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Improving project performance strategy on residential infrastructure based on risk management

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Abstract

Project performance is crucial for ensuring long-term success and providing value for learning in subsequent projects. The failure rate of infrastructure development in Bekasi Regency, West Java, exceeded 60% due to external factors that were not properly managed. These external factors necessitate handling involving many stakeholders, both internal and external. This study aims to formulate a strategy to improve the performance of infrastructure projects in Bekasi, West Java, based on risk management, particularly external risks involving multiple parties. Through quantitative analysis by distributing questionnaires to 200 respondents involved in infrastructure development in Bekasi, this study conducted an analysis using SEM-PLS to determine the correlation and significance of each variable dimension to the risk of infrastructure failure in Bekasi, West Java. The results of the quantitative analysis were validated through in-depth interviews with seven experts to develop strategies for improving project performance. The study's outcome is a recommended strategy formulation for contractors and owners to take various strategic steps to address external risks in residential projects, including unpredictable risks and those related to third parties. The implementation of these recommendations is essential to ensure high project performance in terms of cost, quality, time, safety, and environmental considerations in future infrastructure development in Bekasi and other cities with similar characteristics.

Keywords: Construction project, Contractor, Owner, Project performance, Risk management.

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1. Introduction

In the development of infrastructure projects, risk mapping is important because the better risks can be predicted, the higher the value and benefits the project will provide [1]. Inability to predict risks will cause projects to fail and incur unpredictable costs Antón et al. [2] and Ma et al. [3]. Shrivastava and Rathod [4] state that risks must be divided according to the stakeholders and risk areas that occur to make it easier to resolve the impact of the risks that occur. Various tools have been developed to identify and anticipate the emergence of risks that can affect project performance [5]. Bekasi Regency, the most densely populated district in West Java Province, Indonesia, is experiencing significant infrastructure development to meet the needs of its growing economy. Furthermore, at least 60% of the total infrastructure development by 2023 is expected to fail, ranging from damage to infrastructure to improper functioning for the community. Various risk mapping efforts are being undertaken to identify unforeseen risks that could lead to long-term infrastructure failure. In his research, he stated that there are several factors that must be considered in analyzing infrastructure project risks, which originate from internal risks, project risks, and external risks. Zavadskas et al. [6] construction project risks are divided into controllable risks, namely project risks and internal risks, and uncontrollable risks, namely external risks. Internal and project risks are the responsibility of the contractor and are fully controlled in project risk management. Meanwhile, external risks, consisting of political, economic, demonstration, social, interest rate increases, extreme weather, and contract risks, are risks that involve third parties and must be treated to transfer or accept the risk while minimizing its impact on the organization.

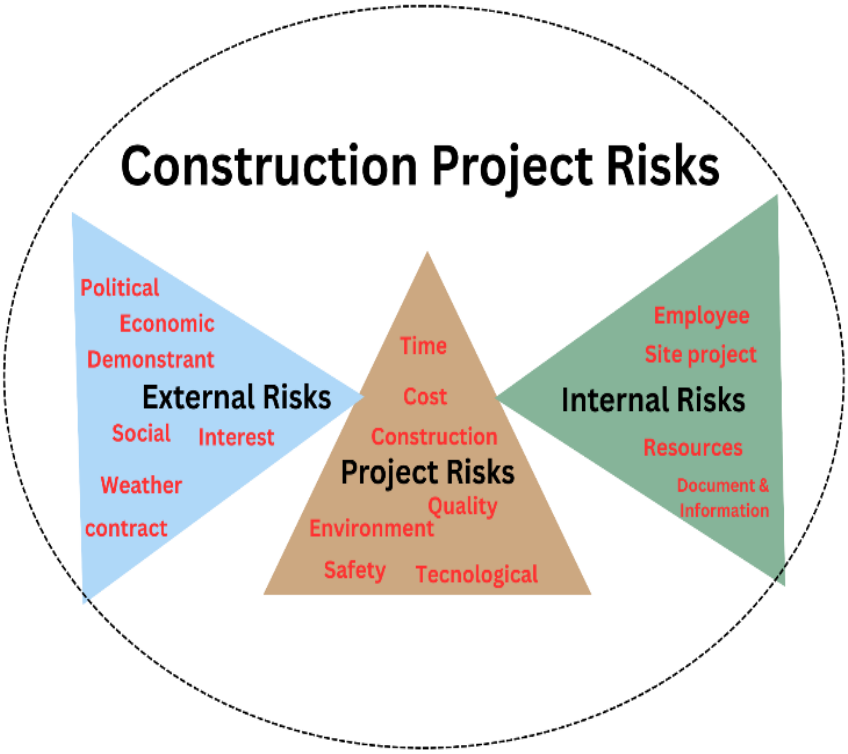

Figure 1.
Risk in a construction project.
Source: Zavadskas et al. [6].

