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External Risk Effect in Infrastructure Design-Build Projects with Lump Sum Contracts

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Abstract: ***The increase of fast completion and cost certainty demands of construction projects were encouraging the Provincial Government of DKI Jakarta to use the design-build as a project delivery system. However, the design-build project experienced several constraints. This research aimed to determine the effect of external risks (consist of land acquisition, utility disruption, and third-party risk) on project performance of infrastructure design-build projects with a lump-sum contract system. A mix-method of quantitative and qualitative approaches used in this research, with data collected by using a questionnaire, interview, and documentation study. The questionnaire sent to contractors involved in design-build contracts for the 2015-2018 period, as many as 78 respondents from 39 projects. Fifty responses received within the stipulated time. Quantitative data analysis carried out by using the Structural Equation Model (SEM) based on Partial Least Square (PLS) using SmartPLS and qualitative data used as supporting data. The research findings were as follows. First, land acquisition, utility disruption, and third-party risk had no significant effect on project time performance. Simultaneously, the external risk contributed 11.7% of the time performance variable. Second, the utility disruption and third-party risk requests had a significant negative effect on cost performance, while the land acquisition risk did not have a significant effect on cost performance. Simultaneously, the external risks contributed to 39.3% of the cost performance. Third, time performance has a positive and significant effect on cost performance. Fourth, there was inadequate and inaccurate information related to the existence of the external risk, as well as an inadequate allocation of risk handling costs. Risk identification was vital. Furthermore, working schedules had to synchronize to the risk management schedule in such a way that the effectiveness and efficiency of the work could be maximized by considering all aspects. The response to risk could differ from project to project even between the same types of construction projects. The risk response determined by considering their impact on the project's time and cost performance.***

Keywords: ***design-build, external risk, lump sum contract, project performance.***

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I. INTRODUCTION

The demands of fast completion and cost certainty of construction projects are increasing. It encourages the Provincial Government of DKI Jakarta, Republic of Indonesia, to use the design-build as a project delivery system. Design-build is a project delivery system that integrates design and construction services into a single contract.

A study of 351 projects in 37 states of the USA showed some benefits of the design-build method compared to the traditional method. In this regard, the design-build method gives a 6% benefit to the total project cost, the cost overrun due to work changes were reduced by 5.2%, and the total project completion time that 33% faster than traditional methods [1].

However, the design-build project's implementation in DKI Jakarta Province has shown non-optimal results. It indicated several delays in projects' completion, both in the construction of buildings and civil buildings (infrastructure). For instance, from a total of 23 design-build construction works initiated by the Education Agency of DKI Jakarta Province, there was 17 project completion that delayed in 2017 (73.9%). Similar delays also occurred in infrastructure construction projects. In this case, as many as 13 (81.25%) infrastructure design-build projects in 2015-2017 having late completion of work, as depicted in Table-I.

Table- I: Duration of Delay in Infrastructure Design-Build Projects in DKI Jakarta 2015-2017

No.	Project Name	Duration of Delay (Days)
1	JLKB Tendean	0
2	JLKB Santa	90
3	JKB Trunojoyo	59
4	JLKB Taman Puring	59
5	JLKB Kemayoran	59
6	JLKB Seskoal	59
7	JLKB Cipulir	120
8	JLKB Ciledug	150
9	*Fly Over* Kuningan	0
10	*Fly Over* Permata Hijau	0
11	*Fly Over* Pancoran	105
12	*Fly Over* Cipinang	60
13	*Fly Over* Bintaro	60
14	*Underpass* Pondok Indah	30
15	*Underpass* Matraman	90

16	*Underpass* Kuningan	15

Source: Archive Project

Furthermore, an initial survey conducted to all projects' heads in 2017 (6 projects) to find out the factors causing delays in the design-build project in DKI Jakarta Province. Based on the survey, the dominant factor that caused the delay in project completion were: (1) existing land condition; (2) administrative issues; (3) requests from third parties; and (4) construction design.

Delay in project completion potentially causes project cost overruns, whereas in contracts with lump sum types, all risks, including additional costs, are the contractor's responsibility. Therefore, this research aims to find out the risk effect on project performance of design-build projects with a lump-sum contract system.

