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A Practical Application of FMEA for IT Project Prioritization : a Case Study at Manufacturing Company

Diena Novitasari[1], Komarudin[2] and Akhmad Hidayatno[3]

[1,2,3] Department of Industrial Engineering, Universitas Indonesia, Depok, Indonesia
diena.novitasari@gmail.com;komarudin01@gmail.com;akhmad.hidayatno@ui.ac.id

ABSTRACT
This research aims to develop a method for information technology (IT) project prioritization that is very easy for a user through a case study in a manufacturing company. This research used descriptive qualitative research based on survey data from unstructured and semi-structured interviews with system development managers. Furthermore, the applicability of the developed method is assessed. A combination of importance analysis and risk analysis using failure mode and effect analysis (FMEA) is useful and applicable to this company. The risk that is considered in this study is the risk of a delayed project for the company. This study contributes to the relevant literature by proposing a very applicable IT project prioritization method.

Keywords: IT Project Prioritization, Risk Analysis, FMEA, Importance Analysis

1. INTRODUCTION

Global competition requires industries to improve performance in all aspects of existing businesses. The use of IT, both hardware and software, can make a positive contribution to industry productivity [21]. In industry, IT is used in various aspects, including accounting, human resources, marketing, manufacturing, research and development systems, decision support systems, CAD / CAM, and in any other aspects. New IT projects continually being planned in response to business activity and market conditions. As a result, the backlog of "needed" projects requires resources that exceed management's ability to provide [17]. Project prioritization consists of assigning priority or rank to a project based on a set of criteria. Project prioritization aims to establish an order of importance among the projects to determine which projects to implement first. An example of the project is such as deciding on strategic investment in manufacturing technology [22]. There are some methods and tools available to help companies to prioritize their IT projects.
This study selects a manufacturing company in Indonesia as a case study research object to study the practicality of the IT project prioritization method. A preliminary interview is used to know the management evaluation of the applicability of previous methods. In this preliminary interview, IT prioritization methods that are proposed by the previous study are introduced. However, none of these methods adequately support managers to set the priority of IT projects. This preliminary interview result shows there is a gap between the available method in previous literature/study and practitioners' needs. As a result, this study presents research that develops an applicable method of IT project prioritization, which is developed based on the case study on the company. This study proposes a method based on existing literature and refines the existing methods through discussion with system development division managers. The structure of the paper is as follows. First, this study will discuss the IT project prioritization problem in the company. Then, it is followed by a gap analysis

between previous study/literature and the current company needs. A method that is a combination of risk analysis and importance analysis is developed. Finally, the managers of this company asses the applicability of the proposed method.

2. METHODS

2.1 Existing IT Project Prioritization

The purpose of this initial phase was to know how this company set the priority of its IT projects. Managers of system development division were chosen as respondents. Then, using a semi-structured interview approach, three managers were questioned at the same time. In this study used a Questionnaires to guide and focus the interview on critical areas. The questions were set to investigate what managers do for prioritizing projects in one work cycle. This company already developed its own IT system since 1995. In 2014 they used the IT project prioritization method using benefit and effort analysis. In 2018, they did not use that method anymore, because most project's benefit is intangible. Although an intangible benefit can be converted into a tangible benefit (e.g. financial value), but practically it is hard to standardize this conversion. For example, a project that has an objective to improve the product development process through a dashboard. One of these project's benefit is to give centralized information for the project development team so that it can decrease missed communication among team members. That kind of benefit is difficult to be converted to financial value.

IT project prioritization is essential to the company because the amount of available resources is not proportional to the number of projects. Usually, in September, the system development division decides the sequence of the projects. Sometimes a new project is initiated after IT project prioritization finished, then project priority must be re-set. In some cases, an alternative solution beside IT (for example macro excel, sharing point, procedure) is proposed to project owners as a temporary solution while projects owner waiting for their turn. The system development division will collect user requirement documents from the project's owner and set proposed project priorities. Since the benefit and effort analysis has not been used anymore, the company does not have a well-structured and documented method to prioritize their IT projects. Priority setting is performed by system development managers based on their knowledge, experience, and intuition. They said that their decision making is based on two types of assessment. First, management will pay attention to the project's urgency. They will analyze the effect of project lateness. A worse effect on business will have a higher urgency. Second, management will assess the project alignment to top management policy and company strategy. In this case, the top management policy is arranged as a system development road map.

