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Risk Analysis of E-Procurement Process of EPC Construction Project Based On Risk Management

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ABSTRACT

EPC project performance is affected by the relation between work processes. E-procurement implemented as a tool to mitigate procurement process risk gives a positive effect and residual risk that needs to be managed further. This research aims to analyze the e-procurement process risk and identify the root causes of critical risks. Data is collected using Focus Group Discussion (FGD) and a questionnaire by 41 e-procurement practitioners from 5 (five) Indonesian construction state-owned enterprises (BUMN). There are 116 risks identified from 22 e-procurement steps, of which three risks are determined as critical risks based on Risk Priority Number analysis, with delay of material requisition document as the highest RPN risk. Fault Tree Analysis identifies that several failure modes, such as miscalculation, misallocation of workforce, and payment issues cause the critical risk. Preparing an in-house engineering team to support the calculation process can mitigate two critical risks at the same time. Risk mitigation causes a residual risk that needs further assessment to determine the proper response.

Introduction

One type of construction work contract that is developing is the Engineering-Procurement-Construction (EPC) project contract. This is supported by data from PwC Indonesia in 2022, wherein the first quarter of 2022, four construction State-Owned Enterprises (SOEs), PT Adhi Karya (Persero) Tbk, PT Waskita Karya (Persero) Tbk (Satriyo & Puspitasari, 2017), PT Wijaya Karya Tbk, and PT Pembangunan Perumahan (Persero) Tbk received new project contracts worth 14 trillion rupiah, of which 85% of the total value of new contracts were EPC construction contracts and energy businesses. Projects with high contract value currently use many EPC contracts; in the international market, EPC projects have increased up to 32 percent of the total value of the construction sector in China (Zhang, Pan, Wang, Sun, & Wang, 2017). A project with an EPC contract is a project where the contractor works on a project with the scope of responsibility for completing the work, including design studies, material procurement and construction, and planning of the three activities (Hatmoko & Khasani, 2019). EPC projects rely heavily on continuity between phases of work.

Another research study. The implementation of EPC projects faces many problems, from interrelationships between works, overlapping phases of work, complex organizational structures, and uncertainty of work outcomes. As one of the processes in

an EPC project, the procurement process takes much time and has many potential disputes, so it requires a third party as an intermediary (Li, Greenwood, & Kassem, 2019). The research was reinforced by research conducted by (Hatmoko & Khasani, 2019) that of the 28 risk factors for delayed EPC work identified, 22 percent of them were procurement factors, where the most significant risk factor was the financial problems of subcontractors in the procurement phase with the impact of delays of up to 33 percent of the duration of work. In line with these findings, (Yeo & Ning, 2002) found that the risk factors identified at the procurement stage were 36.7 percent of the total number of risk factors of the EPC project.

One way to mitigate the risk of the procurement phase is using e-procurement, a digital platform to increase the transparency of the procurement process to improve the quality of bidders. The use of e-procurement in supply chain management is not new in the manufacturing industry and has many benefits. However, the construction sector has not widely used this container (Nguyen & Hadikusumo, 2017). E-procurement is designed to add value to the procurement process. Using e-procurement in Indonesia encourages bidders who have a smaller likelihood of being late to win the tender. This is due to changes in the way selection and existing contractors work better due to broader competition (Ibem et al., 2021). Research on previous EPC business projects that discuss problems in project business flow and alternative business process submissions using Focus Group Discussion data collection methods and business process simulation evaluation (Lewis-Faupel, Neggers, Olken, & Pande, 2016). Identify the risk of delays in EPC work in Oil and Gas industry projects using interviews and calculations of potential delays that can occur. This study found that from a total of 28 risk factors identified, 11% of engineering processes, 22% of procurement processes, and 67% of construction processes, with the highest risk being the financial capacity of subcontractors, which are categories of procurement processes (Dachyar & Sanjiwo, 2018).