II. THEORIES AND CONCEPTS

A. Design-Build Project

According to PMBOK (2017), a project is a temporary endeavor undertaken to create a unique product, service, or result. Fulfillment of project objectives may produce one or more of the following deliverables: (1) a product, could be either the component of another item, an enhancement or correction to an item, or a new end item in itself; (2) a service or capability to perform a service; (3) a result, for instance, as an outcome or document; and (4) unique combination of one or more products, services, or results [2].

Construction projects have several characteristics. First, projects are unique. There are no identical but similar projects. They are temporary, and always involve different groups. Second, projects required resources (for instance, labor, money, equipment, methods, and materials). Third, the organization. Each organization has a variety of objectives in which several individuals with specialized expertise are involved [3].

A construction project that uses the design-build method as its deliverable system has some differences from the traditional method. In a design-bid-build method, the owner contract professional for designing, and then contracts a contractor to build the project with that design [4] Meanwhile, in a design-build method, both design and construction service is the contractor's responsibility. It makes the contract system in a design-build method quite different from traditional contracts [5].

Several possible advantages of using the design-build method are as follows: 1) time savings, 2) cost savings, 3) one point of contact (one-stop shopping), 4) fewer change orders, and 5) reduced risk to project owner. Meanwhile, the possible disadvantages of the design-build method are as follows: 1) loss of control of project design, 2) less project oversight/control of quality, and 3) suitability of design-build team [4].

B. Risk Management

Kerzner (2003) defines risk event as “a discrete event that, if occurring, would have a positive or negative effect on project measures” [6]. The construction project has a high potential risk compared to other projects. It is unlike other industries, more complicated and challenging to manage because it requires special skills and techniques. For managing risks, there must be different priorities for the risks [3].

According to PMBOK (2017), project risk management includes risk management planning, identification, analysis, response planning, response implementation, and monitoring risk on a project [2]. Project risk management aims to improve project performance by systematically identifying and assessing risks, developing strategies to prevent or avoid them, and to maximize opportunities [6].

Risk and uncertainty management has a vital role in project management. Therefore, risk management is not an optional activity. Risk management is crucial for the success of project management, so it needs to be applied to all parts of the project and become part of the project's operational plans and documents. In this way, risk management becomes an integral part of every aspect of project management in every phase and process group [7].

Generally, risk divided into two categories, internal and external risks. An internal risk is a risk that comes from the company or the project itself, for instance, costs, productivity, contracts, completion times, and others. Whereas, external risks do not come from the company or project, for instance, political conditions, regulations, and others [8].

C. Project Performance

Project performance has triple constraints, namely, cost/budgeting constraints, schedule/time, and quality. Meanwhile, according to Kerzner (2006), project management categorized as successful if the project has achieved the project objectives, the allocated times, budgeted costs, at the level of performance/technology stipulated, received by the customer and used the specified resources effectively and efficiently [3].

Several keys concepts generally used in project management are as follows: (1) project measures, are the critical criteria in a project (i.e., project time, project quality, and project cost); (2) project scope, is the target state of the project in terms of project measures; and (3) project ultimacy, is the ultimate state of the project in terms of project measures [5].

D. Lump Sum Contract

Based on Presidential Regulation Number 16 of 2018 on Procurement of Government Goods/Services, there are several types of contracts in construction. First, lump-sum contract or fixed price. It is a contract with fixed project scope and price, within the following condition: all risks borne to the contractor, result-oriented, and payment based on product or output phase. Second, the unit price contract is a contract with a fixed unit price for each unit or element of work with specific technical specifications of work within the stipulated deadline. In a unit price contract, the volume or quantity of work estimated at the contract assignment, payment based on the volume of the work measurement result, and the final value of the contract determined after all work completed. The other types are combination of fixed-price and unit-price contract, turnkey, and umbrella contract [9].

E. Conceptual Model

In this research, the conceptual model developed based on several categories of external risks and project performance (also known as exogenous latent variables). Risks are consisting of utility disruption risk, land-acquisition risk, and third-party risk. On the other side, project performance consists of time performance and cost performance.

