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The Bridge Maintenance Factors Model: A PLS-SEM Approach

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Abstract Bridge maintenance is essential to maintain the function of the bridge in serving transportation. Decision-makers face many challenges in keeping old bridges with excellent and continuous care while the available budget is limited for maintenance planning. Setting up a priority for handling rehabilitation and maintaining a bridge must pay attention to appropriate criteria that directly influence the treatment priority scale system. Then the requirements related to prioritizing maintenance are investigated, and a model is developed to examine the effect and relationship of these criteria in bridge and the priority determination of bridge maintenance. Factors are determined based on existing regulations, previous research literature studies, and stakeholders' interviews regarding bridge rehabilitation and care. The data collected from the questionnaire survey were analyzed with the partial least squares approach of the structural equation modeling technique (PLS-SEM). This model adapts 13 sub-criteria from three priority maintenance criteria: technical (structural), technical (functional), and non-technical. The PLS-SEM model's result confirms that if non-technical and technical-functional influence is strong, the technical-structural will become more substantial and increase the priority support for bridge maintenance. In the context of bridge maintenance, this study's results enrich knowledge about the factors in the decision-making model and the relationship between technical and non-technical aspects.

Keywords Bridge, Maintenance, Factors, PLS-SEM, Decision, Priority

1. Introduction

The road network and bridges are the most valuable assets of a country. Supervision and maintenance have an essential role in maintaining the function of the bridge in serving transportation. The high increase in traffic volume is one factor that influences the deterioration and damage of a bridge. Management's role is indispensable for monitoring and maintenance because bridge management consists of various activities ranging from planning to replacement. Maintenance is the final stage of a project, which passes due diligence to ensure its safety for users [1]. In addition to providing security, such as building maintenance, bridge maintenance also aims to minimize repair costs [2]. With the aim of safety and minimal repair costs, of course, a priority setting for bridge maintenance is needed.

In setting up a priority for handling a bridge's rehabilitation and care, one must pay attention to the factors that directly influence the treatment priority scale system. These factors are determined based on existing regulations, literature studies from previous research, and interviews with stakeholders regarding bridge rehabilitation and maintenance. Therefore, modeling is a process of identifying problems and sorting out the crucial influences rather than decision-making. Previous studies have identified the variables that determine are technical and non-technical variables [3]. BMS provides several defining parameters, namely the value of the condition, vehicle, LHR, and deterioration. Several other studies [4], [5], [6], [7], [8] also divide the analysis parameters in determining priorities, such as technical variables [3], namely the type of damage and implementation time, while the non-technical variables are in the form of economic, transportation, and social variables. Determination of criteria and sub-criteria as parameters in priority is the research subject by [4], six criteria and 18 sub-criteria as general conditions of bridges, road network conditions, traffic aspects, economic and management aspects, social aspects, and regional development and technical aspects of the bridge. [9] discussed the bridge's disease, the traffic, and the strategic environment. The determining criteria [10] complement the previous parameters: road conditions, service levels, damage levels, LHR, government policies, budget capacity, and economic benefits. At the same time, the research of [6] and [7] divides three priority determination variables, namely structure performance, functional performance, and external factors (client impact factor). Therefore, exploring more and expanding on previous studies about how and what factors influence determining the type of bridge maintenance is interesting. This study discusses the elements, the level of influence, and the relationship between each factor determining bridge maintenance priority. In this study, the factors used are technical and non-technical factors with bridges located in the work area of related agencies such as the Ministry/Service/BUMN, including West Java, Banten, Central Java, East Java, and several provinces outside Java Island. This study uses the partial least squares-structural equation modeling (PLS-SEM) method to perform the analysis. Over the past few years, authors, reviewers, and editors have universally accepted PLS-SEM as a multivariate analysis method [11] and [12]. PLS helps researchers empirically validate theoretical research from various disciplines, such as accounting, family business, management information systems, operations management, supply chain, and several other fields [[13], [14], [15], [16], [17]]. Based on the literature review, this research is the first approach to identifying and determining indicators that majorly contribute to determining bridge maintenance priorities and their effects using PLS-SEM. This study expands PLS-SEM use to bridge maintenance by using and combining data sources derived from previous research and BMS.

2. Literature Review

Technical factors are the factors that shape the structural performance and functional performance of a bridge. Adopting research [6] and [7] regarding the performance of the bridge structure is the performance that affects the structural activity of both materials, age, environmental factors, road class, and inspection factors. In contrast, functionality performance is the service performance of a bridge (serviceability). Meanwhile, non-technical factors formed from social, economic, environmental, and even political parameters can influence decision-making priorities and budget allocations. From these parameters, some basic ideas emerge that form and integrate and complement the parameters of [6] and [7] into a single unit in technical and non-technical factors. The technical and non-technical factors which are obtained from previous literature are presented in table 1.

