Performance Evaluation of a Drilling Project in Oil and Gas Service Company in Indonesia by MACBETH Method

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Abstract. Decision-making in a project is a complex undertaking. A project is a temporary organization that is surrounded by inherent uncertainties. Uncertainties that may occur in the project, among others, are the uncertainty of the time, cost, and quality. To overcome this complexity, we need a project performance evaluation. At one of the services the oil and gas in Indonesia, the performance evaluation has been done, but it is done separately and only few criteria are evaluated, so that the overall project performance is still not visible. Therefore it is necessary to evaluate the performance of the company's project with the MCDA (Multi Criteria Decision Analysis) approach using MACBETH (Measuring Attractiveness by a Categorical Based Evaluation Technique) method that can model the elements of the project into a supervisory level group to facilitate decision making by the project manager. These measurements will produce levels of monitoring classification of project element groups, i.e. absolute vigilance, strong attention, close surveillance, and normal monitoring of the project elements. This research finds that the criteria of Effectiveness, Efficiency, Time, Cost, and Complete Reports & Field Tickets require absolute vigilance so that the performance criteria can be increased.

1. Introduction
Decision-making in the project is a complex undertaking [1]. Complexity can appear in many forms and arise from a variety of sources with varying levels of intensity according to the industrial sector or the object of the project. The intensity may vary from time to time, and this variation underscores the dynamic aspect of the complexity of the project. On the one hand, the project is a temporary organization that is surrounded by the inherent uncertainty [2]. Uncertainties that may occur in, among others, the uncertainty of future projects (scheduling, duration, etc.) and uncertainty of costs (procurement, operating expenses, wages, etc.). On the other hand, the project manager can be faced with another form of the complexities involved in dealing with a lot of independent information. Another form of it is the integration and risk. To overcome this complexity, we need a performance evaluation of the project to be able to evaluate the performance of the project and address the problems that occurred on the project and get a lesson for the next projects.

At one of the services the oil and gas in Indonesia, the performance evaluation has been carried out, among others are HSE (Health, Safety, and Environment), CV (Customer Value) Metrics, and the End of Well Report. However, the evaluation is conducted separately and only a few criteria to be evaluated, so that the overall project performance is still not visible. For the purpose, it is necessary to evaluate the company's performance on the project with the MCDA (Multi-criteria decision analysis)
approach using the MACBETH (measuring attractiveness by a categorical based evaluation technique) mathematical method that can model the elements of the project into a supervisory level group to facilitate decision-making by the project manager. These measurements will produce levels of monitoring classification of project element groups, i.e. absolute vigilance, strong attention, close surveillance, and normal monitoring of the project elements. This level of monitoring will be the order of priority for project managers to assist decision making in improving the performance of the project.

2. Literature Review

2.1. Project Management
A project is "a unique process, consisting of a series of coordinated and controlled activities with the initiation and completion is done to achieve the objectives in accordance with specific requirements" [3]. Project management is the planning, organizing, directing, and controlling resources company that has been established to complete specific short-term objectives [4]. Project management involves 5 process groups, i.e. project initiation, project planning, project execution, project monitoring and controlling, and project closing [5].

2.2. Performance Measurement
Performance measurement can be defined as a process for measuring the effectiveness and efficiency of an action [6] using variables that indicate the quantitative measures [7] in order to achieve those objectives derived from the company’s strategic goals [8].

Performance measurement is based on the company’s strategy [7]. It aims to support the implementation and monitoring of strategic initiatives. The selection of performance measures and setting targets of these measures can be seen as a concrete formulation of corporate’s strategy choice. Financial or non-financial measures are necessary to translate strategy into specific objectives that provide guidance for the management of operational measures. Actual results achieved from a variety of measurements reflect how successful the company in achieving the strategy choice.

2.3. Multi-criteria decision analysis (MCDA) and MACBETH
Multi-criteria decision analysis (MCDA) is an alternative evaluation using a number of qualitative and / or quantitative criteria that have different measurement units [9] to address the complex problems which showing high uncertainty and conflicting objectives [10], in which decision makers should select, evaluate or rank the attributes according to the weight of the criteria [11] to determine the overall preference among all alternative options in which the alternatives can achieve some goals [12].