The variables, dimensions, and indicators of this research are as depicted in Table-II. The description of each manifest variable as presented in path diagrams for each construct shown in Figure 1.

Table- II: Research Variables, Dimensions, and Indicators

Variable	Definition	Dimension	Indicator	Item
Utility disruption risk	The existence of the utility system at the project site that was not detected before and disrupted the project implementation [8].	Implementation of work methods	The working methods implementation level due to utility system disruption.	X1_6
		Tools' operationalization	The tools' operationalization level due to utility system disruption.	X1_7
		Material acceptance	The material acceptance level due to utility system disruption.	X1_8
		Work implementation	The work implementation level due to utility system disruption.	X1_9
		Risk probability	Frequency of utility disruption.	X1_10
			The time occurrence of utility disruption risk.	X1_11
Land-acquisition risk	Unfinished land acquisition though the project is already underway.	Implementation of work methods	The working methods implementation level due to unfinished land-acquisition.	X2_6
		Tools' operationalization	The tools' operationalization level due to unfinished land-acquisition.	X2_7
		Material acceptance	The material acceptance level due to unfinished land-acquisition.	X2_8
		Work implementation	The work implementation level due to unfinished land-acquisition.	X2_9
		Risk probability	Frequency of land-acquisition risk.	X2_10
			The time occurrence of land-acquisition risk.	X2_11
Third-party risk	The changing of the scope of work due to the third-party request.	Implementation of work methods	The working methods implementation level due to the third-party request.	X3_6
		Tools' operationalization	The tools' operationalization level due to unfinished land-acquisition.	X3_7
		Material acceptance	The material acceptance level due to the third-party request.	X3_8
		Work implementation	The work implementation level due to the third-party request.	X3_9
		Risk probability	Frequency of the third-party risk	X3_10
			The time occurrence of the third-party risk.	X3_11
Time performance	The level of project performance based on the actual time compared to project planning [10].	Planning	The actual time of the initial survey and measurement.	Y1_1
			The actual time of the land measurement.	Y1_2
			The actual time of the initial survey and measurement.	Y1_3
		Implementation	The actual time of the working method's determination.	Y1_4
			The actual time of tools' determination and arrival.	Y1_5
			The actual time of the material's determination and arrival.	Y1_6
			The actual time of the workers' determination and arrival.	Y1_7
			The actual time of the subcontractor's determination and arrival.	Y1_8
			The actual time of the tools' utilization	Y1_9
			The actual time of the completion of works by the workers.	Y1_10
			The actual time of the completion of works by the subcontractor.	Y1_11
			The actual time of the self-managed work completion time.	Y1_12
Cost performance	The level of project performance based on the actual cost compared to project planning [11].	*Direct cost*	The actual volume of material.	Y2_1
			The actual cost of the material's unit price.	Y2_2
			The actual volume of tools.	Y2_3
			The actual cost of the tools' unit price.	Y2_4
			The actual volume of workers.	Y2_5
			The actual cost of the workers' unit price.	Y2_6
			The actual volume of subcontractor's works.	Y2_7

Variable	Definition	Dimension	Indicator	Item
			The actual cost of the subcontractor works' unit price.	Y2_8
		Overhead cost	The actual volume of employees.	Y2_9
			The actual cost of the employees' unit price.	Y2_10
			The actual volume of general cost.	Y2_11
			The actual amount of the general cost.	Y2_12