Table 1. Technical and Non-Technical Factors

Factors	Description	References	Factors	Description	References
Condition Value	Element Structural Condition Index	[18], [19], [7], [20], [21]	**Average Daily Traffic**	evaluate road performance	[22], [18]
Age	Built with a minimum design age	[23]	**Number of Lanes**	Lanes affect the capacity of the bridge	[18]
Environment	Environmental change factors	[19], [24]	**Asphalt Surface Conditions**	Quality of asphalt	[25], [26]
Load	Classification of roads according to Road Class	[18], [19],	**Drainage System**	drainage system performance	[19], [7], [22],
Natural disaster	Bridge maintenance due to natural disasters	[27]			
Non-Technical	Historical Importance of Bridges, Social, Economic, Politic	[19], [28], [4], [9]			

2.1. Hypothesis Development

2.1.1. Technical (Structural) Factors

Condition Value. The condition value obtained from visual observation based on BMS is a value between 0 to 5, reflecting the bridge's condition or other elements' value. The assessment carried out when checking the shape of the bridge. The evaluation can use for both minor elements, primary elements, or the bridge. Data regarding the volume of the damage condition is entered based on each element's condition value from the condition value 1 to 5 and can also use in calculating the estimated maintenance costs. This estimate may not be reliable enough since data collected through the inspection process is usually associated with subjectivity and uncertainty; much effort has reduced tension [29]. Table 2 presented guidelines for scoring conditions.

Age. Age intervals are obtained based on grouping from historical bridge construction. According to [23], Bridge Roads were built with a minimum design age of 50. The longer the bridge's life, the longer the life of the elements of the bridge itself.

Table 2. Guidelines for scoring conditions ([18]

Score	Bridge Condition
0	The bridge is brand new, with no noticeable damage. The bridge elements are in good condition.
1	Damage was minimal (damage can be repaired through routine maintenance and has no impact on the safety or function of the bridge). Examples: slight scour, surface rust, loose wood planks.
2	Damage that requires future monitoring or maintenance. Examples: slight decay of wood structures, deterioration of masonry elements, accumulation of garbage or soil around the placement. These are all signs that need replacement.
3	Damage that requires attention (damage that may become serious within 12 months). Examples: concrete structures with slight cracks, rotting wood frames, holes in the floor surface of vehicles, the presence of asphalt mounds on the vehicle floor and bridgeheads, moderate scouring of bridge pillars/heads, rusty steel frames.
4	Critical condition (severe damage requiring immediate attention). Examples: frame failure, cracking or collapse of concrete floors, eroded foundations, concrete frames with visible and corroded reinforcement, missing handrails/safety fences.
5	Elements collapse or no more extended function. Example: collapsed superstructure, washed up a pile of earth.

If a component has experienced fatigue due to age, then replaced the part. The older the bridge is, the more it is prioritized to be handled. [19] defines four age categories with values (1-4) assigned to each interval. The four categories are Build New (0-25), New (25 - 50), Old (50 - 75) very old (75 - 100). Same with [19], [24] also divided into four age categories with differences in age intervals; the maximum age is 80 years. Newly built (0-20), New (20 - 40), Old (40 - 60) very old (60 - 80)

Environment. Environmental change factors include human-induced environmental actions that cause chemical and physical damage to concrete. These ecological parameters affect corrosion, river flow, the impact of debris flow, and temperature changes [19].

Load. Identify bridge handling from the data available and screening out. Technical screening filters from the database of bridges that require treatment are due to insufficient traffic capacity, lack of strength, or poor conditions. Road class is regulated in [23] concerning the Classification of roads according to Road Class, consisting of Class I Roads, Class II Roads, Class III Roads. (Class IIIA, IIIB, and IIIC) and Special Class Roads.

Natural Disasters. Bridge buildings that are unwell planned will be vulnerable to natural disasters. Delays in handling bridge maintenance due to natural disasters will result in more severe damage, and of course, the costs for repairing road damage will also be even higher.

2.1.2. Technical (Functional) Factors

In the aspect of bridge functionality, as explained by [22], the functional efficiency of a bridge depends on the volume of traffic it can hold, which is mainly related to the carrying capacity of the bridge, the number of lanes that exist, or the width of the deck, vertical distance and resistance. The assessment process must also carefully consider the drainage system, pedestrians and cyclists' provisions, and any post-design changes.

Average Daily Traffic. The parameters used to evaluate road performance are average daily traffic and degree of saturation. [18] inspection data obtain LHR data. Roads, according to [22], divided into four types of roads based on Average Daily Traffic, namely Minor (LHR $\leqslant$ 150), local access (150 <LHR $\leqslant$ 1000), collector (1000 <LHR $\leqslant$ 3000), and Arterial (> 3000).

