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Analysis Of Pre-Construction Factors as Causes of Road Construction Delays in Parigi Moutong Regency

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ABSTRACT: *Roadconstruction delays remain a recurring problem in regional infrastructure projects, particularly in Parigi Moutong Regency. This problem not only occurs during the implementation phase but can also originate from poorly organized pre-construction activities. This study aims to analyze pre-construction factors causing road construction delays, focusing on three main aspects: procurement of goods/services, pre-construction techniques, and institutional/regulatory aspects. The method used is an explanatory quantitative approach through Structural Equation Modeling–Partial Least Squares (SEM-PLS) with the assistance of SmartPLS software. The analysis results show that all three pre-construction constructs have a significant influence on road construction delays. Institutional/regulatory factors do not have a direct influence, but have a strong indirect influence through two mediating pathways, namely procurement and pre-construction techniques, with a total effect of 0.565 ($t = 6.376$; $p < 0.001$). These findings confirm that the lack of service provider competence, regulatory constraints, and weak inter-agency coordination are the roots of systemic delays. It is necessary to improve the quality of technical planning, simplify procurement mechanisms, and strengthen institutional governance to ensure timely, efficient, and high-quality implementation of road projectsThe widespread application of renewable energy systems requires the use of data acquisition units both for monitoring system operation and control of its operation. In this paper, the topologies for the monitoring system – including remote monitoring – for both solar and wind energies are presented. This feature is essential in renewable energy plants since they are usually installed in inaccessible or remote areas. The measured parameters are available on-line over the Internet to any user.*

KEYWORDS *Analysis, Pre-construction, Delay, Road, SEM-PLS.*

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I. INTRODUCTION

Road infrastructure development is a key factor influencing economic growth and equitable regional development. Roads serve as a means of connectivity, [1]. facilitating the movement of people and goods and significantly impacting public access to healthcare, education, and employment opportunities [2] [3]. Therefore, providing adequate and high-quality roads is a priority and imperative to accelerate the development agenda in Parigi Moutong Regency [4].

Geographically, Parigi Moutong Regency enjoys a strategic location on the island of Sulawesi. This region serves as a connecting route between provinces, including Gorontalo, North Sulawesi, South Sulawesi, and Central Sulawesi. Furthermore, Parigi Moutong Regency is known as one of the largest rice producers in Central Sulawesi [5],This situation demands reliable road infrastructure to ensure smooth logistics distribution and market access for agricultural products and local commodities. [6]

Delays in road project implementation have numerous impacts, both direct and indirect. Direct impacts include increased implementation costs due to additional wages and longer working hours [7] [8] 93]. Meanwhile, indirect impacts include loss of public trust in the contractor's reputation, traffic congestion, potential disputes, and legal risks if the contractor fails to meet the contract deadlines agreed upon between the project owner and contractor [10] [11]

These problems often begin in the pre-construction stage. Mistakes in the preparation of technical documents, from work volume estimates to the clarity of technical specifications, as well as weaknesses in the contract documents at the initial stage, can trigger contractual revisions (Contract Change Orders) during the implementation stage. This can increase costs, time, and potentially lead to disputes in road project implementation [12] [13] [14]. Therefore, the pre-construction stage plays a strategic role in determining the smooth progress of road construction, as weaknesses early on can potentially lead to chain delays in subsequent stages. [15]

Previous studies have identified various factors contributing to construction project delays [16]. Identified inadequate planning as a primary cause of delays. Furthermore, for road construction in North Maluku, [17] [18] [19] in their study stated that the factors causing roadwork delays were contract addenda and slow approval of drawing reviews.

The limitations of local research directly addressing roadwork delays in Parigi Moutong Regency make this study urgent. This situation is further clarified by empirical evidence in Parigi Moutong Regency that delays are recurring, not incidental. According to data from the Public Works, Spatial Planning, and Land Agency of Parigi Moutong Regency, twelve road improvement work packages experienced delays between 2021 and 2024.