Although IT project prioritization that is arranged by system development managers is well accepted by all project owners, they still face difficulty and problem. IT projects are compared by each other's to know the priority order. One of the difficulties of this current method is to set priority for low priority projects (6th and so on). Managers must dive deep into user requirements one by one. That process is confusing and wasting time. Moreover, managers face a long waits project. Some projects have been waiting for more than two years because new projects that have higher priority are always arising every year. It caused delayed project owners to feel worries and unfair. Managers expect future methods can solve the problems above. This company needs an efficient method because this company only has five days to prioritize all IT projects and cannot be extended because it is related to the whole company schedule. Moreover, managers need a method that can help management to decide when resource adjustment is needed. An adjustment can be made through temporary re-assign IT staff or outsourcing. For now, this adjustment is made without proper analysis.

2.2 Define and Fill Gap

The purpose of this stage was to explore previous IT prioritization study. From the review and analysis of 12 studies against criteria used, criteria project's urgency based on the effect of project lateness is never be considered in previous studies. This is illustrated in table 1. The questioned problem in this study is how to measure a project's urgency based on the effect of project lateness on business. The challenge is that the proposed method must be able to measure various kinds of business process and the result should able to be used to compare the urgency of each project. The first idea is using performance. The lower performance, the worse effect it will be on business, it means the project has higher urgency. Simple testing is used to know whether this method is applicable or not. Type of IT projects in the company is defined as follows:

Type 1 Project that supports current process improvement, ex. electronic purchasing
Type 2 Project that supports control and decision-making process, ex. supplier delivery process tracking
Type 3 Project that supports processes that never existed before, ex. the out-plant transaction process of the finished product

Performance measurement is not applicable for project type 2 and type 3. It is difficult and uncommon to measure the performance of the control and decision-making process. For project type 3, it is complicated to measure a process that is never existed before. It is possible to do simulation and measure the process performance without IT support compared to its performance target. However, it is not worth, and it is wasting time. It can be concluded that performance measurement is not applicable to IT project prioritization.

The other idea for measure project urgency is risk measurement. The higher risk, the worse effect it will be on business, it means the project has higher urgency. Similar testing is done to know the applicability of risk measurement to IT project prioritization. The result is risk measurement is applicable to measure all types of projects. The plus point of this method is the commonality of risk measurement. There are several tools and techniques for risk measurement. In this study, FMEA is proposed to risk measurement. An FMEA is a detailed document that identifies ways in which a process can fail to meet the critical requirement [16]. One of the current IT project prioritization that is mentioned before is system development can present an alternative solution beside IT. That process can be included in FMEA. The FMEA method will be completely explained in next section.

Table 1: Previous Works of Literature of IT Project Prioritization.

#	Author (year)	Title	Projects	Project's Urgency Based on the effect of project lateness to business	Project's alignment to top management policy and company strategy
1	Agarwal et al. (1992)	Knowledge-Based Support for Combining Qualitative and Quantitative Judgments in Resource Allocation Decisions	Not mentioned	X	X
2	Agarwal et al. (1994)	MIS Planning: A methodology for systems prioritization	Department of health and social services of the USA	X	V
3	Santhanam & Kyparisis (1995)	A Multiple Criteria Decision Model for Information System Project Selection	Food companies	X	V
4	Kim et al. (2000)	A methodology of constructing a decision path for IT investment	Company in Korea	X	V
5	Sowlati & Sold (2005)	Information Systems Project Prioritization Using Data Envelopment Analysis	Financial institution	X	X
6	Bardhan et al. (2004)	Prioritizing a Portfolio of Information Technology Investment Projects	The US-based energy utility firm	X	X
7	Chen & Cheng (2009)	A comprehensive model for selecting information system project under fuzzy environment	Not mentioned	X	X
8	Ghapanchi et al. (2012)	A methodology for selecting portfolios of projects with interactions and under uncertainty	Government	X	X
9	Rivinus (2013)	IT project prioritization: A practical application of knowledge management principles	Tullow Oil, UK	X	V
10	Neves & Camanho (2015)	The Use of AHP for IT Project Prioritization – A Case Study for Oil & Gas Company	Oil & Gas Company	X	
11	Jazarzadeh et al. (2018)	A methodology for project portfolio selection under criteria prioritization, uncertainty and projects interdependency –a combination of fuzzy QFD and DEA	Not mentioned	X	V
12	Moisiadis (2002)	The Fundamentals of prioritizing the requirement	Not mentioned	X	V