Not many similar studies use the procurement process in EPC construction projects as the primary research object. Variable factors causing delay and failure mode are sourced from literature studies and asked directly to experts/experts (Xiao, Huang, Li, He, & Jin, 2011). Previous research focused on the benefits and barriers in the application of e-procurement. However, there has been no research on identifying the risk of delay in e-procurement in EPC projects in Indonesia to find the leading causes (Kartika, Harsono, & Liansari, 2016). This study aims to identify and analyze the risk/failure mode in the e-procurement process, which can cause delays in completing the e-procurement process. In addition, the root cause of failure mode in the e-procurement process will be searched in this study.

Research Methods

Types of research

The type of research used is exploratory research, aiming to find something by grouping a particular symptom, fact, and condition. The stages of research carried out are determining the background of the problem that leads to the formulation of the main problem, literature studies, and pre-survey stages of collecting data, the risk identification process in the e-procurement process, the risk analysis process using probability and impact assessment, the output of risk analysis will be continued with the process of identifying sources of risk using the FTA method and ending with a discussion of managerial implications along with conclusions and suggestions .

Risk Identification e-Procurement Focus Group Discussion Process. The implementation of risk identification of the e-procurement process of EPC projects is carried out using the Focus Group Discussion (FGD) method. The FGD resource persons were ten practitioners with at least five years of experience in EPC e-procurement applications. The risk identification process maps the risks that can arise in the e-procurement process that will impact the timing of project implementation. The output generated from this process is a list of failure modes at each stage of the e-procurement procurement process, which will be grouped according to the type of risk. Each failure mode identified in the FGD process will be evaluated against two criteria using a scale of 1 to 5, with 5 being the worst score (Fabbri, 2019).

Population and Sample

Sampling using the purposive sampling method with specific considerations, namely experience in using e-procurement in EPC project work. Questionnaire respondents are at least 30 respondents with at least two years of e-procurement application experience.

Questionnaire. The results of risk identification obtained in the previous research stage become a questionnaire form that will be used to obtain the Risk Priority Number (RPN) value of risk assessment from respondents.

Test Validity and Reliability

I carried out the data obtained from the questionnaire to ensure the questionnaire used was consistent and reliable—critical risk analysis. The RPN Value data from the questionnaire will be the basis for the critical risk determination process. The amount of critical risk is determined using the highest RPN (Dwiano, Mulyatno, & Sisworo, 2021).

The Fault Tree Analysis (FTA) process is carried out by making FTA diagrams based on the results of focus group discussions with e-procurement practitioners of EPC projects. Based on the FTA diagram, the minimum cut set determination was carried out using the Method for Obtaining Cut Sets (MOCUS) method. MOCUS is used to identify combinations of multiple sources of risk that can result in a top event. The MOCUS implementation process produces a combination of minimal cut set combinations that can show the top event's root cause, which is determined by the MOCUS FGD resource person who has the highest potential (Aguiar Costa & Grilo, 2015).

Results and Discussion

The risk identification process was carried out with FGD with ten resource persons to determine credible risks based on the experiences of the resource persons and other references. The risk identification process refers to the flow of EPC e-procurement work prepared based on previous research and primary data that the author has collected. This process curates risks in 22 stages of the EPC e-procurement process, with the results of 116 risks agreed as valid risks from 148 risks compiled in the pre-survey and brainstorming stages. The resource person also determines the assessment parameters for the data collection process through questionnaires with a scale of 1-5 for probability and impact assessment (Wang, Tang, Du, Duffield, & Wei, 2016).

Table 1
Impact Assessment Parameters

Impact Assessment Description	Impact Score	Time Impact Parameters
Very Small	1	< 1 hari
Small	2	1-2 hari

Keep	3	3-7 hari
Big	4	7-14 hari
Very Large	5	> 14 hari

Table 2
Impact Assessment Parameters

Description of Probability Assessment	Score Probability
Very rare	1
Infrequently	2
Keep	3
Often	4
Very often	5

The sample in this study is practitioners in active construction SOE EPC projects in Indonesia who have at least two years of experience in the e-procurement procurement process. The questionnaire was conducted online using Google Forms to reach the expected number of samples. Respondents came from various BUMN Karya agencies with PT. PP Persero Tbk is the work agency with the highest number of respondents, with 32 out of 41 total respondents.