Number of Lanes. The number of lanes and the bridge's width are determined based on the needs of passing vehicles every hour; the more crowded the passing cars, the larger the bridge width is needed and the number of lanes. The bridge's width also affects the capacity of a bridge [18] and bridge planning guidelines.

Asphalt Surface Conditions. Five categories of asphalt conditions take the standard of surface layer damage to BMS. They can see the asphalt condition visually with the type of injury described in BMS [18]. The functional life of the bridge can also be affected by deterioration in conditions associated with a decrease in the quality of the asphalt [25]. A more durable pavement is also required for roads through commercial centers to minimize disruption to businesses due to maintenance activities and delay maintenance layers, interfering with property access [26]

Drainage System. Road surface drainage is the natural or artificial infrastructure that functions to cut off or channel water on the road surface with the force of gravity [19] and [7]. Drainage on the bridge functions to drain the water on the vehicle's floor to the exhaust channel so that it does not inundate the base of the bridge vehicle, which significantly disturbs the passage of traffic passing through it. It is essential to evaluate the performance of the drainage system during the inspection. Poor drainage will accelerate corrosion in the strengthening process and deteriorate quality; therefore, it can directly affect the safety of passengers and the durability of the bridge. Based on the inspector's assessment, one of the four conditions (Bad, Average, Good or Very Good) that represents the efficiency level of the bridge can be determined [22]

2.1.3. Non-Technical Factors

Social, economic, environmental, and even political parameters can influence decision-making priorities and budget allocations. External factors such as the study conducted by [19] help build the social implications of remediation into the risk assessment process. The importance of bridges for economic activity can accelerate the decision-making process towards "replacement" or "rehabilitation" [28]. This factor can be classified based on the bridge's criticality level regarding socio-economic, political, and historical considerations. This part of the evaluation is relatively subjective but significant to note. Therefore, the main decision-maker or bridge maintenance planner should establish the appropriate level for this parameter [19].

2.1.4. Priority Factors

According to BMS, the priority of bridges that require maintenance handling is based on technical screening of the bridge structural elements' conditions and the service function of a bridge (traffic capacity) and economic evaluation (NPV and IRR) [8].

2.1.5. Hypothesis

Based on some of the discussions above, this study has the following hypothesis:

Hypothesis 1 (H1). Non-technical factors have a positive influence on technical (structural) elements.

Hypothesis 2 (H2). Technical (functional) factors have a positive effect on priority factors.

Hypothesis 3 (H3). Technical (functional) factors have a positive influence on technical (structural) elements.

Hypothesis 4 (H4). Technical (structural) factors have a positive influence on priority factors.

All association hypothesized, presented in Figure 1.

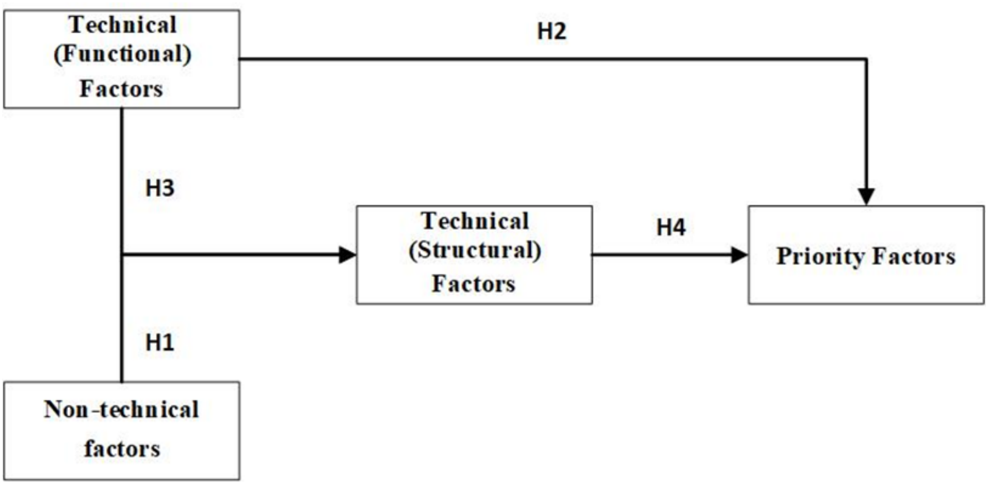

Figure 1. Research Framework

2.2. PLS-SEM

Structural Equation Modeling (SEM) combines two disciplinary methodologies: an economic perspective that focuses on predictions and psychometrics. SEM can describe the concept of a model with latent variables (variables that cannot be measured directly) but measured through its indicators (manifest variables) [30]. According to [31], SEM essentially offers the ability to perform path analysis with latent variables.

