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Risk Factors and Effectiveness of Implementing Multi-Construction Projects for Development of Industrial Facility Sector in Indonesia

Saut B. Siahaan[1], Sofia W. Alisjahbana[2], Onnyxiforus Gondokusumo[1]
Civil Engineering Doctoral Program, Universitas Tarumanagara - Jakarta, Indonesia[1]
Department of Civil Engineering, Bakrie University, Jakarta 12940, Indonesia[2]
Corresponding Author*: saut.328211007@stu.untar.ac.id

ABSTRACT

Purpose: Multi-project management of industrial facility construction has high challenges and complexity. Various factors influence the effectiveness and risks of multi-project implementation. A separate management method is required in implementing multi-projects compared to single projects. An organization must manage multiple projects using organizational resources and personnel. This research aims to obtain best practices in managing multi-project construction of industrial facilities in Indonesia and understand the cause and effect and influence between variables.

Design/ methodology/ approach: This research uses a qualitative approach based on literature observations, reviews, and surveys of the construction sector of industrial facilities in Indonesia. Survey data were analyzed by looking for essential themes related to the research questions. The survey results show that six factors and 50 important variables influence the implementation of multi-project industrial facility construction. These factors are human resources, organization, environment, construction, external, design & technical, and business.

Findings: This research provides an overview of the practices and challenges of multi-project management of industrial facility construction in Indonesia. This research also provides recommendations for developing dynamic system models that can assist in managing the risks and impacts of multi-project implementation.

Paper type: Research paper

Keyword: *Multi-project, industry facility, system dynamic*

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I. INTRODUCTION

Multi-project management refers to managing several interrelated projects with different levels of complexity and characteristics compared to driving a single project (Tsvetkova & Tukkel, 2017). According to Hedberg & Höglander (2013), multi-project refers to a situation where an organization carries out several projects simultaneously, regardless of their interrelationships. Managing multiple projects brings new challenges to project management, such as resource allocation, team coordination, and quality control. The definition of multi-project from relevant previous research is: 1) Activities of an organization or company that involve the simultaneous execution of several projects that may be related (Patanakul, 2013; Patanakul & Milosevic, 2009; Tsvetkova & Tukkel, 2017) or not have relatedness (Hedberg & Höglander, 2013); 2) Projects that interact in terms of intangible resources such as ideas, core values, or innovation, while being constrained by physical resources such as finance, technology, labor, and information that can change over time and require efficient scheduling (Tsvetkova & Tukkel, 2017); 3) Management of a series of projects simultaneously within a company, including portfolio optimization (Kracík et al., 2013); 4) Organizational operational conditions that involve implementing a series of projects simultaneously or sequentially (Engwall & Jerbrant, 2003).

Specifically, the definition of the multi-project construction sector, according to Abdullah & Vickridge (1999), is the management of several construction projects directly or indirectly interconnected by clients,

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business objectives, funding, resources, environment, or operations. Multi-projects are needed to increase management and monitoring efficiency at the organizational level (Abdullah & Vickridge, 1999; Engwall & Jerbrant, 2003; Hedberg & Höglander, 2013; Martinsuo & Ahola, 2022; Patanakul & Milosevic, 2009; Tsvetkova & Tukkel, 2017). In multi-projects, there are interaction and coordination factors between related projects (Abdullah & Vickridge, 1999; Engwall & Jerbrant, 2003; Patanakul, 2013; Tsvetkova & Tukkel, 2017). Multi-projects are used to increase collaboration, cooperative communication between project teams, and technology transfer between projects (Martinsuo & Ahola, 2022; Patanakul & Milosevic, 2009; Tsvetkova & Tukkel, 2017). It increased flexibility to environmental and business changes (Hedberg & Höglander, 2013; Kracík et al., 2013). It is a common method modern organizations use to achieve company strategic goals (Kracík et al., 2013). They were carried out for resource efficiency optimization of resource use (Abdullah & Vickridge, 1999; Engwall & Jerbrant, 2003; Patanakul, 2013). Improving performance and competitiveness (Kracík et al., 2013), reducing costs and risks (Kracík et al., 2013), and achieving maximum benefits by integrating various aspects of design, finance, risk, quality, environment, health, and safety in construction projects (Abdullah & Vickridge, 1999).