There are several commonly used methods of MCDA to assist decision making. Methods are often used are MAUT, MACBETH, AHP, ANP, ELECTRE and PROMETHEE. MCDA method for this study is the method of MACBETH. MACBETH (measuring attractiveness by a categorical based evaluation technique) is a mathematical interactive approach that uses semantic assessment of the differences in the attractiveness of various stimuli to help decision makers expressed their attractiveness relative to a quantity [13]. MACBETH is MAUT method, which is based on a comparison between different situations (which identifies context) made by decision-makers [14]. MACBETH illustrates this situation with an expression of basic performance on the one hand, and the aggregate expression on the other. The principle is to translate the qualitative information derived from the human expertise of decision-makers, into quantitative information. When the answer is inserted into the MACBETH decision support system, this method automatically verify their consistency. This then produces a numerical scale that is representative of the assessment decision-makers. Through the same process this method allows for the generation of scale weighting criteria. Moreover, this method provides a means to facilitate some kind of sensitivity analysis.

The expression of basic performance appraisal is defined by the semantics of the group situation [14]. More precisely, the concept of preference and strength of preference used and associated with the level of verbal attractiveness (none, very weak, weak, moderate, strong, very strong, extreme). Each
interval is scaled so that the resulting lines with MAUT forming a linear transformation (defined by two parameters: the slope and constant). Then, to solve the problem of inter-criteria, simply by specifying, for all interval scales, two common reference points has an absolute meaning for decision makers to adjust the slope and constant. For example, "complete unsatisfactory" performance related to the values 0 and "complete satisfactory" performance related to the value of 1.

2.4. Criteria of Project Performance
There are 3 criteria of project performance: Project Performance Measurement, Project Dimension, and Project Task.

2.4.1. Project Performance Measurement. Project can be considered as a business process [1]. From this point of view we can associate with the Project Management Business Process Management (Business Process Management - BPM). The project can be seen as a sequence of tasks in a manner similar to the process can be viewed as a sequence of events. So, a Project Performance Management System (PPMS) can be defined as a set of metrics, or performance measures, which are used to measure both the efficiency and effectiveness of an action [6]. Performance evaluation assumes the need for a tool to analyze the measurements taken in accordance with the two dimensions of efficiency and effectiveness. This is a question to consider the impact of each component of the performance. Basically, BPM analysis adds a third component: relevance [1]. There are also two additional criteria [15], namely implementability and flexibility, so that there are five performance measures that will be used so that project performance measurement criteria: efficiency, effectiveness, relevance, implementability, and flexibility.

2.4.2. Project Dimension. Each project performance evaluation considers that it is necessary to analyze the measurements. The project manager must maintain a network of projects and monitoring the shift of costs, time, and quality for the duration of the project [16]. In achieving this, the project manager relies heavily on a reliable monitoring system that can provide timely signals to project issues, whether actual or potential. Project Management Body of Knowledge [5] proposed nine essential areas of knowledge management and project management to illustrate: Project Integration, Project Scope, Project Time, Project Cost, Project Quality, Project Human Resources, Project Communication, Project Risk, and Project Procurement. Other than those dimensions, there is an additional criteria, which is Project Safety [15][17][18].

2.4.3. Project Task. In addition to project performance measurements and project dimensions, there is one element to consider in the evaluation of project performance. The element is project tasks, which varies from one project to another. On drilling projects of an oil and gas service company, it is possible to draw the outline of each project task to be able to generalize the task that must be observed. The tasks are Business Cooperation, Prepare Resources, Mobilize Resources, Perform Services, Demobilize Resources, Complete Reports & Field Tickets, and Review Performance.

2.5. Project Performance Measurement System with Multi-Criteria
The idea consists of a combination of decision-support methods for different project contexts [1]. This method should be tailored to the needs of decision-makers in terms of tasks executed project performance measurements used, and project dimensions observed. The model consists of three dimensions: task that followed, the view that is used to analyze the performance (dimensions), and the types of performance measurement. Full details of this system can be seen in [19].

3. Research Methodology
In this section will be explained the stages of data collection and processing that will be used followed by analysis of the research results. The data collected is the secondary data from project performance
reports, as well as primary data in the form of pairwise comparisons of each of the criteria from the experts for evaluating the performance of the project.

3.1. Collecting Data
Pairwise comparison of the data is used in this study to see how important a criterion as compared with other criteria in a group of factors. This data is obtained by using the questionnaire addressed to the experts of the company to the top-level manager who has experience over 7 years in drilling project activities by the company.