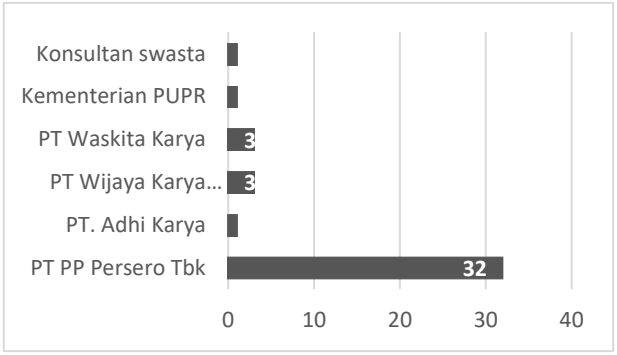

Figure 1. Graph of Number of Respondents by Agency

Respondents have diverse work experience, ranging from 1 year to 26 years of total work experience.

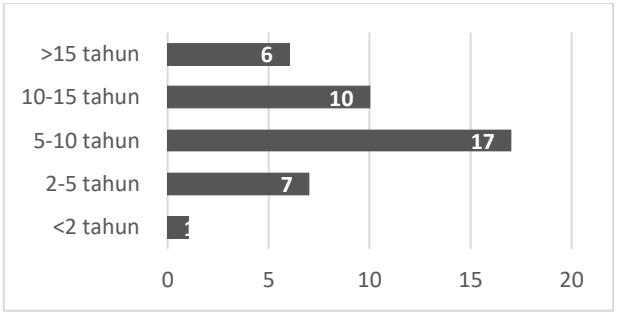

Figure 2
Graph of Number of Respondents by EPC Construction Experience

Respondents were regrouped according to experience in implementing e-procurement on EPC construction work.

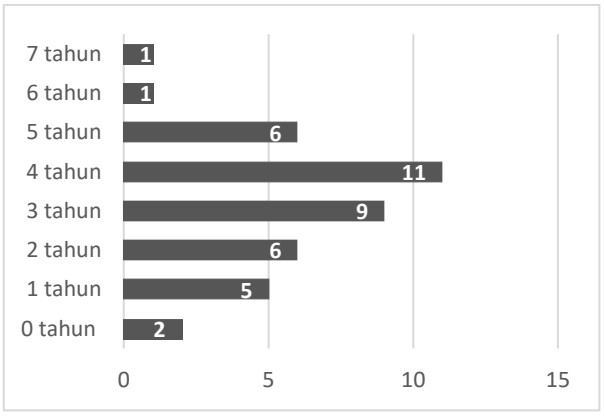

Figure 3
Graph of Number of Respondents by EPC e-Procurement Application Experience

Respondents provide risk assessments using parameters identified in the Focus Group Discussion stage. The results of data collection using questionnaires can be processed using the Risk Priority Number (RPN) calculation formula, namely probability (P) multiplied by impact (I) to determine the risk with the highest priority.

$$RPN = P \times I \quad (1)$$

The results of the questionnaire that have been obtained are then processed normality tests and reliability tests to ensure consistency and validity in measuring the variables studied. The parameters used to assess the validity test are comparing the r table with the r count and the 2-tailed sig values resulting from calculations compared to 0.05 values. The r value of the table for the number of respondents, as many as 38 people, is 0.32, with a significance of 5%. The results of the questionnaire validity test showed that 114 out of 116 question items were considered valid because they had a calculated r value greater than 0.32 and a correlation value smaller than 0.05. Risk items X96 and X12 are invalid and will be excluded from RPN evaluation for critical risk determination. Furthermore, reliability tests were carried out from 114 valid variables based on validity tests using SPSS. The respondents obtained from the questionnaire process, totaling 38 respondents, were considered valid because all respondents filled in all question items. Based on the validity test results, Cronbach's Alpha was obtained at 0.991, more significant than the table r value for 114 items determined by the interpolation method, which was 0.18664, so 114 questions were assessed consistently.