Figure 1 above explains the risk mapping in a construction project, which consists of three parts: project risk, internal risk, and external risk. Project performance is greatly influenced by project risk management, especially cost performance [1]. Cost planning in a project by the planner must take into account the various risks involved to ensure that the costs submitted in the bid are appropriate and do not harm the contractor. Yuan [7] the magnitude of project costs related to risks includes unpredictable weather, fluctuations in interest rates, unstable politics, and rising material prices, all of which are external risks that contractors cannot control. Several external risks are divided from the perspective of the government, client, designer, and contractor, which are external risks that must be anticipated and controlled, Yuan [7] stated that design variations, inflation of material prices, errors in cost estimation, contract ambiguity, corruption, and poor information are risks that have a major impact on projects. Yefany Syahputri and Kitri [8] stated that external risks in enterprise construction projects are high category risks, including bad weather conditions. Alomari et al. [9] state that project risks are related to workers, workplaces, and organizations, where workers and workplaces are risks that must be anticipated psychologically by contractors because they cannot be fully controlled in relation to psychology. The environment has various factors in construction projects. Xu et al. [10] state that the ability to avoid, minimize, monitor, and control the possibility of risks occurring is the highest priority for contractors in project risk management. This ability must be supported by proper risk identification, especially those related to external risks.

This research aims to analyze internal risk factors and external projects. Then, it focuses on strategies based on external risks that cannot be fully intervened and controlled by contractors, requiring cooperation and partnering with other parties [11, 12]. In order to minimize the risks that may arise, the infrastructure development project in Bekasi, West Java, must anticipate potential issues and develop appropriate strategies to minimize risks and prevent infrastructure development failure. Successful risk avoidance, minimization, and control will significantly impact project performance, including cost, quality, time, safety, and the environment [10]. The ability to identify infrastructure development risks in Bekasi, West Java, by understanding the types of risks, will enable the project to achieve its desired objectives [13].

2. Theoretical Literature Review

2.1. Risk Management

Iqbal et al. [13] express risk as a loss/gain or the probability of a loss/gain occurring multiplied by the respective magnitudes. An event is said to be certain if the probability of its occurrence is 100% or completely uncertain if the probability of its occurrence is 0%. Between these two extremes, uncertainty varies considerably. Currently, risk can be assessed using various types of information [6]. Success in the construction industry depends on the level of Risk [14]. Construction projects are considered to have higher inherent risks because they involve many parties in the contract, such as owners, designers, contractors, subcontractors, suppliers, etc., which require close cooperation in resolving various project risks Sari et al. [14] and Bigwanto et al. [15]. Paslawski [16] in conditions of high uncertainty in a project, it will affect the project's flexibility, which will have an impact on project performance. Project Management Institute (PMI) [17] and Okudan et al. [5] risk management as a series of efforts undertaken to increase the probability and/or impact of positive risks and reduce the probability and/or impact of negative risks. Given that unmanaged risks have the potential to derail a project from its initial objectives, risk management is directly linked to project performance. In this regard, risk management is considered an indispensable field of knowledge. Risk management is a systematic process that enables individual risk events and overall risk to be understood and managed proactively. Without effective risk management, project success for the management team will be a challenge in itself.

Al-Bahar and Crandall [18] state that risk is an inherent part of every action. ISO 31000:2018 on risk management states that the risk management process, based on clause 6, consists of risk assessment, risk identification, risk analysis, risk evaluation, and risk treatment [19]. Implementing a risk management framework requires stakeholder awareness. The evaluation component addresses the effectiveness of the risk management framework. Evaluations are conducted periodically to determine whether the risk management framework continues to support the achievement of company objectives. Measurements include alignment between planning, implementation, and established indicators [8, 19, 20].