3.1.1. Questionnaire. This questionnaire aims to filter criteria will be compared, whether the criteria are important for the project activities. If these criteria are not considered important, these criteria will not included in the pairwise comparisons. The questionnaire contained questions about the level of importance of the criteria and the project was given to 7 experts from the project team. In the questionnaire, there are 5 scales: very unimportant, unimportant, average, important, and very important. The results of this questionnaire then calculated and the Geomean values of each criterion then quantified. Geomean value obtained then filtered, if the value is less than 3.5 then the criteria are considered unimportant, so it is not included in the pairwise comparisons. Once the questionnaire processed, the criteria are decreased from 23 to 19. The criteria that are considered less important are flexibility, Project Integration, Project Procurement and Demobilize Resources.

3.1.2. Pairwise Comparison. This questionnaire produced the level of importance of a criterion relative to other criteria. This questionnaire contains a pairwise comparison of each sub-criterion project. This is closed questionnaire and given to the 5 experts from the project team consisting of employees of the company to the top-level managers, and decision makers in a project. In the questionnaire, there are 7 MACBETH scale. The results of this questionnaire then calculated and the Geomean values of each criterion then quantified. Geomean value obtained is the result of a comparison between the criteria with the other criteria. The result of this questionnaire is a pairwise comparison matrix and then inputted into the MACBETH model.

Table 1. Project performance data

| Task                  | Dimension | Measurement   |
|-----------------------|-----------|---------------|
|                       |           | Effectiveness | Efficiency | Relevance | Implementability |
| Business Cooperation  | Scope     | 4.33          | 4.33       | 4.67      | 5.00             |
|                       | Time      | 3.73          | 3.73       | 4.07      | 4.40             |
|                       | Cost      | 3.67          | 3.67       | 4.00      | 4.33             |
|                       | Quality   | 4.00          | 4.00       | 4.33      | 4.67             |
|                       | Human Resources | 4.17    | 4.17       | 4.50      | 4.83             |
|                       | Communication | 3.83    | 3.83       | 4.17      | 4.50             |
|                       | Risk      | 4.07          | 4.07       | 4.40      | 4.73             |
|                       | Safety    | 4.27          | 4.27       | 4.60      | 4.93             |

3.1.3. Project Data. Project data is needed to obtain the value of the performance of each criterion on the project. Performance values obtained vary depending on the performance obtained and performance targets. The closer value to the target performance, the higher performance measured. Table 1 is an example of the value of the performance obtained.
4. Results and Analysis
In this section will be described the model used in the performance evaluation of the project along with the results of the evaluation and a monitoring classification of each criterion on each element to be a suggestion for the company.

4.1. Criteria Weighting
The weights of each criterion can be obtained from pairwise comparison matrices. Weighting criteria for each element is shown in Figure 1.

![Figure 1. The weight of the criteria for each element](image)

Element of the Project Performance Measurements are, weights of Implementability have the highest value, higher than the weight of Effectiveness, Efficiency, and Relevance. This indicates that the implementability of the project is the most influential criteria for the success of the project, while the effectiveness, efficiency, and relevance have an equal level of importance to each other.

Element of Project Dimensions are, the weight of Project Safety criterion has the highest value, followed by Project Quality, Project Time, Project Scope and Project Cost, Project Human Resources, Project Communication, and lastly Project Risk. This indicates that the safety of the project is the most influential criteria for the success of the project, while the project risk has least impact for project success.

Element of Project Tasks are, the weight of Review Performance criterion has the highest value, followed by Complete Reports & Field Tickets, Perform Services, Mobilize Resources, and lastly Business Cooperation and Prepare Resources. This indicates that the review of the project performance is the most important activity in the project, while the business cooperation and preparation of resources is an activity which gives less influence to the success of the project.

4.2. MACBETH model design
MACBETH model consists of three orientations, namely project performance measurement-oriented, project dimension-oriented, and project task-oriented. This model is made by using M-MACBETH software to produce value for each project performance criteria. This paper will only show the task-oriented model of the project.

This project task model combines elements of the project dimension and project performance measurement criteria to be able to generate the value of each project task. This model consists of 8 nodes of project dimensions and 4 subnodes for each node of project performance measurement, as
illustrated in the value tree in Figure 2. Once the value of the performance and value comparisons are included, value criterion level of each element can be generated, as shown in Figure 3.

For elements of Project Performance Measurement, can be seen that Implementability have the highest value, followed by Relevance then Effectiveness and Efficiency. This suggests that the activities in the project could be implemented well, while the effectiveness and efficiency of the project is still running poorly compared to the other criteria observed.