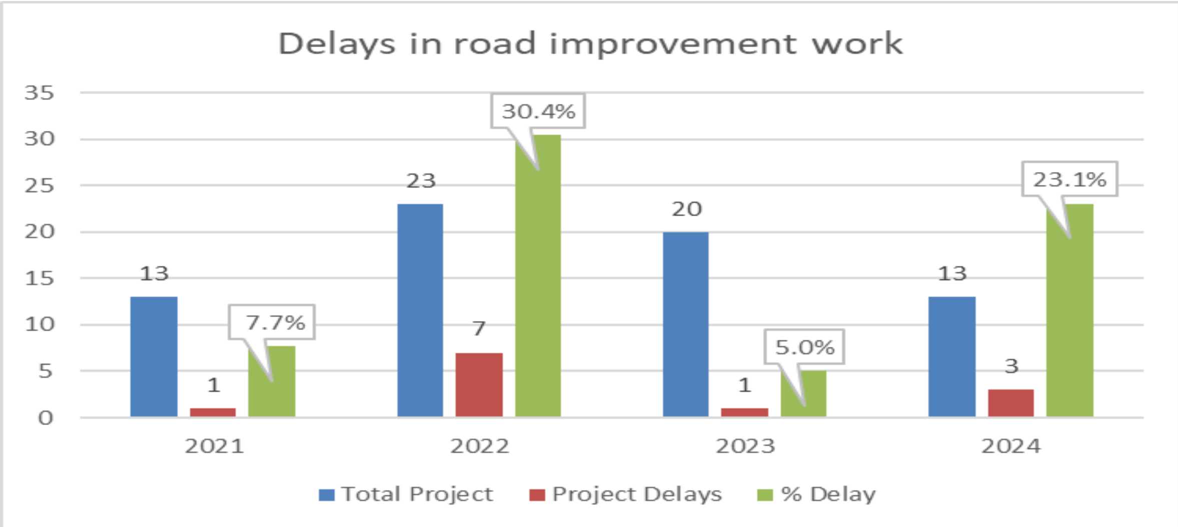

Fig .1. Graph of road work delays in 2021–2024

Figure 1 shows a fluctuating pattern of delays in road projects in Parigi Moutong Regency. 2022 marked a critical point with a delay percentage of 30.43%, while in 2023 there was a decrease, followed by an increase again in 2024. This fluctuation illustrates that delays are not incidental but rather indicate systemic problems in the early stages of the project. In other words, although the number of projects varies each year, the recurring pattern of delays indicates that pre-construction factors such as planning, procurement, and institutional arrangements are not yet optimal.

II. LITERATURE REVIEW

Construction is essentially the process of realizing a plan in physical form. Construction is an activity designed to manage labor, materials, equipment, costs, and time in an integrated manner, so that project objectives can be achieved in accordance with applicable contracts. The success of a construction project is determined by the extent to which available resources can be organized and controlled so that activities can proceed with appropriate quality, cost, and schedule. [20]

In the context of land transportation, roads play a crucial role. Based on Law of the Republic of Indonesia Number 2 of 2022 concerning the second amendment to Law No. 38 of 2004 concerning Roads, roads can be defined as land transportation infrastructure that encompasses all parts of the road, including complementary buildings and equipment, intended for traffic. Roads function not only as a means of vehicular movement but also as regional connectors, supporting the distribution of goods and services, and driving economic growth and public welfare. [21] [22]

Based on hese two definitions, road construction can be understood as the development of land transportation infrastructure, encompassing planning, procurement, and physical implementation on the ground, with the goal of producing reliable, safe roads that meet technical standards.In the context of this research, procurement is understood as a series of planning activities leading up to the determination of service providers that influence the readiness of a road project to be implemented. [23] The researcher explains that the procurement process for goods/services begins with the identification of needs, which occurs in the initial planning phase of the pre-construction phase. This needs identification process is where service users plan and ensure that all procurement of goods and services for road construction is truly based on needs analysis and not on mere whims. [24] [25]

The impact of delays in the initial phase often triggers Contract Change Orders (CCOs). This situation has implications for increased costs, extended implementation times, and potential contractual disputes. Identifying obstacles in the pre-construction phase is expected to minimize or even prevent them from spreading to the implementation phase. [26] [27]

SmartPLS is statistical software used to analyze Structural Equation Modeling (SEM) using the Partial Least Squares (PLS) approach [28]. The main advantage of the SEM-PLS approach is its ability to handle fairly complex models with many constructs and indicators while still being applicable to smaller sample sizes and data that lacks a normal distribution. [29] This differs from covariance-based SEM (CB-SEM), which typically requires large data sets and stricter distribution requirements [30].