Level risk Mapping	Damage				
Probabilities	1	2	3	4	5
1	*Low*	*Low*	*Low*	*Medium*	*Medium*
2	*Low*	*Low*	*Medium*	*Medium*	*High*
3	*Low*	*Medium*	*Medium*	*High*	*High*
4	*Medium*	*Medium*	*High*	*High*	*Very High*
5	*Medium*	*High*	*High*	*Very High*	*Very High*

Figure 2.
Level risk mapping.

Figure 2 above shows the risk mapping level, which is a combination of probabilities and damage, producing the categories low, medium, high, and very high [20].

2.2. External Risk In Construction Projects

External risks are risks that originate outside the organization and are often unpredictable and cannot be fully controlled within the organization. External risks include environmental, logistical, financial, legal, and political risks [21].

Table 1.
Risk external factors.

No.	Risk External	List of dimensions
1	Environment	Floods, earthquakes, difficulty accessing the site, and adverse weather conditions
2	Logistics	Undefines the scope of working, unavailable labour, material and equipment, high competition bids, inaccurate project program, poor communication between the home and field offices
3	Financial	Inflation, exchange rate fluctuation
4	legal	Difficulty in obtaining permits, ambiguity of work legislation, legal disputes during the construction phase among the parties of the contract, delayed dispute resolutions, construction issues, and the lack of specialized arbitrators to help settle disputes quickly.
5	Political	New governmental acts or legislations, Unstable security circumstances (Invasions), Closure

Source: Enshassi and Mosa [21] and Nurdiana et al. [22].

Table 1 above illustrates various external risks in construction projects from the owner's perspective. Environmental risks have the highest weight because they are external risks that are difficult to predict and control if they occur [21].

External risks are not directly related to the construction process, but have a high weight in relation to project achievement [2]. The ability to identify and classify the majority of risks inherent in construction and infrastructure projects is essential, as construction projects are complex and involve numerous factors that can impact the outcome. Risk is fundamentally caused by uncertainty affecting the various participants. It is also important to note that contracting parties must adopt a continuous learning approach to risk identification. Past projects and events provide opportunities to gain experience that can lead to future success, as real-life scenarios can help take action to avoid triggering risk events [2, 22].

2.3. Relationships Between External Risk & Project Performance

Construction projects are complex, unique, and one-off endeavors, involving many people, activities, and requirements to achieve project objectives. Projects are constrained by time, budget, and quality and performance specifications to meet the owner's needs. Each process within a project is unique and requires specialized management techniques and skills to monitor and keep the project on track [23]. During the construction project process, it is necessary to ensure that project performance is achieved by paying attention to the risks that accompany it and by developing appropriate project management strategies for each potential risk in the project [24]. To evaluate and improve the Construction Performance Index, it is necessary to establish clear performance indicators. The use of quantitative scales can help measure the level of risk that has the potential to reduce project performance Ibrahim et al. [24]. Atkinson [25] mapping the iron triangle as a project performance measure involves assessing the levels of success in a construction project based on three key elements: cost, time, and quality. Time refers to the project schedule or the allocated completion period, while cost represents the financial resources allocated to the project. Quality pertains to the level of excellence or compliance with the specifications expected from the project's output. These three elements are interrelated; any adjustment or change in one element will influence the others. Balancing time, cost, and quality is essential for successful project management, as changes in one aspect are affected by risks at every phase of construction [26].

External risk is something that is unpredictable and causes project performance to change. By anticipating external risks from the start, a strategy can be developed to minimize or even eliminate the potential risks that occur. Sari et al. [14] state that partnering from the start before the project begins can increase value and innovation in the project, and recognizing potential risks early can improve procurement management in the project [27]. Good communication between stakeholders before the project starts will result in the project having lower external risks [28]. External risks that frequently arise and are unpredictable, such as weather, financial, social, and political conditions [21, 22], can be anticipated with good communication among the owner, contractor, designer, and subcontractor, as this will likely cause delays and postponements of project work.