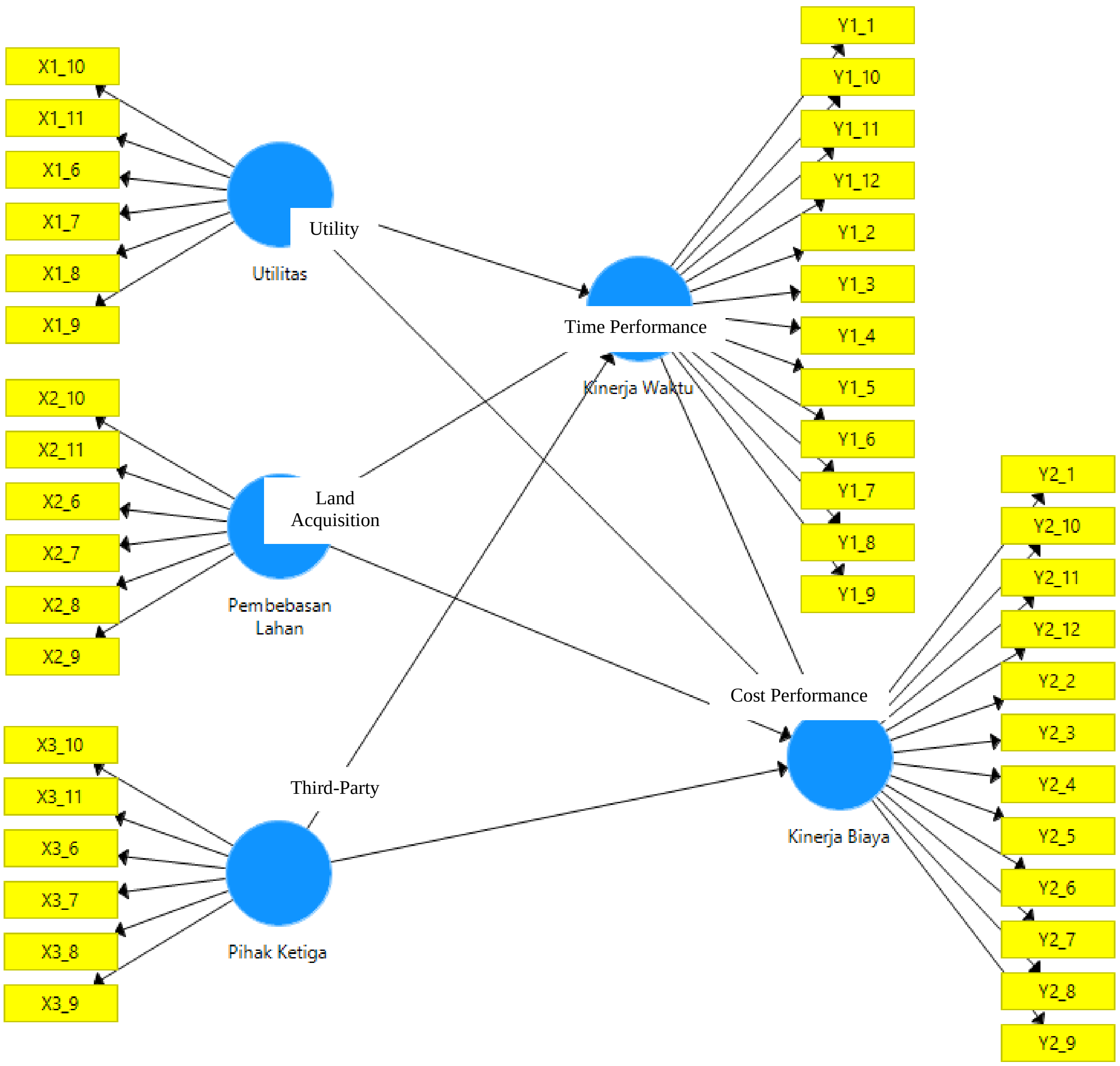

Fig. 1. Conceptual Model

III. RESEARCH METHOD

This research used a mix-method of a quantitative and qualitative approach. The research stages are as follows. First, identify problems that occur in construction projects, especially in design projects with a fixed price contract system. Second, conduct a theoretical study that used to clarify the problem, formulate hypotheses, and research instrumentation. Third, quantitative data collected by using a questionnaire and qualitative data collected by interviews, questionnaires, documentation studies, and observations. Fourth, the data collected, both quantitative and qualitative, are then analyzed. Fifth, the presentation of quantitative and qualitative data analysis data, as well as the discussion of research results. Sixth, research reports preparation.

Data collection was conducted in April-July 2019. The questionnaire was sent to contractors (excluding consultant and owner) that involved in design-build contracts for the 2015-2018 period, as many as 78 respondents from 39 projects. Fifty responses received within the stipulated time. Quantitative data analysis carried out by using the Structural Equation Model (SEM) based on Partial Least Square (PLS) using SmartPLS. Qualitative data used as supporting data. Data analysis, both quantitative and qualitative, was done in sequential steps, as follows: data collection, data reduction, data display, and conclusion.