There is a huge challenge in managing multiple projects in parallel with limited resources. Multi-project management is required to ensure alignment between strategic and project objectives and optimize resources and risks (Kracík et al., 2013). According to Payne (1995), a separate management method is needed in implementing multi-projects compared to single projects. The division of workload management of work tasks (Elonen & Artto, 2003; Engwall & Jerbrant, 2003) is a problem in multi-project management. An organization is required to manage multiple projects regarding the use of organizational resources and personnel (Hedberg & Höglander, 2013). The main elements of multi-project construction management, according to Abdullah & Vickridge (1999) are 1) Multi-project objectives and strategies; 2) Multi-project organization; 3) Multi-project master plan; 4) Integrated information and communication systems; 5) Financial strategy, risk management, quality management, environment, health and safety, design strategy, and contract and procurement strategy; 6) Planning and controlling resources, schedules, costs and progress for each project in multiple projects; 7) Regular measurement of benefits, evaluation and corrective action. Multi-project differs from project portfolio management, which focuses more on aligning strategy and organizational goals. Multi-project also differs from program management, focusing more on achieving significant results and benefits through related projects.

Industrial projects are projects related to the construction or repair of industrial facilities, including factories in the form of places or buildings used to carry out economic activities related to the processing or manufacturing of raw materials or finished goods. Industrial facility construction projects can include various types, such as developing production plants, refineries, power plants, chemical plants, and their derivatives. Developing industrial facilities requires planning, design, construction, operation, and maintenance under engineering and environmental standards.

The context of multi-project management in previous research includes various issues, such as 1) Effectiveness and efficiency of multi-project management (Abdullah & Vickridge, 1999; Kracík et al., 2013; Patanakul & Milosevic, 2009).; 2) Problems of resource allocation, risk management, and work environment challenges in a multi-project context (Hedberg & Höglander, 2013; Martinsuo & Ahola, 2022; Patanakul, 2013); 3) Assignment of project managers, orientation and organizational culture, as well as multi-project manager competencies (Patanakul, 2013); 4) In the construction sector, the problem of difficulties in getting attention from senior management, establishing multi-project definitions, schedule management, risk management, change, multi-project management structures, communication, coordination, and comprehensive guidance for multi-project management in the construction industry (Abdullah & Vickridge, 1999).

This research aims to analyze risk factors and factors that influence the effectiveness of implementing multi-construction projects in developing industrial facilities in Indonesia based on existing problems. A literature review was carried out to deepen the understanding of the research variables. The variables found in previous research were verified through questionnaires distributed to selected industrial facilities development sector respondents. The collected data is analyzed to identify factors that influence the development of multi-construction projects in industrial facilities and to support planning and anticipatory efforts in dealing with potential problems in the future.

II. METHODS

This research was carried out in five stages, which are: 1) Literature review to obtain research variables and answer research problems; 2) Testing research variables using a qualitative approach and concluding using descriptive analysis; 3) Modeling research variables using a dynamic system approach; 4) Model testing with multi-project construction implementation data on industrial facilities with multi-project implementation conditions in Indonesia using a quantitative approach and dynamic system analysis; 5) Optimization of models to

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obtain optimum policies, quantitative approaches, dynamic system analysis. A qualitative approach was taken in the first stage by concluding descriptive analysis. In the second stage, questionnaires were given to respondents, including professionals and experts in Indonesia's industrial facilities development industry. A Likert scale from 1 to 5 is used in the questionnaire to measure research variables, and frequency analysis is used as a tool to test research variables. There are six factors explored, namely: 1) Resources, 2) Organization, 3) Environment, 4) Construction, 5) External, 6) Design and Technical, and 7) Business factors. There are 50 research variables: 24 project risk variables, 15 multi-project risk variables, and 11 multi-project effectiveness variables. Project risk variables and multi-project risk variables are listed in Table 1

