results of achievement of ratio performance whether the achievement is appropriate with the targeted achievement, under the target or the standard scale.
5. The quality; every criterion has its own different influenced to the measured productivity. Therefore, it needs to know the quality in degree of importance ( in percent) that shows the relative influence of criteria work unit productivity that has been measured because the total of the criteria are 100%.
6 The grade; those of the grades that has been got from every period can be by multiplies the score on certain criteria
7 Indicator; the total grades of each criterion is included in the performance indicator box. The number of the indicator is 300 because the entire criterions get 3 when the matrix is operated. Also, the increasing of productivity is determined with the performance indicator. The measurement of OMAX is done to the 3 groups of objective matrix, which is:

![Figure 1. Mode structure of OMAX](image)

2.5. Productivity Evaluation
After the productivity measurement is done, the next step that should be done is productivity cycle (evaluation step). Productivity evaluation needs to be done to know the productivity is increasing or decreasing to the short and long term plans. If the evaluation cannot be done, the judgment to the results of the measured productivity becomes fail. It cannot be said the grade of productivity is good or bad. There are some good ways how to evaluate, which are:

a. It needs to plan a determination that leads to changes in the grade of productivity in two consecutive periods and it should be developed to a way that allows making the change happen.
b. The method should be improved to get the productivity grade based on the budget and it can be compared with the present results.
c. A good preparation is needed from stage to stage to evaluate the productivity of grade with the sequential and given measurement period.

2.6. Fishbone Diagram
Fishbone diagram is called Ishikawa diagram that shows the relation of the cause-effect. It is related with the total productivity management the diagram can be used to show the factors of the cause-effect. The diagram is often called as fishbone diagram because it is same with the fish skeleton. This diagram is introduced by Prof. Kaouru Ishikawa from Tokyo University in 1953.

3. Methodology
This research will use secondary data and it is given from the company such as company profile, history of company production data, production data, and steel plate consumption data.
After the data are collected, data processing will be done by discussing the results with the company about the ratio indicator to do measurement and the quality of each ratio.

Then, the next step that should be done is OMAX method in order to know the level of productivity and the level of performance every month. After that, the data will be revised by using quality tools which are traffic light system, cause-effect diagram, and tools5W+1H.

4. DISCUSSION

Table 1. The production cost for each unit of pioneer ship with the type 750 DWT in 2016 and 2017 Adi Perkapalan company.

| No | Job Type / Material                          | Vol | Unit | Cost 2016       | Cost 2017       |
|----|---------------------------------------------|-----|------|-----------------|-----------------|
| 1  | Hull                                       | 1   | LOT  | IDR 5,478,620,775.00 | IDR 5,664,737,743.00 |
| 2  | Hull Equipment                             | 1   | LOT  | IDR 2,782,864,903.00 | IDR 2,865,090,905.00 |
| 3  | Galley and Mess Room Equipment             |     |      |                 |                 |
|    | Galley                                    | 1   | LOT  | IDR 21,095,382.00   | IDR 22,912,911.00 |
|    | Room Equipment                             | 1   | LOT  | IDR 36,704,707.00   | IDR 37,025,781.00 |
| 4  | Engine Installation                        | 1   | LOT  | IDR 3,629,929,168.00 | IDR 3,753,866,547.00 |
| 5  | Auxiliary Motors and Pumps                 | 1   | LOT  | IDR 883,905,718.00  | IDR 906,240,229.00 |
| 6  | Tanks Outside the Hull                     | 1   | LOT  | IDR 52,344,149.00   | IDR 53,969,783.00 |
| 7  | Equipment                                  |     |      |                 |                 |
|    | Installation of the PelDRLexing System     | 1   | LOT  | IDR 476,781,281.00  | IDR 484,052,188.00 |
|    | (Valve, Flends & equipment)                |     |      |                 |                 |
|    | Electrical installation                    | 1   | LOT  | IDR 530,840,353.00  | IDR 540,111,446.00 |
|    | Firefighters                               | 1   | LOT  | IDR 176,367,052.00  | IDR 181,855,633.00 |
| 8  | Mooring and Anchoring                      | 1   | LOT  | IDR 348,319,155.00  | IDR 359,132,964.00 |
| 9  | Safety Equipment                           | 1   | LOT  | IDR 410,300,897.00  | IDR 418,223,030.00 |
| 10 | Other Equipment                            | 1   | LOT  | IDR 759,524,945.00  | IDR 779,331,368.00 |
| 11 | Engines Deck                               | 1   | LOT  | IDR 961,532,476.00  | IDR 993,998,177.00 |
| 12 | Development Services and Third Parties     |     |      |                 |                 |
|    | Total Input (Cost)                         | 1   |      | IDR 3,548,169,031.00 | IDR 3,679,451,295.00 |
|    | Total Output (Selling Price)               | 1   |      | IDR 20,097,299,992.00 | IDR 20,740,000,000.00 |