In the writings of [32], there are generally two types of SEM according to Fornell and Bookstein in 1982, namely covariance-based structural equation modeling (CB-SEM) developed by Joreskog in 1969 and partial least square path modeling (PLS-SEM) developed by wold in 1974. PLS-SEM must go through five stages of analysis where each step will affect the next step. These stages are model conceptualization (PLS-SEM can handle constructs with reflexive and formative indicators), determine algorithmic analysis methods, determine resampling methods, draw path diagrams and evaluate models (assessing the outer and inner models). The external model, through confirmatory factor analysis, assesses the validity and reliability of the model. This model tests the convergent and discriminant validity of the latent construct-forming indicators and composite reliability and Cronbach alpha for the indicator block. [31]. The inner model predicts the relationship between latent variables and evaluates the variance percentage (R^2).

3. Research Methods

3.1. Population and Sample

To meet data needs in the research can use the research instrument as one of the tools. The instruments used in this study were questionnaires and field observations. This study obtained quantitative data through an online survey linked to the Kobo Toolbox form on various social media platforms. Online surveys are an easy sampling method, and researchers adopted this method to collect data during the Covid-19 outbreak [12].

The online survey involved respondents who have carried out planning, construction, and management of bridges either as owners (related agencies such as Ministry/Services/BUMN) or design consultants and supervisors or contractors or contractor experts. This research area is located in Indonesia on Java Island, covering West Java, Banten, Central Java, East Java, and several regions outside Java Island. Apart from related agencies, academics in the bridge sector were also respondents for the interview. Between November and December, conducted data collection for the 2020 period. The number of respondents who answered the questionnaire totaled 102 of the approximately 150 questionnaire forms distributed online through the Kobo toolbox (Computer Assisted Personal Interview) platform, an open-source that uses tablets, smartphones, or other gadgets that function as charging mediums. The number of respondents who meet the sample requirements needed for data processing using PLS is a minimum of 30 to 100 cases.

3.2. Variables and Indicators

From the explanation above, this study uses specific related variables and indicators. Table 3 describes the composition of the variables and their hands.

3.3. Variables and Indicators Measure

The Interval scale method, known as The Likert scale, is the measurement scale used in this study. The Likert scale has the form of questions through a range of values which will then be scored. Questions on the Likert scale have positive, neutral, and negative sentences. Respondents gave an assessment using a relative scale "(1) very unsupportive", "(2) not supportive", "(3) neutral", "(4) supportive", and "(5) very supportive".

3.4. PLS Analysis

The five stages of analysis using PLS are the model conceptualization stage, the algorithm analysis stage, the resampling method determination stage, the path drawing stage, and the model evaluation stage [32].

3.4.1. Conceptualization of the Model

In this study, the construct domain specification and determining the question items define the variables and indicators. There are three exogenous variables, namely technical-structure, technical-functional and non-technical (Table 3)

Table 3. Variables and indicators

Variables	Indicators	
Technical (Structural) Factors	1.	Condition Value
	2.	Disaster
	3.	Age of structure
	4.	Environment
	5.	Load
Technical (Functional) Factors	1.	Average daily traffic
	2.	Drainage System
	3.	Number of lanes
	4.	Asphalt Surface Conditions
Non-technical factors	1.	Historical Importance of Bridges
	2.	Social
	3.	Economic
	4.	Politic
Priority	1.	Economic Evaluation
	2.	Serviceability
	3.	Condition of structure

While data collection was created and distributed questionnaires with a construct measurement score of 1-5, the data collected tested reliability and validity at the model evaluation stage. Moreover, based on the above-mentioned theoretical review, the following statements were hypothesized for this research and presented in figure 1.

3.4.2. Determine the Algorithm Analysis Method

The second stage use in model estimation. PLS uses the SMART PLS 3.0 program, the PLS algorithm's method with three factorial schemes: centroid and path (structural weighting). PLS uses a path scheme (structural weighting) [32]. After doing this algorithm, the method is the determination of the sample. PLS does not demand a large selection of at least 30 to 100 cases. The sample of this research is 102 samples.

3.4.3. Determine the Resampling Method

This research uses bootstrapping because the SMART PLS software only provides one resampling method. Bootstrapping uses the entire original sample for resampling.

3.4.4. Draw a Path Diagram

The fourth stage is to draw a model path diagram. That is estimated with the following conditions: a theoretical construct that shows the latent variable marked in a circle or ellipse, the observed variable or the indicator drawn in a square, the asymmetry relationship with a single arrow symmetrical relationship with the direction of the double arrow. The path diagram shows in figure 2.