Table 1 Construction Multi-Project Risk Variables

Var No.	*Project Risk*	*Var No.*	*Multi-project Risk*
X2.1	*Inefficient work supervision* (Nasirzadeh et al., 2008).	*X1.1*	*Availability of necessary resources and coordination* (Ghasemi et al., 2018; Hofman & Grela, 2022; Micán et al., 2021).
X3.1	*Collecting contributions from surrounding/local communities in project implementation* (Nasirzadeh et al., 2008).	*X1.2*	*Relationships and dependencies between projects* (Ghasemi et al., 2018; Hofman & Grela, 2022; Micán et al., 2021).
X3.2	*Conditions and conditions of the project environment regarding project implementation* (Leon et al., 2018).	*X2.2*	*Involvement of top and middle-level managers in the implementation* (Ghasemi et al., 2018; Micán et al., 2021).
X4.1	*Increased construction costs due to lack of information* (Nasirzadeh et al., 2008)	*X2.3*	*Availability of risk management at the multi-project level* (Ghasemi et al., 2018).
X4.2	*Construction cost levels are not defined* (Leon et al., 2018; Wan & Liu, 2014).	*X2.4*	*Transparency of data and information* (Ghasemi et al., 2018).
X4.3	*Construction errors due to design failure* (Nasirzadeh et al., 2008)	*X2.5*	*Flow of information and communication* (Ghasemi et al., 2018; Hofman & Grela, 2022; Micán et al., 2021).
X4.4	*Low work efficiency* (Nasirzadeh et al., 2008; Rodrigues, 2001; Wan & Liu, 2014).	*X2.6*	*Conflict between project managers* (Ghasemi et al., 2018; Hofman & Grela, 2022; Micán et al., 2021).
X4.5	*Low work productivity* (Kim et al., 2020; Leon et al., 2018; Nasirzadeh et al., 2008; Rodrigues, 2001; Wan & Liu, 2014).	*X2.7*	*The conflict between stakeholders* (Hofman & Grela, 2022; Micán et al., 2021).
X4.6	*Construction accidents* (Leon et al., 2018; Nasirzadeh et al., 2008).	*X2.8*	*Competency level of project managers* (Ghasemi et al., 2018; Hofman & Grela, 2022; Micán et al., 2021).
X4.7	*Rework or postponement of work* (Leon et al., 2018; Nasirzadeh et al., 2008; Wan & Liu, 2014).	*X2.9*	*Company portfolio structure* (Ghasemi et al., 2018; Hofman & Grela, 2022; Micán et al., 2021).
X4.8	*Demands for accelerated project duration from the initial plan* (Kim et al., 2020; Leon	*X2.10*	*Project financing* (Hofman & Grela, 2022; Micán et al., 2021).

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Var No.	*Project Risk*	*Var No.*	*Multi-project Risk*
	et al., 2018; Nasirzadeh et al., 2008; Rodrigues, 2001; Wan & Liu, 2014).		
X4.9	*Geological and topographic conditions are different and undetected in the planning stage* (Nasirzadeh et al., 2008).	*X2.11*	*Significant changes to project requirements and scope* (Hofman & Grela, 2022; Micán et al., 2021).
X5.1	*Law Changes in employment affect work costs/wages* (Almashaqbeh et al., 2019; Kim et al., 2020; Nasirzadeh et al., 2008; Wan & Liu, 2014).	*X2.12*	*Multi Project Management Standards* (Ghasemi et al., 2018; Hofman & Grela, 2022; Micán et al., 2021).
X5.2	*Changes in work safety regulations* (Kim et al., 2020; Nasirzadeh et al., 2008; Wan & Liu, 2014).	*X3.3*	*Changes in the project environment* (Ghasemi et al., 2018; Hofman & Grela, 2022; Micán et al., 2021).
X5.3	*Weather conditions not detected at the planning stage* (Nasirzadeh et al., 2008; Wan & Liu, 2014).	*X5.4*	*Availability of work contracts with goods providers (suppliers)* (Micán et al., 2021).
X5.5	*Equipment operating error rate* (Leon et al., 2018; Nasirzadeh et al., 2008).		
X6.1	*Design errors are not detected at the tender stage of work implementation* (Nasirzadeh et al., 2008).		
X6.2	*Changes in construction work due to design changes* (Wan & Liu, 2014).		
X6.3	*Changes in design and construction implementation due to technological changes* (Wan & Liu, 2014).		
X7.1	*Changes in project costs* (Wan & Liu, 2014).		
X7.2	*Deficit of financial resources* (Nasirzadeh et al., 2008).		
X7.3	*Inflation Rate* (Almashaqbeh et al., 2019; Nasirzadeh et al., 2008).		
X7.4	*Global Recession* (Almashaqbeh et al., 2019).		
X7.5	*Market acceptance of the product* (Wan & Liu, 2014).		

Source: processed data, 2023

Multi-project effectiveness variables that influence each other with project risk variables and multi-project risk variables are explained in Table 2. These variables came from relevant previous research studies and were tested by professionals and multi-project construction experts by answering research questionnaires given to respondents.