This hypothesis states that the main variables studied play a significant role and influence based on the mechanisms and interactions that occur during the pre-construction phase. Meanwhile, for the hypothesis of dominant factors causing delays, the most dominant construct is identified by assessing the strength of the influence through path coefficients, both in direct and indirect relationships formed through mediation pathways [31]. This assessment refers to the total effect value in the model, as the total effect represents the accumulation of all influences derived from the series of path coefficients. The construct with the largest total effect is determined as the most dominant factor in explaining delays in the pre-construction phase. [32] [33]

III. METHODOLOGY

This study uses a quantitative approach to explain the causal relationship between pre-construction factors, including procurement of goods/services, pre-construction techniques, and institutional/regulatory factors, on road construction delays in Parigi Moutong Regency. This approach tests the proposed hypotheses and identifies the most dominant factors influencing delays through SEM-PLS analysis using the SmartPLS application.

In addition to analyzing the relationships between latent variables, the researchers also present respondent profiles and the distribution of questionnaire responses for each indicator. This data is processed using descriptive analysis in the form of tables, percentages, and average Likert-type scores, facilitating understanding and analysis of the actual conditions in the field based on respondents' perceptions of the factors causing road construction delays.By using this combination of two methods, we can not only describe the actual conditions in the field using descriptive statistics but also explain the causal influence between latent variables on the causes of road construction delays.

In determining the sample size, the researchers referred to a relevant approach for SEM-PLS, namely the 10-times rule, which is a general rule of thumb for determining the minimum sample size, as well asusing statistical power and effect size calculations. This rule suggests that the minimum sample size is ten times the largest number of indicators in a single latent construct or ten times the number of arrows leading to the endogenous construct. In this study, each latent construct has four conceptual indicators, so the minimum sample size required based on this rule is 40 respondents. Therefore, the 50 respondents used were deemed sufficient for analysis using SEM-PLS.

After establishing the population and sample, the next step was to determine the research instrument to be used to collect data. The instrument used was a Likert-scale questionnaire designed to measure respondents' perceptions of pre-construction factors causing road work delays. The questionnaire was structured around four latent constructs. These latent constructs were derived into four conceptual indicators for each latent construct. From these 16 indicators, the researchers developed 24 items. This number of questions is greater than the number of indicators because the researchers divided the questions into two items for planned redundancy. This was to anticipate items that did not meet validity criteria or multicollinearity in the SEM-PLS analysis, ensuring that other indicators could represent the construct.

This questionnaire uses a Likert scale with five response options ranging from "not very influential" (score 1) to "very influential" (score 5). This scale allows respondents to provide a step-by-step assessment, resulting in more varied data collection and more accurate statistical analysis.

3.1. Research Variables and Indicators

The variables used in this study are factors occurring during the pre-construction period, or the stages prior to construction, that can cause delays in road construction. The selection of variables was based on a literature review and previous research, which showed that the causes of road construction delays during the pre-construction stage are more influenced by managerial aspects than by physical implementation in the field.

The study used four main variables: three independent (exogenous) variables and one dependent (endogenous) variable. The independent variables include goods/services procurement (X1), pre-construction technical factors (X2), and institutional and regulatory factors (X3), to provide a comprehensive overview of the factors causing road construction delays in Parigi Moutong Regency.

Using the SEM-PLS approach, this study will examine the contribution of each factor and the causal relationships between variables, both directly and indirectly (mediating effects), while also identifying the dominant factors that contribute most to delays. Therefore, this research model not only illustrates the relationships between variables but also serves as an analytical tool to provide a more comprehensive understanding of the root causes of road project delays in the study area.