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IV. RESEARCH FINDINGS AND DISCUSSION

A. Demography of the Respondents

Based on the completed questionnaire sets, the demography of the respondents presented in Table-III. Majority of the respondents, or 64%, had a bachelor's degree background and 32% with a graduate degree. Also, 62% of respondents had working experiences for more than 15 years in handling construction projects, with minimum working experience is 5 to 10 years (12%).

Table- III. The Respondents' Characteristic

Characteristic	Frequency	Percentage	Cumulative Percentage
Education Level			
High School	2	4	4
Bachelor	32	64	68
Graduate	16	32	100
Postgraduate	0	0	100
Working Experience			
<2 years	0	0	0
2-5 years	0	0	0
5-10 years	6	12	12
10-15 years	13	26	38
>15 years	31	62	100

Source: Primary Data (Calculated), 2019

B. Model Evaluation/Analysis

The unidimensionality of each construct tested by looking at the convergent validity of each construct indicator. Manifest variables with external loading 0.5 or higher are considered acceptable, and manifest variables with loading values less than 0.5 excluded from the model. Thus, all constructs have met the validity requirements, as shown in Fig. 2.

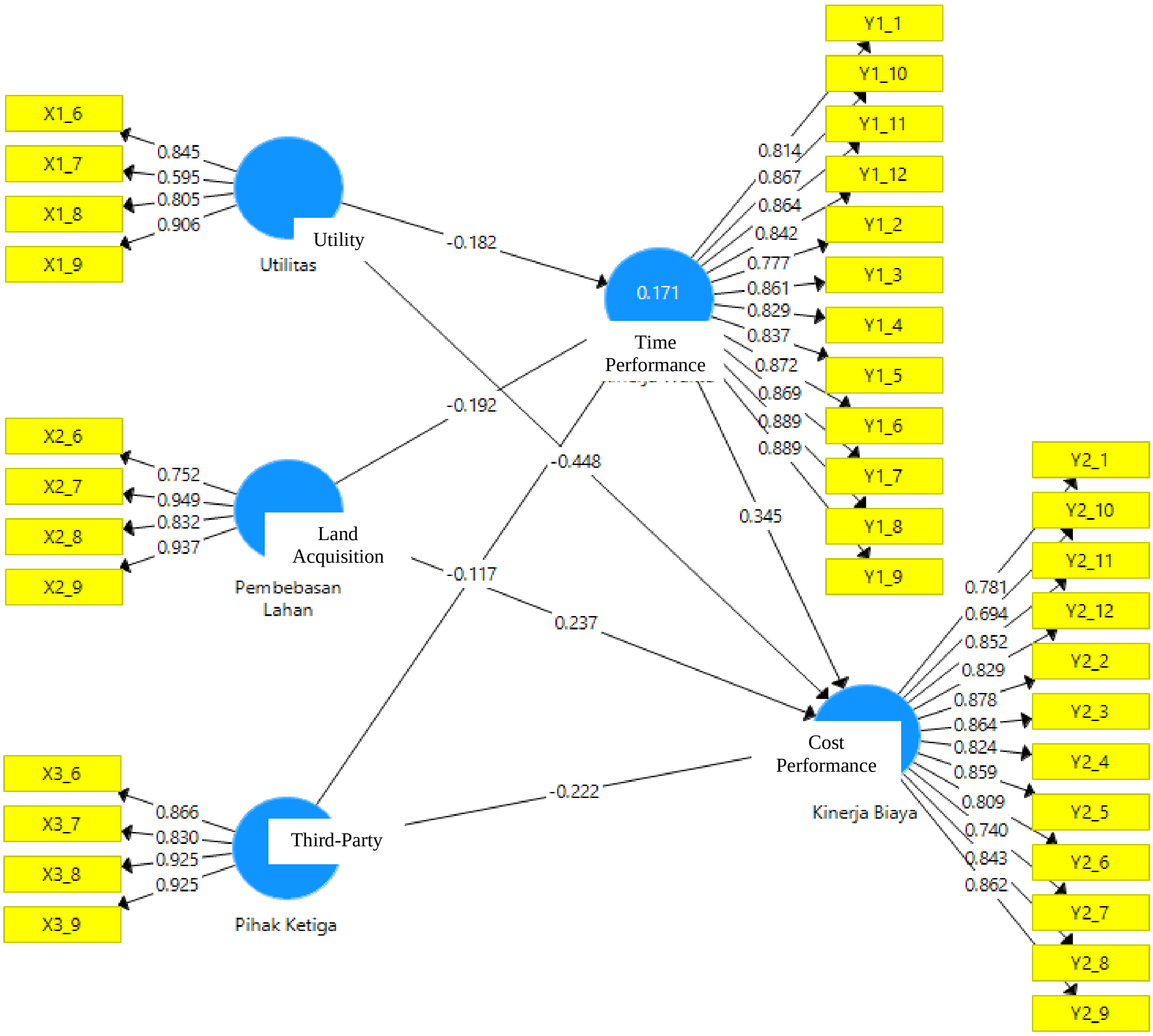

Fig. 2. Outer Loading Re-estimate

The next step is to evaluate the outer model using two criteria, namely discriminant validity and composite reliability. Based on the Average Variance Extracted (AVE) value, all constructs have an AVE root value higher than the correlation between constructs and other constructs. So, it concluded that all constructs had met the validity requirements. Furthermore, based on the analysis results, the value of Cronbach's Alpha and Composite Reliability is above 0.80; thus, each construct is very reliable.

The inner model evaluated by looking at the value of R Square. R Square Adjusted Time Performance value of 0.117 means that the influence of the Utility Disruption Risk, Land Acquisition Risk, and Third-Party Risk to Time Performance is 11.7%.

The value of the effect size of Utility Disruption Risk (0.024) and Land Acquisition Risk (0.026) are classified as weak, while Third-Party Risk (0.011) is feeble or has no effect.

Table- IV. The R Square Value

	R Square	*R Square Adjusted*
Cost Performance	0,443	0,393
Time Performance	0,171	0,117

Source: Primary Data (Calculated), 2019

The value of R Square Adjusted Cost Performance of 0.393 means that the influence of the Utility Disruption Risk, Land Acquisition Risk, Third-Party Risk, and Time on Cost Performance is 39.3%. The value of the effect size of Utility Disruption Risk (0.209) and Time (0.177) are classified as moderate, while Land Acquisition Risk (0.057) and Third-Party Risk (0.057) are relatively weak.