3.4.5. Model Evaluation

Model evaluation using SMART PLS 3.0 software. As stated in Barclay's writing, they quoted in [33] that the PLS analysis model consists of two stages: assessing the measures' reliability and validity and assessing the structural model.

4. Data Analysis

4.1. Demographics Data of Respondents

Table 4 presents the demographic characteristics of respondents. The gender of respondents consisted of 89% of respondents were male, and 11% of respondents were female. The age of the respondents is very varied, seen from the composition of the age of 31-40 years by 45% respondents, 41-50 years old by 30% respondents, 21-30 years old by 14% respondents, and age> 51 years by 11% respondents. This age group shows that the parties involved in the planning, construction, and management of bridges, either owners (related agencies such as Ministries / Services / BUMN) or as planning consultants, supervisory consultants, contractors, or experts in this study, are in the productive age range. Respondents who participated in filling out the questionnaire were 57% respondents came from the PUPR ministry, 9% of respondents came from supervisory consultants, 4% respondents came from contractors and supervisory consultants. In comparison, 26% were respondents from the ministry of public works office. The characteristics of the position respondents are Experts/Engineers 17% respondents, as Staff 16% respondents, others are positions as available position in the ministry of public works service and academics as lecturers who have experience in bridge management, amounting to 15 % respondents.

Then the role of section chief 11% respondents, PPK 11% respondents, Technical Assistant by 10% respondents, Head of the unit work by 8% respondents, and Head of division for 7% respondents and Field Supervisor by 6% respondents. Most positions come from experts. The role of experts is vital to support the decision-making process as representatives of stakeholders in the implementation of maintenance. Based on the PUPR ministerial circular letter [34] supported by the ministerial regulation regarding the procurement of construction services [35], experts have duties in implementing construction works. One of them is maintenance work, and experts submit reports to stakeholders in the Ministry of PUPR; therefore, decisions are made quickly.

4.2. Assess the Measures' Reliability and Validity

Evaluation of the reliability and validity, namely the outer model's measurement, tested the validity and reliability. There are two basic framework assessments of this outer model, namely convergent and discriminant validity. Convergent validity, which consists of individual item reliability, can see it from the standardized loading factor value, internal consistency or construct reliability, the average variance extracted, and discriminant validity in the cross-loading value. Table 5 presented the outer model's measurement.

The discriminant validity assessment can be seen in the cross-loading value, an alternative to the AVE test and the Fornell-Larker Criterion Correlation. Fornell–Larcker criterion was used to assess the discriminant validity of constructs, which involved comparing the square root values of AVE of each construct with the correlation between constructs. On the other hand, the cross-loading method suggests that the external loadings of constructs should be greater than the loadings of corresponding constructs. Adequate discriminant validity of all constructs can validate with that [12].

Table 6 shows that the external Fornell Lacker Criterion value is higher than the construct correlation value between functional and structural externals. Likewise, with Fornell Lacker Criterion's value on functionality and structure. With the result, all the estimation model constructs meet the requirements and criteria for discriminant validity. While in table 7 shows the effect of cross-loading.