To clarify the flow of relationships between variables in this study, the research model

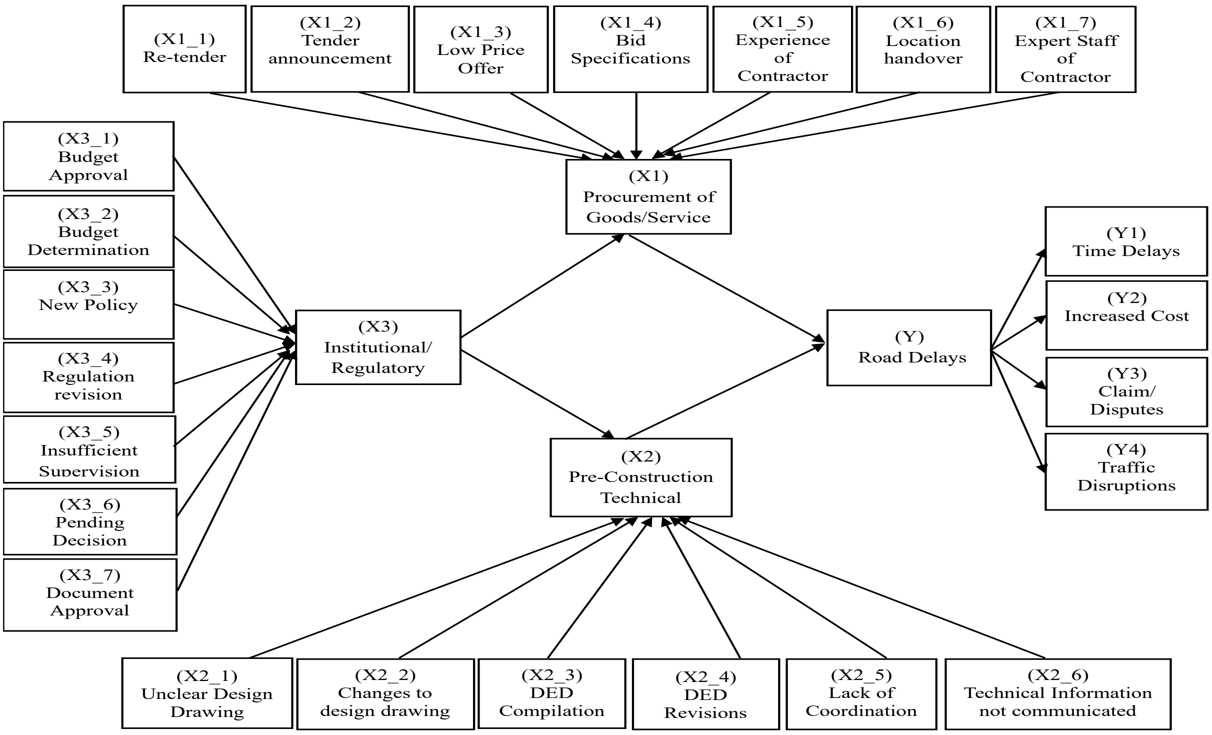

Fig. 2. SEM-PLS analysis framework research model

3.2. Data Analysis Techniques

The data obtained from the questionnaires were analyzed using two approaches: descriptive and inferential analysis. Descriptive analysis illustrates the tendencies or tendencies of respondents' responses to each indicator, while inferential analysis uses Structural Equation Modeling–Partial Least Squares (SEM-PLS) to examine the relationships between latent variables. In model measurement, validity and reliability tests were conducted on the reflective constructs, while formative constructs were analyzed through the significance of outer weight values and multicollinearity checks using Variance Inflation Factor (VIF) values.

3.2.1.Descriptive Analysis

Descriptive analysis aims to determine the tendencies of respondents' responses to each research indicator. The questionnaire data uses a 1-5 Likert scale, so the average/mean value can be calculated to determine the level of influence of each indicator. The mean formula is written as follows:

$$= \frac{(1 \times f_1) + (2 \times f_2) + (3 \times f_3) + (4 \times f_4) + (5 \times f_5)}{f_1 + f_2 + f_3 + f_4 + f_5}$$

Description :

f1, f2, f3, f4, f5 Number of respondents who chose a scale of 1 to 5

X ̄: Average value (mean)

The mean value is then interpreted into categories of influence levels based on the following scale intervals:

Score Range	Category
1,00 - 1,80	Very Low
1,81 - 2,60	Low
2,61 - 3,40	Medium

3,41 - 4,20 High
4,21 - 5,00 Very High

This analysis provides an initial overview of respondents' perceptions of each research indicator before further model testing.