Table 2. The results of productivity calculations based on Mundel theories

| No | Job Type / Material                          | Productivity | Increase / Decrease |
|----|---------------------------------------------|--------------|---------------------|
| 1  | Hull                                        | 100.19       | 0.19                |
| 2  | Hull Equipment                              | 100.23       | 0.23                |
| 3  | Galley and Mess Room Equipment              |              |                     |
|    | Galley                                     | 95.01        | -4.98               |
|    | Room Equipment                              | 102.3        | 2.3                 |
| 4  | Engine Installation                         | 99.79        | -0.21               |
| 5  | Auxiliary Motors and Pumps                  | 100.65       | 0.65                |
| 6  | Tanks Outside the Hull                      | 100.08       | 0.08                |
| 7  | Equipment                                  |              |                     |
|    | Installation of the PelDRLexing System      | 101.64       | 1.64                |
|    | (Valve, Flends & equipment)                 | 101.42       | 1.42                |
|    | Firefighters                                | 100.08       | 0.08                |
| 8  | Mooring and Anchoring                       | 100.09       | 0.09                |
| 9  | Safety Equipment                            | 101.24       | 1.24                |
| 10 | Other Equipment                             | 100.57       | 0.57                |
| No | Job Type / Material                  | Productivity | Increase / Decrease |
|----|-------------------------------------|--------------|---------------------|
| 11 | Engines Deck                        | 99.82        | -0.17               |
| 12 | Development Services and Third Parties | 99.51        | -0.48               |

Table 3. Job Weight in 2017 and 2016

| No | Job Type / Material                  | Job load | Achievement (2017) | Realistic Target | Minimum Target | Achievement (2016) |
|----|-------------------------------------|----------|--------------------|------------------|----------------|---------------------|
| 1  | Hull                                | 27.31%   | 87%                | 88%              | 73%            | 80%                 |
| 2  | Hull Equipment                      | 13.81%   | 97%                | 97%              | 84%            | 90%                 |
| 3  | Galley and Mess Room Equipment      | 0.11%    | 100%               | 100%             | 95%            | 95%                 |
| 4  | Room Equipment                      | 0.18%    | 100%               | 100%             | 95%            | 95%                 |
| 5  | Engine Installation                 | 18.10%   | 77%                | 79%              | 70%            | 72%                 |
| 6  | Auxiliary Motors and Pumps          | 4.37%    | 80%                | 86%              | 75%            | 78%                 |
| 7  | Tanks Outside the Hull              | 0.26%    | 83%                | 89%              | 75%            | 79%                 |
| 8  | Installation of the PeIDRlexing System (Valve, Flends & equipment) | 2.33%    | 88%                | 90%              | 80%            | 85%                 |
| 9  | Electrical installation             | 2.60%    | 81%                | 91%              | 80%            | 87%                 |
| 10 | Firefighters                        | 0.88%    | 98%                | 100%             | 95%            | 98%                 |
| 11 | Mooring and Anchoring               | 1.73%    | 94%                | 100%             | 90%            | 96%                 |
| 12 | Safety Equipment                    | 2.02%    | 100%               | 100%             | 99%            | 99%                 |
| 13 | Other Equipment                     | 3.76%    | 92%                | 97%              | 90%            | 91%                 |
| 14 | Engines Deck                        | 4.79%    | 79%                | 87%              | 75%            | 81%                 |
| 15 | Development Services and Third Parties | 17.74%   | 86%                | 93%              | 80%            | 85%                 |
Table 4. The results of calculation between traffic light system and OMAX method