2.3 IT Project Evaluation Criteria

The purpose of this section is to know whether there are other criteria that will be considered by the company or not. This study arranged a questionnaire of project evaluation criteria that are already presented by Jiang and Klein [11]. There are six criteria and 35 variables. The results of the questioner were as follow:

- Organizational needs related criteria

- Contribution to organizational goals/objectives
- Aid the organization in competing in the market
- Importance to the organization for future success
- Importance to the functioning of the organization
- environment-related criteria
- Required by regulations
- Response to competition
- Required by customers/suppliers
- New industry standard
- Lawsuit requires information

Contribution to organizational goals/objectives can be described as a project's alignment to top management policy and company strategy, variable that mentioned before. Importance analysis will be proposed to measure all these variables. Importance analysis will be explained in 2.4.2.

2.4 Method Development

2.4.1 Definition of Urgency and Priority

According to the managers' perspective, they refer to urgency as pressingness of the business condition and the promptness of the necessary process improvement, regardless of other projects. The level of urgency will be defined by risk analysis and importance analysis. The result of the analysis will be presented on two axes matrix; x-axes show importance, and y-axes show risk. Managers refer to priority as a sequence of projects. The project priority can easily define by looking at the matrix.

2.4.2 Urgency Assessment

The urgency assessment results in risk analysis and importance analysis. This company can use risk analysis to know the risk if the projects delayed to operational conditions and use importance analysis to know the project's contribution to variables that are mentioned before. Urgency assessment will be done sequentially as follow:

- Define user requirement
  Project owner define user requirements. The user requirement consists of information that briefly explains the summary of the IT project. For example, project team member, requirement summary, project's objective, project scope, etc. System development staff use user requirement for better understanding about that IT projects and make sure all requirement already approved and supported by related division's managers.
- Risk analysis using FMEA
  An FMEA is a detailed document that identifies ways in which a process can fail to meet the critical requirement. FMEA lets project owners to lists all the possible causes of failure in case their project is delayed/late. Then, system development division can determine types of controls/mitigation plan beside of IT solution to reduce risk. However, it is possible and allowed to have no mitigation plan. In some cases, the only way to reduce/mitigate risk is through IT solutions, or the mitigation plan is not approved by project owner and management. Risk analysis using FMEA is proposed to reduce project

urgency and the need for additional resources to run IT projects. The FMEA procedure is adapted from [16]. as follow:

a. Define the scale table for the consequence, probability, and risk matrix.
   Determination of consequence and probability rating will be easier and faster through scale table. This scale can be different between processes. For example, Bertolini & Braglia present a scale table related to the manufacturing process that is different compared to the scale table, which is related to the carbon management process presented by Aarnes & Hill [1]. In this case study, this company already has its scale table that already used to arrange a corporate risk register. table 2 and table 3 show a consequence and probability scale that is used in this study. [13]. used the consequence scale to analyze supply chain risk. table 4 shows a risk matrix that is used in this study.
b. Determine the critical process that will be improved by its project
   The objective of an IT project is to improve the business process. In one project consist of one or more business process that consists of several processes. Instead of analyzing all the processes, this risk analysis only focuses on conducting the FMEA analysis on the critical process. The analysis only on the critical process is typical in FMEA practitioners [13]. One Project is allowed to have more than one critical process.
c. Determine all potential failure mode of each process
d. Determine the effects of failure mode
e. Evaluate the consequence of each effect (consequence rating).
f. Evaluate the probability of each failure (probability rating)
g. Determine the final risk based on the risk matrix.
h. Determine the mitigation plan, back to (b) if available
i. End. table 5 shows FMEA analysis for some IT projects at The company

Table 2: Consequence Scale.

Scale	Description
Very high	When a potential failure mode affects the safe operation of the product and involves non- conformance with government regulations. May endanger people or products.
High	When a high degree of customer dissatisfaction is caused by the failure. Does not involve the safety of people or product or compliance with government regulations. May disrupt subsequent processes/operations and/or require rework.
Moderate	When a moderate degree of customer dissatisfaction is caused by the failure. The customer is made uncomfortable or is annoyed by the failure. May cause rework or result in damage to equipment.
Low	When a failure will cause only a slight annoyance to the customer.
Minor	When a failure is not likely to cause any real effect on subsequent processes/operations or require rework. Most customers are not likely to notice any failure. Any rework that might be required is minor.