3.3. Measurement Model Analysis (Outer model)

This analysis is used to test the validity and reliability of the relationship between latent constructs and their indicators. Because this study uses a combination of formative and reflective models, the tests performed are differentiated as follows:

a. For formative constructs (X1, X2, X3):

• This analysis focuses on the outer weight values to assess the contribution of each indicator to the latent construct.

• The significance test for outer weights is conducted using t-statistics > 1.96 and p-values < 0.05.

• Potential multicollinearity between indicators is tested using variance inflation factor (VIF) values with tolerance limits of < 3.3 or < 5.0.

• The decision to retain or remove indicators with insignificant outer weight values is based on conceptual relevance and theoretical support, not solely on statistical results.

b. For the reflective construct (Y):

• Convergent validity was assessed using factor loading values > 0.70 and AVE ≥ 0.50.

• Discriminant validity was assessed using the HTMT and Fornell-Larcker Criterion.

• Construct reliability was tested using Composite Reliability (CR) and Cronbach's Alpha, with an ideal value of ≥ 0.70.

3.4. Structural Model Analysis (Inner Model)

Structural analysis is used to examine the relationships between latent constructs. This test is conducted using several tests, namely:

a. The coefficient of determination (R2) to determine the proportion of variance in the endogenous variable that can be explained by the exogenous variables simultaneously. The higher the R2 value, the better the model's predictive ability for the endogenous variable. Hair et al. (2022) categorizes a value of 0.75 as strong, 0.50 as moderate, and 0.25 as weak.

b. The f2 (Effect Size) test assesses the magnitude of the influence of each exogenous construct on the endogenous construct. Interpretation of effect sizes follows the guidelines of Sarstedt et al. (2019), which refer to Cohen's classic guidelines: a value of 0.02 is small (small effect), 0.15 is medium (medium effect), and 0.35 is large (large effect).

c. The Q2 (Predictive Relevance) test is an indicator of the model's overall predictive ability. Q2 indicates how useful the model is in the real world, not just in sample data. The category used if Q2 > 0, the model has predictive relevance, while Q2 ≤ 0, the model has no predictive relevance.

d. Path Significance Test (Bootstrapping) is used to test the significance of the relationship between latent constructs with a p-value < 0.05.

3.5. Goodness of Fit Model Test

Goodness of Fit testing is performed to ensure the constructed model aligns with the empirical data. In SEM-PLS, the Goodness of Fit test does not use classical indices like covariance-based SEM, but rather uses the following measures:

1. Standardized Root Mean Square Residual (SRMR): used to assess overall model fit, with an SRMR ≤ 0.08 indicating a good model fit.
2. NFI (Normed Fit Index) and Chi-Square/Saturated Model (optional, as a complement to SRMR).
3. d_ULS (Squared Euclidean Distance) and d_G (Geodetic Distance) are used to examine differences between the estimated model and the empirical model.

In SmartPLS, these indicators appear after bootstrapping in the model fit summary menu.

IV. RESULTS AND DISCUSSION

This research model consists of three exogenous, formative constructs (X1, X2, X3), and one endogenous, reflective construct, namely road work delay (Y). The relationship between the variables is shown, where the exogenous construct influences the endogenous construct of road work delay. The relationship formed in this research model indicates the presence of a mediator variable, where institutions/regulations do not directly lead to the delay construct but rather through the other two constructs goods/services procurement and pre-construction technical aspects to channel their influence on road work delays.

Conceptually, this model illustrates that the effectiveness of institutions/regulations in the pre-construction phase determines the smoothness of the procurement process and technical readiness in the field. If institutional coordination runs smoothly, the procurement and technical preparation processes will be more efficient, reducing potential delays to road work in Parigi Regency.