| Job Type / Material Achievement (2016) | Score | Month | Realistic Target | Achievement (2016) | Average Target | Minimum Target |
|---------------------------------------|-------|-------|------------------|---------------------|----------------|---------------|
|                                      |       |       |                  |                     |                |               |
|                                       | 1     | 2     | 3                | 4                   | 5              | 6             |
|                                       | 7     | 8     | 9                | 10                  | 11             | 12            |
|                                       | 13    | 14    | 15               | 16                  |                |               |
|                                       |       |       |                  |                     |                |               |
|                                       | 1     | 2     | 3                | 4                   | 5              | 6             |
|                                       | 7     | 8     | 9                | 10                  | 11             | 12            |
|                                       | 13    | 14    | 15               | 16                  |                |               |
|                                       |       |       |                  |                     |                |               |

|                                      |       |       |                  |                     |                |               |
|                                      | 1     | 2     | 3                | 4                   | 5              | 6             |
|                                      | 7     | 8     | 9                | 10                  | 11             | 12            |
|                                      | 13    | 14    | 15               | 16                  |                |               |
|                                      |       |       |                  |                     |                |               |

| 2017 Score | Score of 2016 | Weight | 2017 Value | Value of 2016 | Performance Indicator |
|------------|---------------|--------|------------|--------------|----------------------|
| 10         | 10            | 11     | 10         | 10           | 10                   |
| 5          | 5             | 5      | 5          | 5            | 5                    |
| 1          | 1             | 1      | 1          | 1            | 1                    |
| 3          | 3             | 3      | 3          | 3            | 3                    |
| 4          | 4             | 4      | 4          | 4            | 4                    |
| 2          | 2             | 2      | 2          | 2            | 2                    |

| 2017 Score | Score of 2016 | Weight | 2017 Value | Value of 2016 | Performance Indicator |
|------------|---------------|--------|------------|--------------|----------------------|
| 10         | 10            | 11     | 10         | 10           | 10                   |
| 5          | 5             | 5      | 5          | 5            | 5                    |
| 1          | 1             | 1      | 1          | 1            | 1                    |
| 3          | 3             | 3      | 3          | 3            | 3                    |
| 4          | 4             | 4      | 4          | 4            | 4                    |
| 2          | 2             | 2      | 2          | 2            | 2                    |

| 2017 Score | Score of 2016 | Weight | 2017 Value | Value of 2016 | Performance Indicator |
|------------|---------------|--------|------------|--------------|----------------------|
| 10         | 10            | 11     | 10         | 10           | 10                   |
| 5          | 5             | 5      | 5          | 5            | 5                    |
| 1          | 1             | 1      | 1          | 1            | 1                    |
| 3          | 3             | 3      | 3          | 3            | 3                    |
| 4          | 4             | 4      | 4          | 4            | 4                    |
| 2          | 2             | 2      | 2          | 2            | 2                    |

| 2017 Score | Score of 2016 | Weight | 2017 Value | Value of 2016 | Performance Indicator |
|------------|---------------|--------|------------|--------------|----------------------|
| 10         | 10            | 11     | 10         | 10           | 10                   |
| 5          | 5             | 5      | 5          | 5            | 5                    |
| 1          | 1             | 1      | 1          | 1            | 1                    |
| 3          | 3             | 3      | 3          | 3            | 3                    |
| 4          | 4             | 4      | 4          | 4            | 4                    |
| 2          | 2             | 2      | 2          | 2            | 2                    |