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Table 2. Multi-Project Construction Effectiveness Variables

Var No.	*Factor*	*Multi-Project Effectiveness*
X1.3	*Resources*	*Availability of tangible resources* (Engwall & Jerbrant, 2003; Tsvetkova & Tukkel, 2017).
X1.4	*Resources*	*Availability of intangible resources* (Engwall & Jerbrant, 2003; Tsvetkova & Tukkel, 2017).
X1.5	*Resources*	*Resource allocation* (Engwall & Jerbrant, 2003; Tsvetkova & Tukkel, 2017).
X2.13	*Organization*	*Oriented of multi-project management* (Kracík et al., 2013).
X2.14	*Organization*	*Multi-project management* (Hedberg & Höglander, 2013; Kracík et al., 2013; Ruan & Na, 2017).
X2.15	*Organization*	*Organizational culture* (Patanakul, 2013; Patanakul & Milosevic, 2009).
X2.16	*Organization*	*Project manager competencies* (Patanakul, 2013; Patanakul & Milosevic, 2009).
X2.17	*Organization*	*Dependencies between projects* (Hedberg & Höglander, 2013; Ruan & Na, 2017).
X2.18	*Organization*	*Availability of resources* (Hedberg & Höglander, 2013; Ruan & Na, 2017).
X2.19	*Organization*	*Communication between projects* (Hedberg & Höglander, 2013; Ruan & Na, 2017).
X2.20	*Organization*	*Project personnel workload* (Hedberg & Höglander, 2013; Ruan & Na, 2017).

Source: processed data, 2023

The third, fourth, and fifth stages of research will be continued in the next research. This research is based on the study and verification of variables carried out in the first and second stages of research.

III. RESULTS AND DISCUSSION

To resolve research problems regarding the risk and effectiveness of multi-projects throughout the implementation of engineering design work, material procurement, and construction of industrial facility development projects, field observations and interviews were carried out to obtain information on the implementation of industrial facility construction project work. Data collected through a questionnaire in 2023 comes from answers from professional respondents and industry experts on industrial facility development construction projects. Questionnaires were given and analyzed by 61 selected respondents. The total number of respondents who provided answers was 47 respondents.

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1. General Description of Respondents

Respondents in this research are professionals and experts in the construction sector who are involved in industrial facility development projects. Descriptive data was collected by filling out questionnaires that reflected the respondents' profiles and were used to confirm the initial research variables that had been formulated, as listed in Table 3.

Table 3 Demographic Respondent

Demographic Type	Description	Frequency	Percentage
Gender	Male	47	100%
Age	<35 years old	4	8,5%
	35-44 years old	25	53,2%
	45-54 years old	13	27,7%
	55-65 years old	5	10,6%
Education	Diplome / Polytechnic	1	2,1%
	S1 – bachelor's degree	34	72,3%
	S2 – Postgraduate	12	25,5%
Type of company currently working.	Project owner / Client	26	55,3%
	EPCm / Planning Consultant / Supervision Consultant / Construction Management	4	8,5%
	EPC Contractor	14	29,8%
	Construction Contractor	1	2,1%
	Vendors / Suppliers	2	4,3%
Department of work (Place or location where the respondent currently works)	Project Management	22	46,8%
	Design / Engineering	17	36,2%
	Construction	4	8,5%
	Procurement	1	2,1%
	Others	3	6,4%
	< 10 years	7	14,9%

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Demographic Type	*Description*	*Frequency*	*Percentage*
Work experience (In the field of industrial facility construction)	*10-14 years*	*20*	*42,6%*
	15-20 years	*8*	*17,0%*
	>20 years	*12*	*25,5%*
Total length of work	*< 10 years*	*1*	*2,1%*
	10-14 years	*17*	*36,2%*
	15-20 years	*13*	*27,7%*
	>20 years	*16*	*34,0%*
Project Value in US Dollars (Respondent's highest project value and has been involved for at least six working calendar months)	*$1-$10 million*	*2*	*4,3%*
	$11-$50 million	*5*	*10,6%*
	$51-$100 million	*1*	*2,1%*
	$101-$200 million	*5*	*10,6%*
	$201-$500 million	*4*	*8,5%*
	>$500 million	*29*	*61,7%*
	Others	*1*	*2,1%*

Source: processed data, 2023

All selected respondents were male, and 80% of respondents were aged between 35-45 years. The educational background of the respondents was 97.8% undergraduate (S1) and postgraduate (S2). Respondents mainly came from the company providing the project (client) at 55.3% and EPC Contractors at 29.8%. Respondents mostly worked in project management departments (46.8%), engineering design, and engineering and construction departments (44.7%). Respondents' work experience in industrial facility construction is mainly in the range of 10-14 years (42.6%), 15 years, and above 15 years, around 42.5%. Respondents had been involved in projects above US$ 500 million for at least six months, 61.7%.