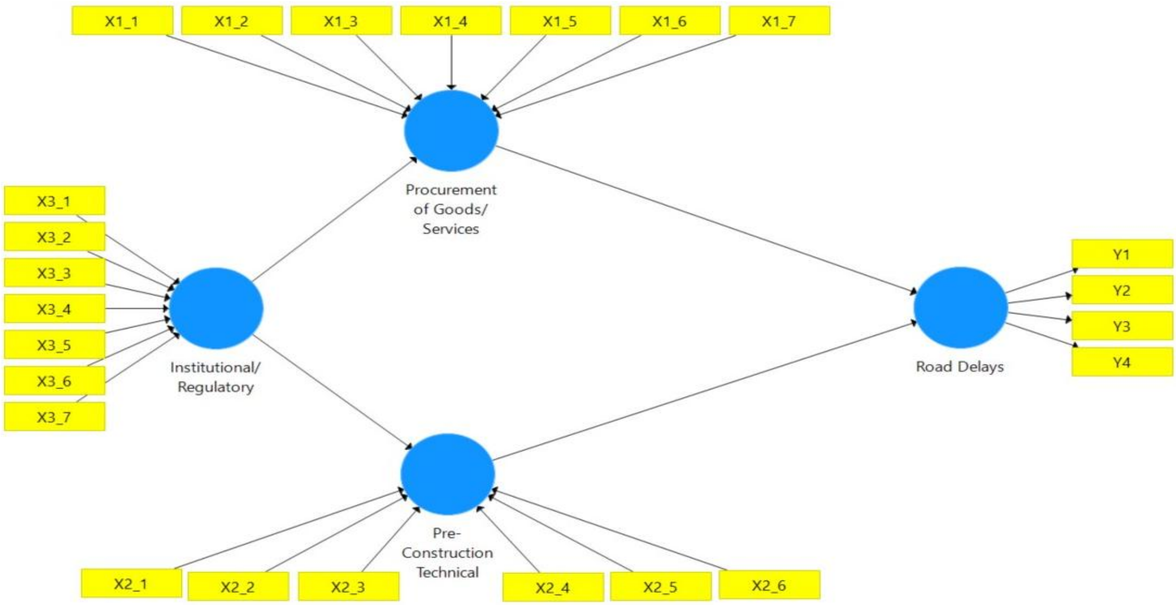

Fig .3. Research Model of SEM-PLS analysis results

4.1. Multicollinearity Test

This test is useful for detecting overlapping or similar meanings among indicators. Multicollinearity analysis uses the Variance Inflation Factor (VIF) values generated by SmartPLS. The results are shown in Table 1 below:

Table 1.: Results of SmartPLS Multicollinearity Analysis

Indicator	VIF	Criteria	Description
X1_1	2.723	< 3,3	no multicollinearity
X1_2	2.789	< 3,3	no multicollinearity
X1_3	1.099	< 3,3	no multicollinearity
X1_4	1.144	< 3,3	no multicollinearity
X1_5	1.417	< 3,3	no multicollinearity
X1_6	1.392	< 3,3	no multicollinearity
X1_7	1.398	< 3,3	no multicollinearity
X2_1	1.728	< 3,3	no multicollinearity
X2_2	1.556	< 3,3	no multicollinearity
X2_3	1.509	< 3,3	no multicollinearity
X2_4	2.234	< 3,3	no multicollinearity
X2_5	1.286	< 3,3	no multicollinearity
X2_6	1.395	< 3,3	no multicollinearity
X3_1	1.822	< 3,3	no multicollinearity
X3_2	2.855	< 3,3	no multicollinearity
X3_3	2.677	< 3,3	no multicollinearity
X3_4	2.480	< 3,3	no multicollinearity
X3_5	1.597	< 3,3	no multicollinearity
X3_6	2.070	< 3,3	no multicollinearity
X3_7	1.749	< 3,3	no multicollinearity

Source: SmartPLS collinearity output results

Based on the results of the collinearity statistical analysis in SmartPLS, all VIF values for each indicator were below 2. This indicates that there is no multicollinearity among the indicators in the formative variables (X1, X2, and X3). Each indicator makes a unique contribution to the formation of the latent construct. The results of this test are used as considerations in reducing an indicator, in addition to the significance test.

a. Significance Test

The significance test for this formative construct is conducted to ensure that each indicator contributes significantly to forming its latent construct. Each indicator does not have to be correlated, but each indicator has its own role in forming the latent construct. The results of this test are reflected in the outer weight value in bootstrapping, with a t-statistic ≥ 1.96 or p-value ≤ 0.05 indicating a significant indicator in forming the construct.

Indicators with low t-statistic values in the significance test for the formative construct cannot be simply reduced; additional considerations are required, depending on the multicollinearity level. The indicators have the same meaning and theoretical relevance considerations where the indicators are conceptually considered important to represent the construct.