For elements of Project Dimensions, can be seen that Project Scope have the highest value, followed by Project Safety, Project HR, Project Risk, Project Quality, Project Communications, Project Time and lastly Project Cost. This suggests that the activities carried out in this project in accordance with project scope and safety has been maintained properly. However, it appears that poor project performance in terms of time and cost, which indicates that the project duration longer than scheduled, and the cost of the project is greater than budgeted, so improvement on both these criteria is needed.

![Figure 2. Value Tree of project task model](image)

![Figure 3. Project performance value](image)

Elements of Project Tasks, can be seen that Business Cooperation have the highest value, followed by Perform Services, Mobilize Resources, Prepare Resources, Review Performance, and lastly Complete Reports & Field Tickets. This suggests that the activities of the project initiation, the business cooperation with stakeholders, run well. Meanwhile the performance of activities such as completion of the project closure report and review of performance is still not good, even though both of these activities are the most important activity.
4.3. Monitoring Classification

After getting the value of project performance, monitoring classification level of project performance can be determined. Monitoring classification is divided into 4 levels of classes [19], Absolute Vigilance, Strong Attention, Close Surveillance, and Normal Monitoring. For the element of project performance measurements, the classification can be classified as follows:

| Table 2. Monitoring classification for Project Performance Measurements |
|---------------------------------------------------------------|
| Classification | Criteria          |
| Absolute Vigilance | Effectiveness, Efficiency |
| Strong Attention |                      |
| Close Surveillance | Relevance          |
| Normal Monitoring | Implementability   |

Table 2 shows the effectiveness and efficiency criteria require absolute vigilance to improve its performance. Companies should make sure that the project can be run more effectively and more efficiently. Meanwhile relevance requires close surveillance, so the project activities relevance can be better, and implementability only needs normal surveillance because the activities that need to be done in the project are implemented properly.

Element of the project dimensions can be classified as follows:

| Table 3. Monitoring classification for Project Dimensions |
|-------------------------------------------------------------|
| Classification | Criteria           |
| Absolute Vigilance | Time, Cost          |
| Strong Attention | Communication, Quality |
| Close Surveillance | Risk, HR           |
| Normal Monitoring | Safety, Scope      |

Table 3 shows that the time and cost of the project require absolute vigilance to be able to improve their performance. Companies should make sure that the project implementation time can be shortened and the project cost can be reduced. Meanwhile communication and quality of the project require strong attention, communication in the project should be smoothened and project quality should be improved. Then the project risk and HR requires close surveillance, so that the project risks can be minimized and HR projects can be better, and safety and scope of the project only need normal monitoring because their performance is considered good, the project can be run safely and in accordance with the scope of the process.

Table 4 shows that the completion of the reports requires absolute vigilance to be able to improve its performance. Companies should improve project report to be more complete and informative. Meanwhile review performance requires special supervision, it needs to be improved and the methods used need to be more varied. Then the tasks of Prepare Resources and Mobilize Resources require close surveillance, the equipment and personnel preparation and transportation to the site needs to be improved, and the tasks of Perform Services and Business Cooperation only need normal monitoring as the execution of drilling activities at the site and the process of getting the project partners are considered good.
5. Conclusion
Based on the research that has been done, some conclusions can be drawn according to the research objectives to be achieved. First, in the context of the drilling project, the most important criteria for evaluating the performance of the project is Implementability for project performance measurement, Project Safety for project dimensions, and Review Performance for project tasks. Then the highest value of the project performance criteria for each element is Implementability with a value of 0.86, Project Scope with a value of 0.84, and Business Cooperation with a value of 0.86. In contrast, the lowest value of the project performance criteria for each element is Effectiveness and Efficiency with a value of 0.73, Project Costs with a value of 0.70, and Complete Reports & Field Tickets with a value of 0.73. Also there are four levels of supervision for each classification criteria in the project, with the criteria of Effectiveness, Efficiency, Time, Cost, and Complete Reports & Field Tickets require absolute control so that the performance criteria can be increased.

As a refinement of materials for future research, suggestions that could be considered is the comparison of performance between the two joint performance between elements, so that the comparison between the combined performance ratings can be more accurate. The addition of project elements can be done, considering elements such as stakeholder or project sponsorship in the performance evaluation. In addition, this study can be tested on an ongoing project, so that the evaluation results can be directly applied and the results can be directly monitored.

Conclusions from the study were expected to be able to overcome the problems of existing projects, and for companies to measure the overall performance of the various criteria to be able to see the value of the overall project performance. There are also levels of classification criteria for supervision of any of the elements of the project, so the project can be carried out surveillance activities in accordance with the classification levels so that the project will increase the performance as a whole and bring success to the implementation of future projects.

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