Table- V. The f Square Value

	Cost Performance	Time Performance
Cost Performance		
Time Performance	0,177	
Land Acquisitio	0,057	0,026
Pihak Ketiga	0,057	0,011
Utilitas	0,209	0,024

Source: Primary Data (Calculated), 2019

C. Statistical Description of Research Variables

The lowest effect of utility disruption risk found in material acceptance with the highest average value of 3.12. The highest effect found in the implementation of working methods with the smallest average value of 2.70. Overall, the average value of the risk utility disruption variable is 2.91. Based on Table-VI, it could be concluded that the utility disruption risk that had not been overcome caused partial or half of working methods, operational tools, materials, and work implementation by workers that could not be carried out.

Table- VI. The Variable Profile of Utility Disruption Risk

Indicators	Item	Average
The working methods implementation level due to utility system disruption.	X1_6	2.70
The tools' operationalization level due to utility system disruption.	X1_7	2.96
The material acceptance level due to utility system disruption.	X1_8	3.12
The work implementation level due to utility system disruption.	X1_9	2.84
Variable Average		2.91

Source: Primary Data (Calculated), 2019

Table-VII shows that the lowest effect of land acquisition risk found in material acceptance, while the highest effect found in the work implementation by workers. Overall, the land acquisition risk that had not been overcome caused partial or half of working methods, operational tools, materials, and work

Table- VII. The Variable Profile of Land Acquisition Risk

Indicators	Item	Average
The working methods implementation level due to unfinished land-acquisition.	X2_6	2.60
The tools' operationalization level due to unfinished land-acquisition.	X2_7	2.56
The material acceptance level due to unfinished land-acquisition.	X2_8	2.78
The work implementation level due to unfinished land-acquisition.	X2_9	2.54
Variable Average		2.62

Source: Primary Data (Calculated), 2019

The lowest effect of third-party risk found in tools operationalization, while the highest effect found in the material acceptance and work implementation by workers. Overall, the third-party risk that had not been overcome caused partial or half of working methods, operational tools, materials, and work implementation by workers that could not be carried out.