In the following table, the researcher displays the results of the bootstrapping of the significance test per indicator to make it easier to analyze the indicator data as in the following table 2:

Table 2 Bootstrapping results of indicator significance test (X1)

Indikator	T Statistics	P Values	Description
X1_1 ->Procurement of Goods/Services	0.331	0.741	Not significant
X1_2 -> Procurement of Goods/Services	0.182	0.856	Not significant
X1_3 -> Procurement of Goods/Services	0.134	0.894	Not significant
X1_4 -> Procurement of Goods/Services	0.310	0.757	Not significant
X1_5 -> Procurement of Goods/Services	4.418	0.000	Significant
X1_6 -> Procurement of Goods/Services	0.725	0.469	Not significant
X1_7 -> Procurement of Goods/Services	1.633	0.103	Not significant

Source: SmartPLS bootstrapping results, processed by researchers.

From the bootstrapping results for indicator (X1), consisting of seven indicators, only indicator X1_5 showed a significant influence on the latent construct, with a t-statistic of 4.418. This indicates that this indicator has the most significant contribution in shaping the Procurement of Goods/Services variable. Meanwhile, the other indicators still had t-statistics below the specified criteria.

Furthermore, the bootstrapping results for the significance test of the Pre-construction Technical indicators are as follows:

Table 3. Bootstrapping results for indicator significance test (X2)

Indicator	T-Statistics	P Values	Description
X2_1 -> Pre-construction Technical	0.238	0.812	Not significant
X2_2 -> Pre-construction Technical	0.292	0.770	Not significant
X2_3 -> Pre-construction Technical	0.662	0.508	Not significant
X2_4 -> Pre-construction Technical	1.498	0.134	Not significant
X2_5 -> Pre-construction Technical	2.292	0.022	Significant
X2_6 -> Pre-construction Technical	3.293	0.001	Significant

Source: results of bootstrapping outer weights SmartPLS, processed by researchers

The test results revealed two indicators that met significance: X2_5 with a t-statistic of 2.292 and X2_6 with a value of 3.293, indicating that these indicators play a significant role in the formation of the Pre-Construction Technical construct. The other indicators, however, had t-statistics below 1.96, thus failing to meet significance.

The significant results for Institutional/Regulatory are shown in Table 4 below

Table 4. Bootstrapping results for indicator significance test (X3)

Indicator	T-Statistics	P Values	Description
X3_1 -> Institutional/Regulatory	1.038	0.299	Not significant
X3_2 -> Institutional/Regulatory	0.472	0.637	Not significant

X3_3 -> Institutional/Regulatory	0.620	0.535	Not significant
X3_4 -> Institutional/Regulatory	0.804	0.421	Not significant
X3_5 -> Institutional/Regulatory	0.076	0.940	Not significant
X3_6 -> Institutional/Regulatory	2.195	0.028	Significant
X3_7 -> Institutional/Regulatory	1.192	0.233	Not significant

Sumber: results of bootstrapping outer weights SmartPLS, processed by researchers

From the significance test for the Institutional/Regulatory indicators, one indicator, X3_6, was declared significant, with a t-statistic of 2.195, greater than 1.96. For indicators that did not contribute statistically, researchers will analyze the results of multicollinearity and significance tests, as well as their theoretical relevance to construct formation before considering whether to retain or remove them.

The bootstrapping results for the significance test for the roadwork delay indicator are shown in Table 5 below:

Table 5 Bootstrapping results for the significance test of the indicator (Y)

Indicator	T-Statistics	P Values	Description
Y1 <- Road Delay	2.692	0.007	Significant
Y2 <- Road Delay	5.239	0.000	Significant
Y3 <- Road Delay	3.760	0.000	Significant
Y4 <- Road Delay	4.572	0.000	Significant

Sumber: results of bootstrapping outer weights SmartPLS, processed by researchers

V. DISCUSSION OF RESULTS

These significant results indicate that service provider experience, poor information and communication, and effective decision-making are the most influential indicators in shaping pre-construction factors that led to road work delays in Parigi Moutong Regency. After obtaining multicollinearity values and significance test values, an evaluation of indicators that did not meet significance based on theoretical relevance was conducted. Research Model after Reduction.