Determining the amount of critical risk using a scree plot from the results of RPN calculations that have increased significantly is a limitation in selecting critical risks.

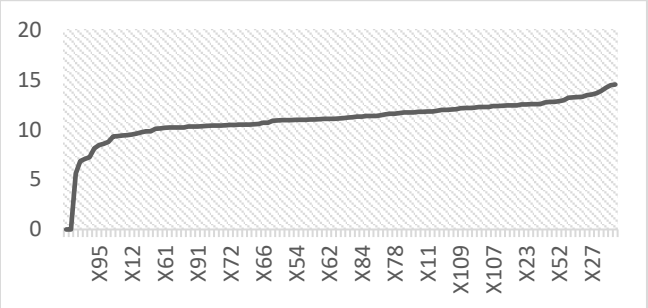

Figure 4
Scree Plot Risk Priority Number based on Questionnaire Results

Risks that become critical are risks with a significant increase in RPN calculation compared to the previous risk RPN value. Risks with significant increases in RPN results that have now been mapped indicate critical risks. The questionnaire results showed a significant increase in 3 risks with the highest RPN values, namely X43, X20, and X18.

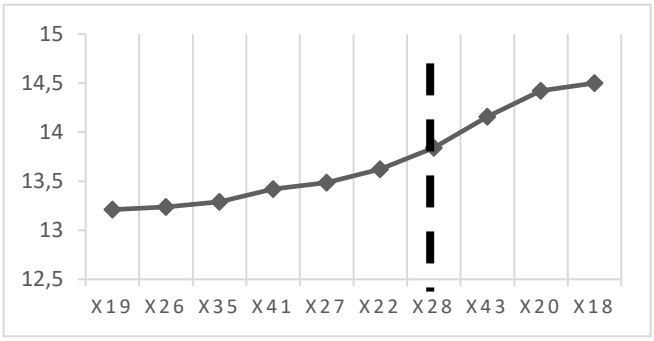

Figure 5
Scree Plot Risk Priority Number Risiko Kritis

Fault Tree Analysis - Resource persons conduct focus group discussions to carry out the Fault Tree Analysis (FTA) process based on critical risks determined from the results of previous questionnaires. The resource person provided input on the factors causing the risk by experience in e-procurement implementation in EPC projects. The FTA analysis process is carried out simultaneously for three critical risks, namely X43, X20, and X18, to produce 1 (one) FTA diagram for each work risk.

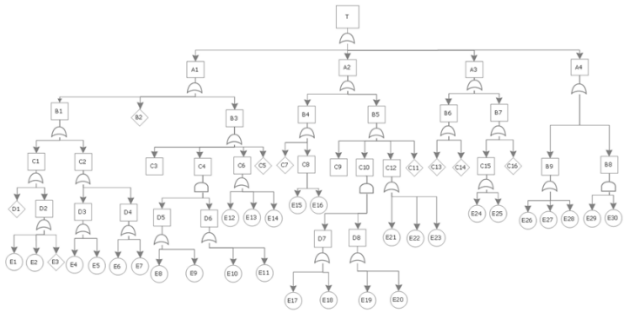

Figure 6
Fault Tree Diagram Risiko Kritis X43

Fault Tree Diagram for the risk of submitting budget changes due to overbudget is made based on the experience of resource persons and prepared a Minimal Cut Set to simplify the causes of risk. There are 39 combinations of Minimal Cut Sets found. Then, the resource person will determine the Minimal Cut Set with the most significant potential to occur among all Minimal Cut Sets. The minimum cut set with the most significant frequency is the occurrence of C6 or inaccuracies in the calculation caused by E13, E14, or E15. Inaccuracies in calculations occur if there is a lack of workforce in the tender evaluation process or software used when the tender calculation is inaccurate, or if there is additional scope of work after the engineering process is carried out.