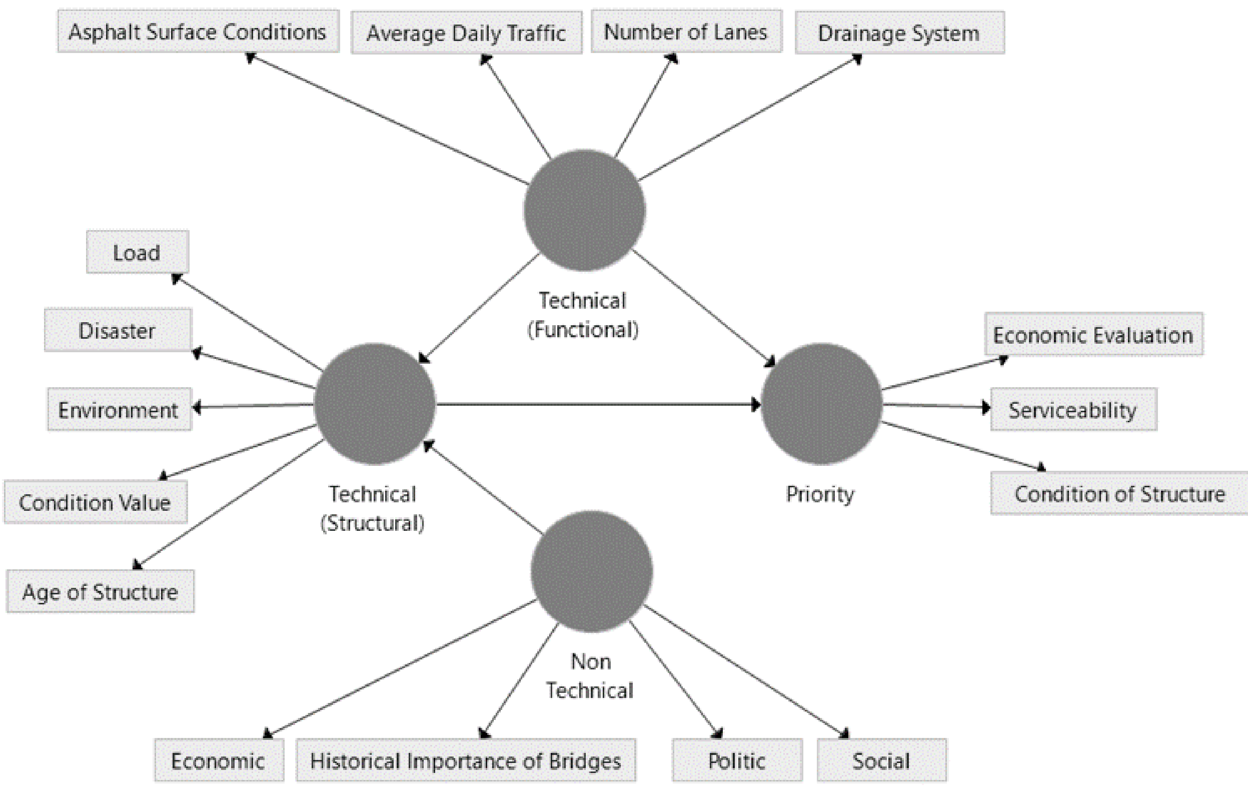

Figure 2. Path Diagram (Result from Smart-PLS Software 3.3.3)

Table 4. Demographic Characteristic of Respondents

Description		**Freq.**	**%**	**Valid %**	**Cum. %**	**Description**		**Freq.**	**%**	**Valid %**	**Cum. %**
Gender	Male	89	89	89	89		Central Java	37	37	37	70
	Female	11	11	11	100		East Java	7	7	7	77
	Total	100	100	100			Others	23	23	23	100
Age	> 51 year	11	11	11	11		Total	100	100	100	
	21-30 year	14	14	14	25	Position	Technical Assistant	10	10	10	10
	31-40 year	45	45	45	70		Head of division	7	7	7	17
	41-50 year	30	30	30	100		Section Chief	11	11	11	28
	Total	100	100	100			Head of the work unit	8	8	8	36
Agency	Ministry of Public Work	57	57	57	57		Supervisor	5	5	5	56
	Supervisor consultant	9	9	9	66		Chief of PPK	11	11	11	67
	Design consultant	4	4	4	70		Staf	16	16	16	83
	Contractor	4	4	4	74		Expert/Engineer	17	17	17	100
	Others	26	26	26	100		Others	15	15	15	51
	Total	100	100	100			Total	100	100	100	
Area	Banten	2	2	2	2						
	D.I Yogyakarta	12	12	12	14						
	DKI Jakarta	9	9	9	23						
	West Java	10	10	10	33						

Table 5. The Outer Model's Measurement

No.	Indicator	Loading Factor	Composite Reliability	Cronbach Alpha	AVE
Technical (Structural) Factors			0.851	0.782	0.536
1.	Condition Value	0.688			
2.	Disaster	0.752			
3.	Age of structure	0.659			
4.	Environment	0.848			
5.	Load	0.696			
Technical (Functional) Factors			0.801	0.629	0.574
1.	Average daily traffic	0.808			
2.	Drainage System	0.719			
3.	Number of lanes	0.554			
4.	Asphalt Surface Conditions	0.722			
Non-technical factors			0.823	0.713	0.539
1.	Historical Importance of Bridges	0.716			
2.	Social	0.806			
3.	Economic	0.633			
4.	Politic	0.768			
Priority			0.856	0.664	0.748
1.	Economic Evaluation	0.587			
2.	Serviceability	0.818			
3.	Condition of structure	0.781			

4.3. Assessment of the Structural Model

The structural or inner-model measurement aims to predict the relationship between latent variables by looking at the variance percentage. R-Square: Based on data processing performed using Smart PLS. The table generated the R square value. The table shows that the R-square value of the structural variable is 0.435, which means that 43.5% of functional variables and external variables affect structural variables. In comparison, other factors influenced the remaining 56.5%. Simultaneously, the priority variable has an R-square of 0.420, meaning that 42% of the priority variables are affected by structural variables, functional and external, while other factors influence 58%. The structural model is presented in figure 3.