Based on multicollinearity tests and outer weight tests to check the significance of an indicator, a new research model was obtained that has undergone simplification while maintaining the complete conceptual meaning of each construct. This new research model is considered more efficient, clear, and easy to interpret because each construct is formed by indicators that have distinct and complementary contributions. The researchers present this reduced research model as follows:

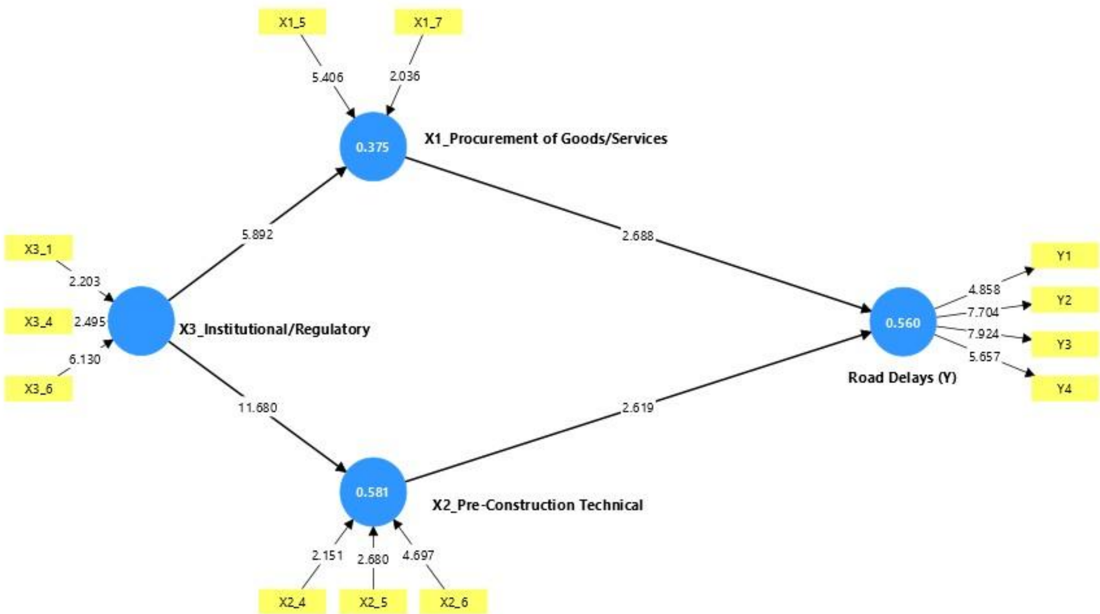

Fig. 4. Research Model after reduction

Hypothesis testing was conducted on the previously formulated preliminary assumptions. H1, H2, H3, and H4 were tested using path coefficients using a bootstrapping procedure to determine the significance of the direct influence of exogenous constructs on endogenous constructs based on t-statistics and p-values. The effect was declared significant if the t-statistic value was greater than 1.96 at the 5% significance level ($p < 0.05$).

Meanwhile, H5 and H6 were tested to assess the indirect or mediating effect of the institutional/regulatory variable (X3) on road construction delays (Y) through two intermediary constructs: pre-construction techniques (X2) and procurement of goods/services (X1). This mediation effect test used a specific indirect effect bootstrapping approach to ensure statistical significance of the mediation pathway.

To determine the dominant factor influencing road construction delays among the three constructs, the largest significant path coefficient value was used, as this value represents the magnitude of the direct influence of the exogenous construct on the endogenous construct.The following table presents a summary of the results of hypothesis testing (H1–H6) based on the results of the inner model analysis that was carried out using SmartPLS.

VI. CONCLUSION

All pre-construction factors were proven to have a significant influence on road work delays. Path coefficient tests showed that the three constructs, namely procurement of goods/services, pre-construction techniques and institutions/regulations, had a significant influence on road work delays in Parigi Moutong Regency (p-values <0.05). This finding emphasized that the source of delays does not only originate from the implementation stage, but can also originate from procurement, regulatory changes and suboptimal project preparation in the pre-construction stage. The procurement of goods/services factor had a significant direct influence on road work delays ($\beta = 0.416$, $p < 0.007$). This indicates that the competence of the provider, the availability of experts and the experience of the contractor in the procurement process, play an important role in contract preparation and impact the timeliness of work implementation.

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