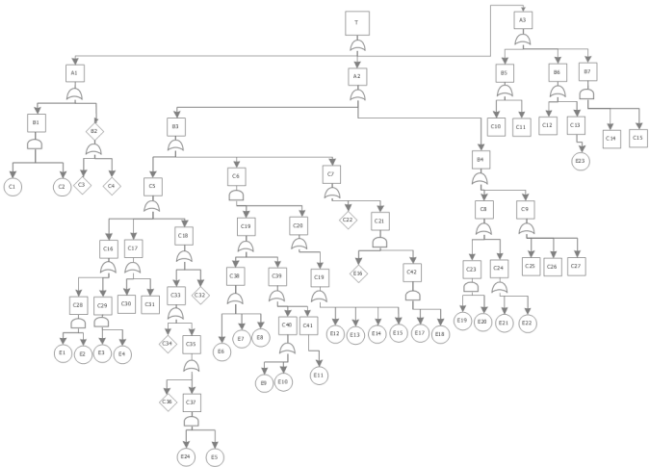

Figure 7
Fault Tree Diagram Risiko Kritis X18

Fault Tree Diagram for the risk of material requisition from Engineering delay in the work package manufacturing process is made based on the experience of the resource person and prepared a Minimal Cut Set to simplify the cause of risk. There are 42 combinations of Minimal Cut Sets found. Then, the resource person will determine the Minimal Cut Set with the most significant potential to occur among all Minimal Cut Sets. The minimum cut set with the most significant frequency is the occurrence of C38, or the consultant vendor does not perform, which is caused by E6, E7, or E8. Consultant vendors do not perform if there is a lack of staffing in the design calculation process, workforce overload, or problems in progress payments.

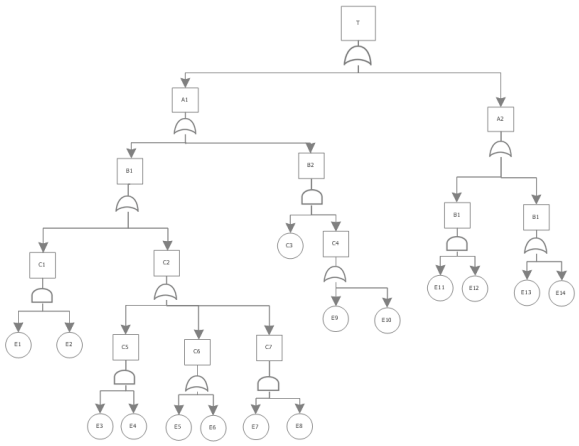

Figure 8
Fault Tree Diagram for Critical Risk X20

A fault tree diagram for the risk of incomplete design is made based on the experience of the resource person, and a minimal cut set is prepared to simplify the cause of the risk. There are ten combinations of Minimal Cut Sets found. Then, the resource person will determine the Minimal Cut Set with the most significant potential to occur among all Minimal Cut Sets. The minimum cut set with the most significant frequency is the occurrence of C5 or no procedure caused by E3 and E4. The absence of procedures for archiving documents occurs when time is limited for creating procedures and managerial errors.

Conclusion

The results showed 3 (three) critical risks among 116 identified in 22 stages of the e-procurement implementation process of EPC project construction. The risk of delay in implementing e-procurement due to material requisition delays from the engineering team at the stage of making work packages is a risk with the highest RPN value of 14.5. Another critical risk that needs attention is incomplete documents when making work packages and the need to submit budget changes when making purchase requisitions. Mitigation of the occurrence of these events is significant, both in the form of reducing the possibility of activities or reducing the impact that can occur. The resource persons brainstormed the FGD process to determine the event with the highest probability of occurring in each critical risk. The factor causing the risk of material requisition delays from the engineering team at the stage of making work packages with the highest probability of occurring is the occurrence of consultant vendors not performing due to errors in the design calculation process, workforce allocation errors with other projects, or problems in progress payments. Mitigation of the occurrence of these events is significant, both in the form of reducing the possibility of activities or reducing the impact that can occur.

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