Table 6. The Fornell-Larker Criterion Correlation

No.	Fornell-Lacker Criterion	Non-technical	Technical (Functional)	Priority	Technical (Structure)
1.	Non-technical	0.734			
2.	Technical (Functional)	0.545	0.707		
3.	Priority	0.358	0.512	0.736	
4.	Technical (Structural)	0.505	0.616	0.643	0.732

Table 7. Cross Loading

Code	Technical (Structural) Factors	Technical (Functional) Factors	Non-technical factors	Priority
Condition Value	0.688	0.244	0.122	0.452
Disaster	0.752	0.529	0.469	0.547
Age of structure	0.659	0.417	0.241	0.490
Environment	0.848	0.548	0.512	0.549
Load	0.696	0.443	0.302	0.382
Average daily traffic	0.580	0.808	0.464	0.402
Drainage System	0.434	0.719	0.376	0.427
Number of lanes	0.14	0.554	0.500	0.186
Asphalt Surface Conditions	0.433	0.722	0.301	0.361
Historical Importance of Bridges	0.326	0.362	0.716	0.239
Social	0.429	0.513	0.806	0.283
Economic	0.297	0.389	0.633	0.264
Politic	0.410	0.332	0.768	0.267
Economic Evaluation	0.420	0.296	0.457	0.587
Serviceability	0.479	0.455	0.289	0.818
Condition of structure	0.515	0.368	0.083	0.781

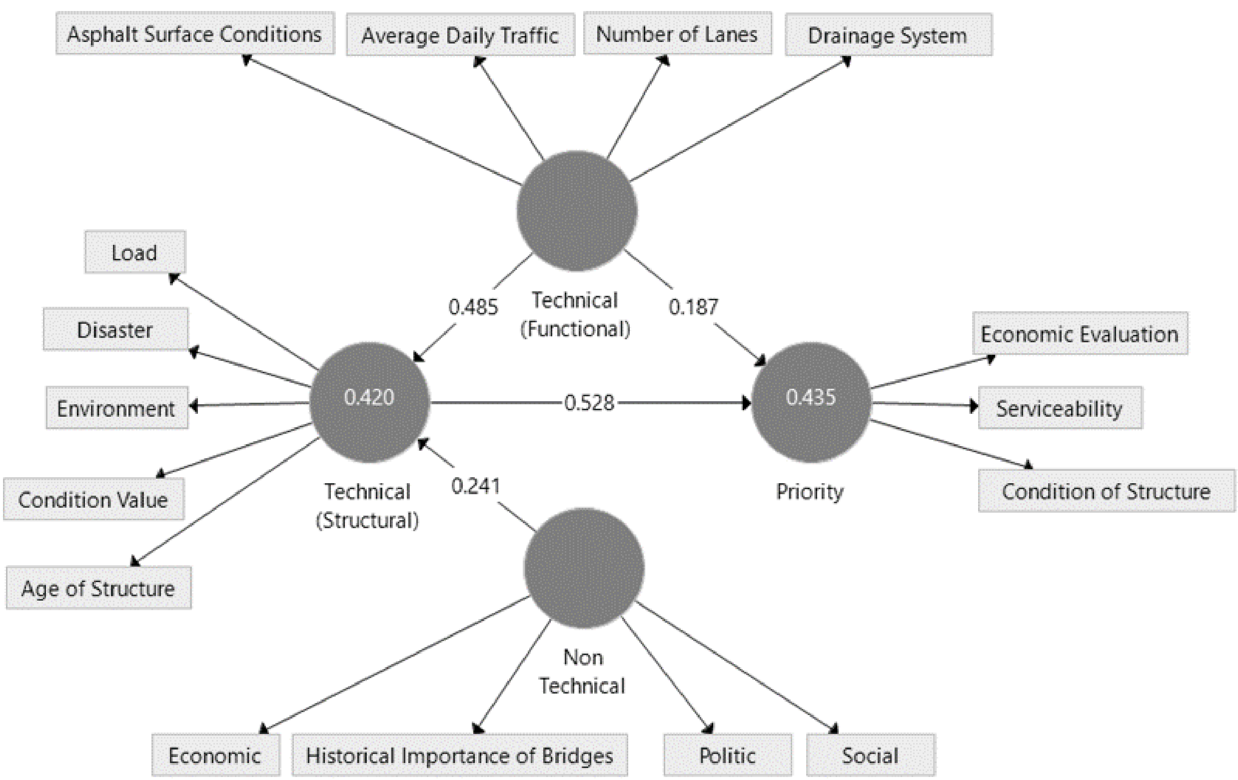

Figure 3. Structural Equation Model

5. Discussion

With the results of the accepted hypothesis, the path coefficient value can see the strong influence between variables if it shows the numbers of 0.67, 0.33, and 0.19, meaning that these variables' impact is substantial, moderate, and weak [32]. Only one variable does not significantly affect the priority variable from the path coefficient table results, namely the functional variable. Other variables have a T-statistic value> 1.96