2. Respondent Assessment Recapitulation Data

Data collected from respondents' answers was obtained from a Likert scale questionnaire. The Likert scale measures the respondents' level of agreement, opinion, or assessment of a statement in a questionnaire, using different levels of strength of agreement or disagreement. The Likert scale used is Scale 1: Very no effect; Scale 2: No effect; Scale 3: Neutral; Scale 4: Influential; Scale 5: Very Influential. The statement items for the variation of research variables consist of 1) X1 research variables from resource factors; 2) X2 is a research variable from organizational factors; 3) X3 research variables from environmental factors; 4) X4 research variables from construction factors; 5) X5 research variables from external factors; 6) X6 research variables from design and technical factors, and 7) X7 research variables from business factors.

3. Variable Frequency Test

The frequency test on the Likert scale questionnaire is used to get an idea of the distribution of respondents' responses to each question item. Figure 1 identifies response patterns, level of agreement, and response variability as a basis for further analysis. The results show that Scale 3 is for neutral, scale 4 is for the Influential, and scale 5 is for Very Influential.

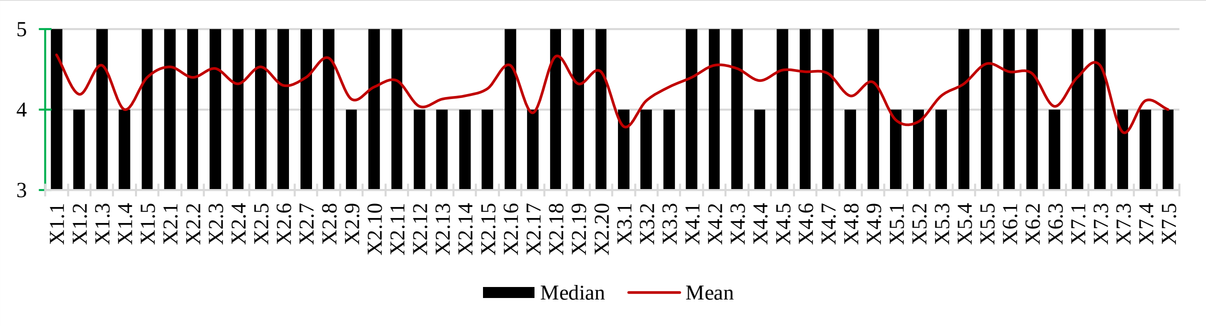

Figure 1 Research Variable Frequency Test

Source: data is processed, 2023

The average value of all research variables is 4.30, with a median value of 5. Variables: level of dependency between projects (X2.17), level of involvement of local workers (X3.1), level of changes in labor laws/regulations (X5.1), the level of change in work safety laws/regulations (X5.2) and the inflation rate (X7.3) have an average rating of respondents with a value between Scale 4 and Scale 3.

4. Test the Validity of Research Variables

The research variables have significant correlations and are interrelated. The results of the validity test of research variables in Figure 2 reveal three variables with the lowest calculated R values, namely: 1) 2) X5.1 Level of change in labor laws/regulations, with a calculated R-value of 0.394; 3) X1.4 Level of availability of intangible resources, with a calculated R-value of 0.450. The value of the R-table is 0.294.

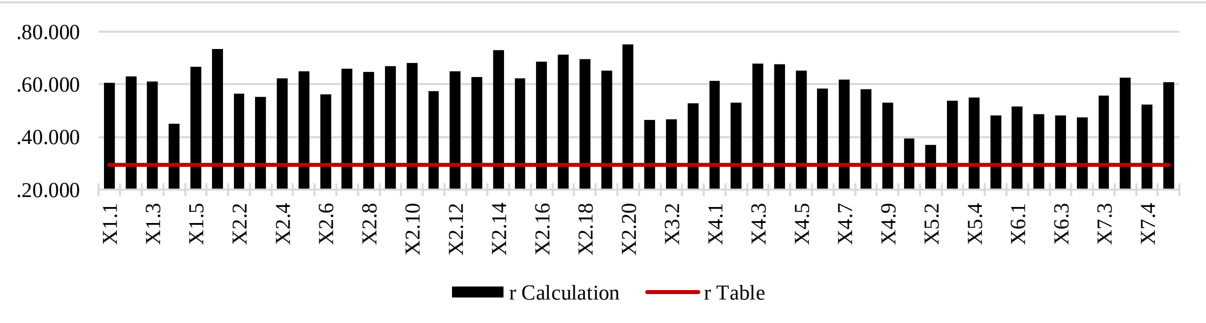

Figure 2 Validity Test Result

Source: SPSS Processing Data, 2023

5. Research Variable Reliability Test

A reliability test is used to ensure consistency in the measurement of research variables. Cronbach's Alpha statistical method was used to test the reliability and consistency of the questionnaire. The Alpha value of 0.960 exceeds the threshold value of 0.7 as an acceptable reliability value, Figure 3.