Table 3: Probability Scale.

Scale	Description
Almost certain	90%
Likely	70%
Possible	50%
Unlikely	20%
Rare	6%

Table 4: Risk Matrix.

	Probability				
Consequence	**Almost Certain**	**Likely**	**Possible**	**Unlikely**	**Rare**
Very high	Very high	Very high	Very high	High	High
High	Very high	Very high	High	High	Moderate
Moderate	High	High	High	Moderate	Moderate
Low	High	Moderate	Moderate	Low	Low
Minor	Moderate	Moderate	Low	Low	Low

- Importance analysis
  This company can user importance analysis to asses a project's contribution to a variable that is important to the company. This analysis is done through a simple and easy scoring process. This kind of analysis is not a new thing in IT prioritization literature.
  Importance analysis is started with ordering an importance variable based on its importance for the company. The result is, there are three levels of variable ordered by its importance, as follows:
  - Required by regulation becomes the essential variable because of good corporate governance (GCG). The score is defined by whether the objective of the project is to regulation compliance or not.
  - Project's alignment to top management policy and company strategy. Firstly, all top management policies and company strategies are weighted. The score is defined by how the IT project's objective aligns with top management policy or company strategy.
  - Miscellaneous variables consist of the rest of the variable that is already mentioned in phase 3. For different variables, the weight of each variable is defined.

  Instead of measuring all three variables, it is enough to measure the highest variable that can be contributed by the IT project. This kind of measurement gives more meaning full information for IT project prioritization to The company. Table 6 shows how importance analysis is done. The variable that is used in importance analysis can be adjusted. Adjustment is based on company preference.

2.4.2 Risk and Importance Matrix

This matrix helps managers to not only know but also understand project priority. Priority is determined by risk. Projects with the same risk will be prioritized by its importance. Figure 1 shows the risk and importance analysis matrix of the company. This matrix not only shows the priority but also gives information about how many projects that should be done immediately. A project that should be done immediately is the project that has a very high risk. If the resource is not enough, this method allows managers to consider three alternatives. First, managers can limit project scope based on FMEA, only user requirements for critical processes that will be included. Second, adding more resources. The last, managers can decide to let the project wait until the resource is available. Projects with the same risk and

importance can be a trigger for managers to arrange a meeting with project owners to decide which project will be done first.

2.5 Method Evaluation

Compared to the method used before and methods that are proposed by previous study a significant improvement in the IT project priority setting activities. An assessment for method performance was done for the proposed method and previous method. The assessment uses variables that have been used by [7]. as shown in table 7, using scale 5 – 1, 5 is very satisfied and 1 not satisfied.
An interview with managers of The company is used to know the proposed method of advantages and disadvantages. The advantages as follow:

- Project owner participation is high
- Project priorities are easily known and understood by users with different educational backgrounds because they are explained with a matrix

Table 5: Risk Analysis Using FMEA.

	Final Risk	Mitigation Plan	Failure Mode	Effect	Consequence	Probability	Final Risk
Project 1	Very high	-	-	-	-	-	-
Project 2	High	Entering structure directly to data base	Forget to enter data	Stock data and actual cost faulty	Moderate	Unlikely	Mo-derate
Project 3	Moder ate	-	-	-	-	-	-

Process	Failure Mode	Effect	Conse-quence	Proba-bility
Entering material data	Entering non-compliant material	Penalties	Very high	Possible
Entering REM structure	Not able to enter irregular part	Stock data and actual cost faulty	Mode-rate	Almost Certain
First tear supplier good receipt	Late transaction	Finish goods cannot be processed	High	Rare

Table 6: Importance Analysis.