| 2017 Score | Score of 2016 | Weight | 2017 Value | Value of 2016 | Performance Indicator |
|------------|---------------|--------|------------|--------------|----------------------|
| 10         | 10            | 11     | 10         | 10           | 10                   |
| 5          | 5             | 5      | 5          | 5            | 5                    |
| 1          | 1             | 1      | 1          | 1            | 1                    |
| 3          | 3             | 3      | 3          | 3            | 3                    |
| 4          | 4             | 4      | 4          | 4            | 4                    |
| 2          | 2             | 2      | 2          | 2            | 2                    |

| 2017 Score | Score of 2016 | Weight | 2017 Value | Value of 2016 | Performance Indicator |
|------------|---------------|--------|------------|--------------|----------------------|
| 10         | 10            | 11     | 10         | 10           | 10                   |
| 5          | 5             | 5      | 5          | 5            | 5                    |
| 1          | 1             | 1      | 1          | 1            | 1                    |
| 3          | 3             | 3      | 3          | 3            | 3                    |
| 4          | 4             | 4      | 4          | 4            | 4                    |
| 2          | 2             | 2      | 2          | 2            | 2                    |

| 2017 Score | Score of 2016 | Weight | 2017 Value | Value of 2016 | Performance Indicator |
|------------|---------------|--------|------------|--------------|----------------------|
| 10         | 10            | 11     | 10         | 10           | 10                   |
| 5          | 5             | 5      | 5          | 5            | 5                    |
| 1          | 1             | 1      | 1          | 1            | 1                    |
| 3          | 3             | 3      | 3          | 3            | 3                    |
| 4          | 4             | 4      | 4          | 4            | 4                    |
| 2          | 2             | 2      | 2          | 2            | 2                    |

| 2017 Score | Score of 2016 | Weight | 2017 Value | Value of 2016 | Performance Indicator |
|------------|---------------|--------|------------|--------------|----------------------|
| 10         | 10            | 11     | 10         | 10           | 10                   |
| 5          | 5             | 5      | 5          | 5            | 5                    |
| 1          | 1             | 1      | 1          | 1            | 1                    |
| 3          | 3             | 3      | 3          | 3            | 3                    |
| 4          | 4             | 4      | 4          | 4            | 4                    |
| 2          | 2             | 2      | 2          | 2            | 2                    |

| 2017 Score | Score of 2016 | Weight | 2017 Value | Value of 2016 | Performance Indicator |
|------------|---------------|--------|------------|--------------|----------------------|
| 10         | 10            | 11     | 10         | 10           | 10                   |
| 5          | 5             | 5      | 5          | 5            | 5                    |
| 1          | 1             | 1      | 1          | 1            | 1                    |
| 3          | 3             | 3      | 3          | 3            | 3                    |
| 4          | 4             | 4      | 4          | 4            | 4                    |
| 2          | 2             | 2      | 2          | 2            | 2                    |
Notes:
- The green color with the threshold (level 7 up to level 10) means the target has been achieved.
- The yellow color with threshold (level 3 up to level 6) means that the target has not been achieved but it is almost near with the targeted performance.
- The red color with the small threshold from level 3 means the performance is under the target.

Those of the problem are analyzed by using cause-effect diagram. The following is the cause-effect Diagram:

![Cause-effect Diagram](image)

**Figure 2.** Cause-effect diagram toward the decreasing of performance to develop services and the third part.

| No | Factors       | What                          | Why                                         | Who        | Where        | When     | How                                                                 |
|----|---------------|-------------------------------|----------------------------------------------|------------|--------------|----------|----------------------------------------------------------------------|
| 1  | Personal      | Lack of Information           | Because integrated information is a key      | All personnel | All division | every year | Hold information technology training                                  |
|    |               | Lack of Training              | Because knowledge and deepening of the field is very important | All personnel | All division | every year | hold training in each scientific field in each division              |
|    |               |                               |                                              |             |              |          | A good Socialization can be done to the employees in or due to avoid miscommunication and it is needed to have training continuously |
|    |               | Lack of coordination          | The coordination is more increased to achieve the target | All personnel | All division | every day |                                                                 |

**Table 5.** The proposals of 5w+1H for the development services and the third part
### 5. CONCLUSION

1. There is a decreasing to the productivity calculation by using Mundel Model which is Galley. It is very significant for the decreasing of productivity index which 4.98%. But, Mundel Model is not really accurate to be used because the factors are not appropriate to be implemented and the Galangan kapal company is monitoring its wide production.