Reliability Statistics

Cronbach's Alpha	N of Items
.960	50

Figure 3 Cronbach's Alpha Value of Research Variables

Source: SPSS Processing Data, 2023

6. Advanced Research Model

Analysis of risk factors and effectiveness of implementing multi-project industrial facility development construction in Indonesia based on tests of variables found in previous research verified by selected respondents in Indonesia's industrial facility development sector. Fifty variables were then used as an initial model for further analysis using a dynamic systems approach by looking at the cause-and-effect relationships between research variables. Observations were made to see the behavior of the system, Figure 4.

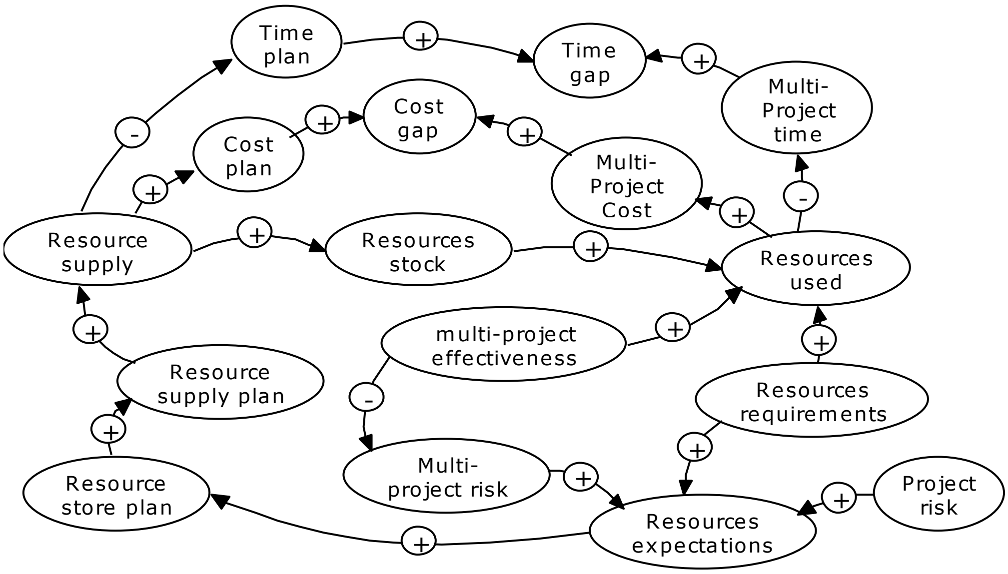

Figure 4 Advanced Research Model with Sistem Dynamics Approach

Source: processed data, 2023

IV. CONCLUSION

The conclusions obtained from this research are based on frequency, validity, and reliability tests for the result of responses from selected respondents: 1) 24 confirmed project risk variables could be used as variables in further research. Twenty variables were approved by respondents and had an average value between 4 and 5, meaning they were approved and strongly approved by respondents. There are four research variables, namely the inflation rate, collecting contributions from surrounding/local communities in project implementation, law changes in employment affect work costs/wages, changes in work safety regulations (x7.3; x3.1; x5.2; x5.1), which have a response with an average value below 4, which means respondents disagreed with it. 2) 15 confirmed multi-project risk variables can be used as variables in further research. All variables were approved by respondents and had an average value between 4 and 5, meaning they were approved and strongly approved by respondents. 3) 11 confirmed multi-project effectiveness variables can be used as variables in further research. One variable, namely the level of dependency between projects (x2.17), received a response from respondents with an average value below 4, which means it needs to be more approved. 4) In future research, interactions between variables and variable values can change over time; thus, a dynamic systems approach will be used to solve research problems. 5) Simulations and scenarios for the effectiveness of implementing a multi-project construction for the development of industrial facilities in Indonesia based on project risks and multi-project risks, as well as interactions and relationships between variables that can change throughout the implementation time, are carried out to obtain the right policies in implementing multi-projects to obtain time optimum and predictable implementation and costs at the planning stage.

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