Variable	Item	Weight	Score (High 3; Medium 2; Low 1)		
			Project 1	Project 2	Project 3
Required by regulation	-	-	√		
Top management policy and company strategy	Strategy 1	5		3	
	Strategy 2	3		3	
	Strategy 3	2		-	
	Total Weight x Score			24	
Miscellaneous variables	Aid the organization in competing in the market	1			
	Importance to the organization for future success	3			3
	Importance to the functioning of the organization	1			
	Response to competition	1			
	Required by customers/suppliers	3			3
	New industry standard	1			
	Total Weight x Score				18

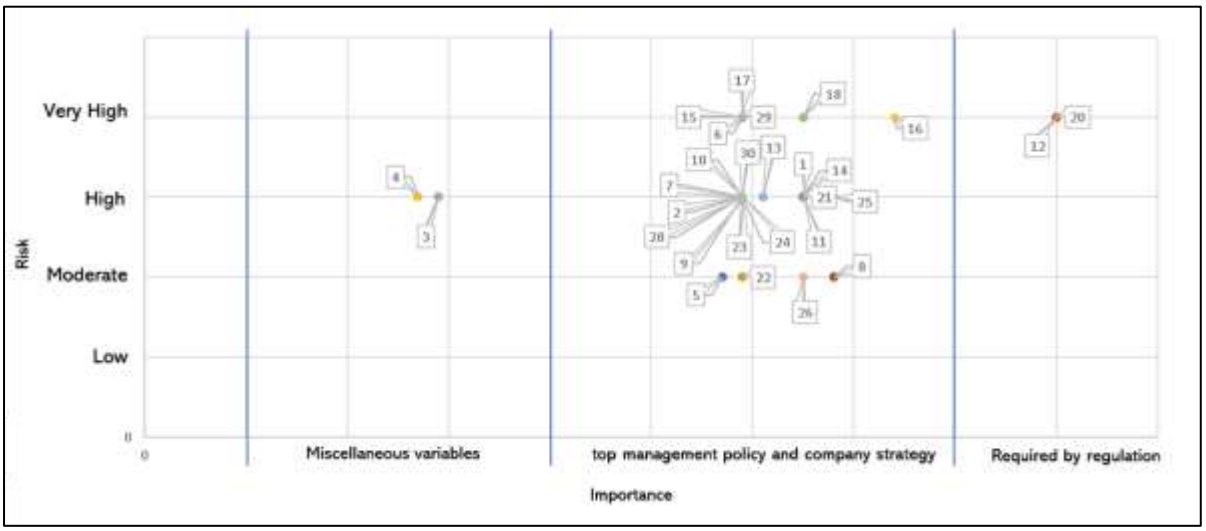

Figure 1: Risk and Importance Analysis Matrix.

- Visualize data and provide detailed data
- If something is deemed inappropriate, the supporting data can be reviewed
- With this matrix, project priorities are not only in order but also with urgency
- "Snapshot" decision making, can show a trade-off when making decisions
- Can help in making decisions in managing resources
- If too many projects are urgent, FMEA can be the basis for limiting the scope of the project, so that more projects can be done
- It helps to focus on mitigation plans in the form of solutions other than IT, and their urgency is known. It could be that even though there is a solution other than IT, the urgency remains high.
- Importance analysis can be adjusted to the needs of the company

Table 7: Proposed Method's Performance Assessment.

#	Variable	Performance 1 – 5
1	Perceived as Effective	5
2	User-friendly	5
3	Realistic Method	5
4	Perceived as Efficient	5
5	Fits management decision-making style	5
6	Understood by Management	5
7	Minimize conflict	5

The disadvantages of this proposed method as follow:

- Learning time is needed for companies that are not familiar yet with risk analysis. That company must develop its own consequence, probability and risk scale first. The

company is regularly using risk analysis, so this disadvantage is not counted for The company.

- Moderate and low priority projects will potentially have a long waiting time because the project that has higher priority always arising every year

3. CONCLUSION

This study aims to develop a method for information technology (IT) project prioritization that is very easy for a user through a case study in a manufacturing company. This study shows that there is a variable that is not mentioned before in the previous study. The project's urgency based on the effect of project lateness to the business variable is expressed as a risk if the projects delayed to operational conditions. The main outcome of this study is the creation of a practical and procedural method to set IT project priority easily that not only shows the project's priority but also shows project urgency.

Urgency is used by managers to know which project that must be done as soon as possible. That information allows managers to decide resource adding or scope limitation.

It is understood that this proposed method cannot solve the long waiting time of moderate and low-risk projects. A mechanism of IT project prioritization that is include waiting time would require further studies. [23]. use clinical urgency and waiting time to prioritize access to elective surgery. That concept may also effective for IT project prioritization. Project risk (very high, high, moderate, and low) shows the urgency of the IT project. A study about the minimal time before treatment for each project urgencies is worthy. So, a project that has low priority not waiting all the time until the resource is enough. That mechanism can be fair for project owners.

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