Table- VIII The Variable Profile of Third-Party Risk

Indicators	Item	Average
The working methods implementation level due to the third-party request.	X3_6	3.14
The tools' operationalization level due to unfinished land-acquisition.	X3_7	3.26
The material acceptance level due to the third-party request.	X3_8	3.10
The work implementation level due to the third-party request.	X3_9	3.10
Variable Average		3.15

Source: Primary Data (Calculated), 2019

Description of time performance variable aims to determine the level of the time performance on design-build projects with a fixed price contract system. Table-IX shows the highest average value found on the completion of works by the subcontractor, while the lowest value is on the actual time of the material's determination and arrival. Overall, the average value of the time performance variable is 3.61. It could be concluded that the average time delayed was three weeks.

Table- IX The Variable Profile of Time Performance

Indicators	Item	Average
The actual time of the initial survey and measurement.	Y1_1	3.40
The actual time of the land measurement.	Y1_2	3.40
The actual time of the initial survey and measurement.	Y1_3	3.84

Indicators	Item	Average
The actual time of the working method's determination.	Y1_4	3.62
The actual time of tools' determination and arrival.	Y1_5	3.56
The actual time of the material's determination and arrival.	Y1_6	3.36
The actual time of the workers' determination and arrival.	Y1_7	3.38
The actual time of the subcontractor's determination and arrival.	Y1_8	3.40
The actual time of the tools' utilization	Y1_9	3.78
The actual time of the completion of works by the workers.	Y1_10	3.76
The actual time of the completion of works by the subcontractor.	Y1_11	3.90
The actual time of the self-managed work completion time.	Y1_12	3.86
Variable Average		3.61

Source: Primary Data (Calculated), 2019

Furthermore, the description of the cost performance variable shown in Table-X. The highest average value found on the actual volume of tools, while the lowest value is on the actual volume of subcontractor's works, the actual cost of the subcontractor works' unit price, and the actual cost of the employees' unit price. Overall, the average value of the cost performance variable is 2.74. It could be concluded that the average increase in the volume/cost of the project was in the range of 2.5-5.0%.

Table- X The Variable Profile of Cost Performance

Indicators	Item	Average
The actual volume of material.	Y2_1	2.54
The actual cost of the material's unit price.	Y2_2	2.64
The actual volume of tools.	Y2_3	3.14
The actual cost of the tools' unit price.	Y2_4	2.84
The actual volume of workers.	Y2_5	2.92
The actual cost of the workers' unit price.	Y2_6	2.52
The actual volume of subcontractor's works.	Y2_7	2.48
The actual cost of the subcontractor works' unit price.	Y2_8	2.48
The actual volume of employees.	Y2_9	2.82
The actual cost of the employees' unit price.	Y2_10	2.48
The actual volume of general cost.	Y2_11	3.00
The actual amount of the general cost.	Y2_12	3.02
Variable Average		2.74

Source: Primary Data (Calculated), 2019

D. Hypothesis Test Result

The effect of each variable on project performance as depicted in Table-XI. So, it could be concluded that three research hypotheses accepted from seven proposed hypotheses, namely: Hypothesis IV, Hypothesis VI, and Hypothesis VII.