2. The results of the calculation by using the objective matrix method (OMAX) showed that the increasing of the total of its productivity in 2017 and 2016. But, the management service and the third part keep decreasing and there is no any change. It can be seen through the red color to the table that the threshold is smaller from level 3. It means that the progress is under the achieved target. In addition, management service and the third part did not increase from 2016 and 2017 which is 84 % under the average 87%.

3. Improvement and evolution are needed to be done to achieve a better standard productivity. Some suggestions from management to do some enhancement to improve its productivity for the services and the third part. Those of the solution are: a. the employees should be given

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| No | Factors | What | Why | Who | Where | When | How |
|----|---------|------|-----|-----|-------|------|-----|
| 2  | Method | Not Optimal | In order the management of the company increase the management services and the third part | Production manager | Production division | Every day | Coordination to remind each other for the services and the third part in making standard rules |
|    |        | Lack Of Renewal | in order to better carry out developments in the current industrial era 4.0 | Quality control | Production division | Every renewal | One of them follows ISO rules |
|    |        | Late supply | The supplier can be on time by following the schedule | Supplier manager | Production manager | When the products are produced | Standardization needs to be done to check the material, monitor the schedule routinely from supplier |
|    |        | Materials | The layout of the space is not optimal | warehousing manager | Warehousing division | When there is a lot of material buildup | Arrangement or redesign |
| 3  |        | Less of the warehousing and the access | To reduce the time of delay and the placement | warehouse manager | Warehousing division | When it is supplied and saving | Making a plan for the request and save it well. |
|    |        | Location layout | To reduce the time of delay and the placement | warehouse manager | Warehousing division | When it is supplied and saving | Making a plan for the request and save it well. |
| 4  | Environment | Bureaucracy | Bureaucratic licensing which is lacking | Head of the company | Both sides | Every year | Evaluate and change the flow of licensing better |
clear information to avoid the miscommunication and training can be done continually from the personal. b. Coordination to remind each other for the services and the third part in making standard rules. c. Standardization needs to be done to check the material, monitor the schedule routinely from supplier, d. making a plan for the request and save it well.

REFERENCES
[1] DJ Sumanth 1984 Productivity Engineering and Management (New York: McGrawHill Book Company)
[2] Riggs JL 1987 Production system planning, analysis, and control (Willey: Singapore).
[3] Winarni 2013 Analysis of Measurement of Productivity Using the Mundel and APC Models (Analisis Pengukuran Produktifitas Dengan Menggunakan Model Mundel Dan APC)
[4] Wahyuni HC, Setiawan 2016 Implementation of Objective Matrix (OMAX) Method for Productivity Measurement at PT .ABC. E. ISSN. 2541-5115 (Implementasi Metode Objective Matrix (OMAX) Untuk Pengukuran Produktivitas Pada PT.ABC. E. ISSN. 2541-5115
[5] Fitri Agustina, Nina Aris Riana 2011 Productivity Analysis with Objective Matrix (OMAX) Method at PT. X (Analisis Produktivitas dengan Metode Objective Matrix (OMAX) di PT. X)
[6] Mukharromah IN, Deoranto,Mustanir, Sita 2017 Analysis of measurement of company performance using the Green Supply Chain Management (GSCM) method in the black tea business unit (Analisis pengukuran kinerja perusahaan dengan metode Green Supply Chain Management (GSCM) di unit bisnis teh hitam)
[7] Alifatul Fitriyah, Umar Wiwi 2015 Analysis of Achievement of Productivity Increased Use of Welding Machines Using OMAX Models at PT. Dock and Shipping Surabaya (Analisa Pencapaian Peningkatan Produktivitas Penggunaan Mesin Las Dengan Menggunakan Model OMAX Di PT. Dok Dan Perkapalan Surabaya).