Hypothesis testing: The hypothesis's testing can see in table 8

Table 8. The Hypothesis's Testing

No.	H	Latent Variable	Finding			Conclusion
			Path Coef.	T-Statistics	P-Value	
1.	H1	Non-technical factors have a positive influence on technical (structural) factors	0.241	2.335	0.017	Yes, Supported (Weak)
2.	H2	Technical (functional) factors have a positive influence on priority factors	0.187	1.920	0.078	Not Supported
3.	H3	Technical (functional) factors have a positive influence on technical (structural) factors	0.485	4.570	0.000	Yes, Supported (moderate)
4.	H4	Technical (structural) factors have a positive influence on priority factors	0.528	5.858	0.000	Yes, Supported (moderate)

The structural model results show a positive relationship between all technical structures and priority constructs. The first hypothesis of technical structure is non-technical, which refers to the influence of socio-economic, political, and historical considerations. It has a positive but weak effect (β = 0.241) on the technical structure. The second hypothesis is that technical-functional, which refers to the level of service, does not directly affect priority but has a moderately positive impact (third hypothesis, β = 0.485) on the technical structure. The fourth hypothesis is that technical design has a moderate positive effect and effect (β = 0.528) on priority.

These findings confirm that if non-technical and technical-functional influence is strong, the technical-structural will become more substantial and increase the priority support for bridge maintenance. This research also considers the bridge maintenance decision makers' positive effect of technical structure with the backing from technical-functional and non-technical to priority.

This analysis shows that the bridge maintenance decision-makers must pay attention to several conditions, such as the average daily traffic (BMS) with the width and number of bridge lanes. It pays attention to the asphalt surface conditions and the drainage system [[3]-[8]].

Besides, to be more convincing in the decision-making process, non-technical factors show the significance of economic, social, political, and historical interests. These findings also align with the evidence from the literature [19] and [28] that external factors help the risk assessment process. Subjective but essential to note that there is an appropriate level setting for this parameter, namely, economic activity can accelerate the decision-making process towards replacement or rehabilitation.

6. Implications for Research

In the context of bridge maintenance, this study's results enrich knowledge about the factors in the decision-making model and the relationship between technical and non-technical aspects. The confirmation of this theoretical model will support the current bridge maintenance system to guide bridge maintenance decision-makers to make decisions not subjectively, efforts to improve the quality of bridge maintenance and ultimately based on the maintenance's suitability budget. Decision-makers certainly need to understand better the significant factors that influence decision-making in bridge maintenance. The practical contribution of this study is that the decision-maker should hold more events and workshops on the maintenance of infrastructure, either bridges or some other buildings. In addition, occupants motivate with training and adequate awareness among decision-makers about the potential factors influencing decision-making. Therefore, those individual decision-makers have a better understanding of bridge maintenance in the future. Provide an investigation of other factors affecting bridge maintenance. Consequently, this will provide more comprehensive results and influence decision-makers to determine the factors influencing bridge maintenance.

7. Conclusions

The indicator analysis shows that all the goodness of fit model criteria is fulfilled according to the rule of thumb analysis of validity and reliability using confirmatory factor analysis of the outer model. There are 13 significant indicators: (1) the technical variable (structure) indicator is the value of conditions, natural disasters, age, environment, and load. (2) technical variable (functional) indicators are the average daily traffic, drainage system, number of lanes, and asphalt surface conditions. (3) indicators of non-technical variables are the bridge's historical, economic, social, and political importance. These findings can assist decision-makers who intend to maximize maintenance funding sources and minimize subjectivity. Also, in line with the opinion that bridge maintenance is essential for future assets, we need a model to make maintenance decisions. The bridge maintenance program that has been running at the Ministry of Public Works is BMS. Of course, it requires the development of parameters that complement the BMS and support the decision-making process. Training is one way to socialize other potential factors in bridge maintenance. This training can help decision-makers to understand bridge maintenance better and complement its aspects.

8. Limitations of This Study and Future Research

Although the current research has provided significant insights into the factors affecting bridge maintenance among decision-makers, this study finds several limitations. This study's questionnaire survey is limited to those who have done the planning, construction, and management of bridges either as owners (related agencies such as ministries/services/BUMN) or as planning consultants, supervisory consultants, contractors, or experts in the region: West Java, Banten, Central Java, East Java, and several provinces outside Java. However, for future research, it can do by increasing the number of respondents who provide feedback and input from parties with interest in bridge maintenance and expanding the questionnaire distribution area.

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