Table- XI The Research Hypothesis

Research Hypothesis		Coefficient	T Statistic	P Value	Note
H I	There is a significant negative effect of the utility disruption risk on the time performance of a design project with a fixed price contract system.	-0,182	1,140	**0,255**	Rejected
H II	There is a significant negative effect of the land acquisition risk on the time performance of a design project with a fixed price contract system.	-0,192	1,234	**0,218**	Rejected
H III	There is a significant negative effect of the third-party risk on the time performance of a design project with a fixed price contract system.	-0,117	0,662	**0,508**	Rejected
H IV	There is a significant negative effect of the utility disruption risk on the cost performance of a design project with a fixed price contract system.	-0,510	4,579	**0,000**	**Accepted**
H V	There is a significant negative effect of the land acquisition risk on the cost performance of a design project with a fixed price contract system.	0,171	1,289	**0,198**	Rejected
H VI	There is a significant negative effect of the third-party risk on the cost performance of a design project with a fixed price contract system.	-0,262	2,057	**0,040**	**Accepted**
H VII	There is a significant positive effect of the time performance on the cost performance of a design project with a fixed price contract system.	0,345	2,486	**0,013**	**Accepted**

E. Discussions

Based on the discussion's result with most of the research respondents and other related parties found that there are several essential findings as follows. First is the effect of the external risk to projects' performance with a fixed price contract system. Based on the quantitative and qualitative data analysis, not all risk variables have a significant effect on project performance, especially to project time performance. Significant negative effects only shown by the utility disruption risk and third-party risk on cost performance, while the positive effect found on the relationship between time performance and cost performance.

In the context of quality performance, it concluded that quality performance is not negotiable. The required specifications must be met because they are related to the heavy construction that will be used by the wider community.

In terms of time performance, majority of the respondents said that it is better to accelerate the implementation time. In other words, after being left behind due to external risk, the pursuit or acceleration of work is the best step. Therefore, additional resources needed that also increased the number of tools, materials, or the number of workers. However, the late completion of work that not caused by the contractor was not subject to a late fee.

For cost performance, the acceleration of time completion time also increased the actual projects' cost. In this regard, the general costs and employee costs increase are due to the increase in implementation time. Furthermore, cost increase also caused by idle time because of waiting for the handling of the external risk. Another option was to return the tools, but this option constraint by the additional costs of tools' mobilization and demobilization.

Concerning the transfer of risk or risk sharing, risk sharing is not entirely successful because third parties such as subcontractors or tool providers are not willing to contract at a fixed price where third parties will fully bear the risk. Certain parties choose to get a lower profit opportunity with fewer risks.

The other thing that related to handling external risks is scheduling work. The adjustment of job scheduling needed to synchronize to the risk management schedule in such a way that the effectiveness and efficiency of the work can be maximized by considering all aspects. If the handling of the risks turns out to be a setback, then a new work plan could be made.

Second, the process of change in design and technical engineering. Changes in design caused by several conditions as follows: (a) needs in the field due to utility conditions that not adequately informed at the tender process; (b) design changes due to third-party requests that not included in the initial contract; and (c) design changes due to new technologies that could improve efficiency.

Related to changes that cause cost consequences, a capable and trusted independent checker also needed. Besides, there must be standard procedures for implementing changes from technical studies and commercial studies if needed.

Third, related to job handover. Handover to projects owned by the government must be carried out externally by the Audit Board of Indonesia (BPK). The problem that often arises is the discrepancy between the project design at the tender phase with the as-built drawing. Not all auditors could accept this discrepancy, that changes in drawing/design could occur in design-build projects. Socialization is needed related to the work process of the design project, and then it could be used as an operational standard.

V. CONCLUSION

There was no external risk that had a significant effect on time performance. The significant effect showed by utility disruption risk and third-party risk to cost performance, and time performance to cost performance.

There are several recommendations based on this research as follows. First, the project owner must coordinate the risk management in the context of relocation of utility disruption, land acquisition, and handling of third-party risk before the design-build project begun. It is vital to have a fixed price contract system that is fair and balanced.

Second, after the existence of utility disruption risk, land acquisition risk, and third-party risk identified, the schedule for the risk transfer or risk handling must be conveyed before the project begun. Furthermore, the risk handling progress must be informed to the contractor so that further anticipation could be prepared.

Third, after the critical parts of the risk identified, the contractor also advised identifying risks themselves, for instance, by using geo-radar to detect the utility existence or by checking directly the land that has not acquisition. It is needed to get the most efficient technical planning and work method planning.

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