3. Materials and Methods

This study employs mixed methods, specifically combining quantitative and qualitative approaches simultaneously. The quantitative approach utilizes SEM-PLS (Structural Equation Modeling - Partial Least Squares) analysis to identify internal, project-related, and external factors influencing project performance in infrastructure development in Bekasi, West Java. The qualitative approach involves conducting in-depth interviews with seven experts, including owners, contractors, and academics, to confirm and validate the external factors identified by the researcher. The detailed research methods are as follows:

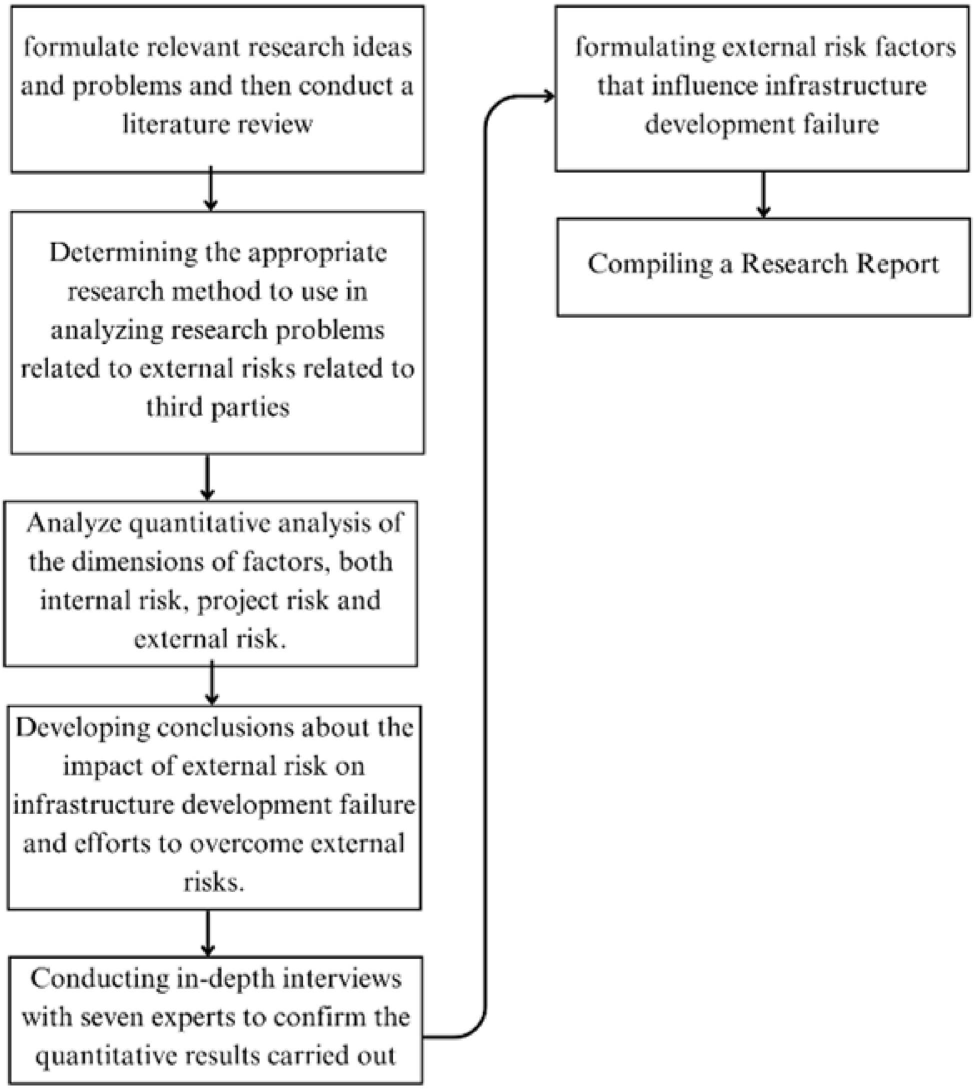

Figure 3.
Research Method.

Figure 3 above illustrates the research methodology used in this study, which involved quantitative analysis and in-depth interviews to validate the quantitative results. The detailed list of experts in this study includes two government experts, three contractors, and two academics.

4. Results

The analysis was conducted using SEM-PLS by distributing questionnaires to 200 respondents related to residential infrastructure development in Bekasi, West Java. Path diagram analysis was performed to assess the correlation between the independent variable (X) and the dependent variable (Y). A minimum loading factor of 0.7 was used in the analysis [29-31], which shows a strong correlation between variables. The path diagram analysis is presented in Figure 4 as follows:

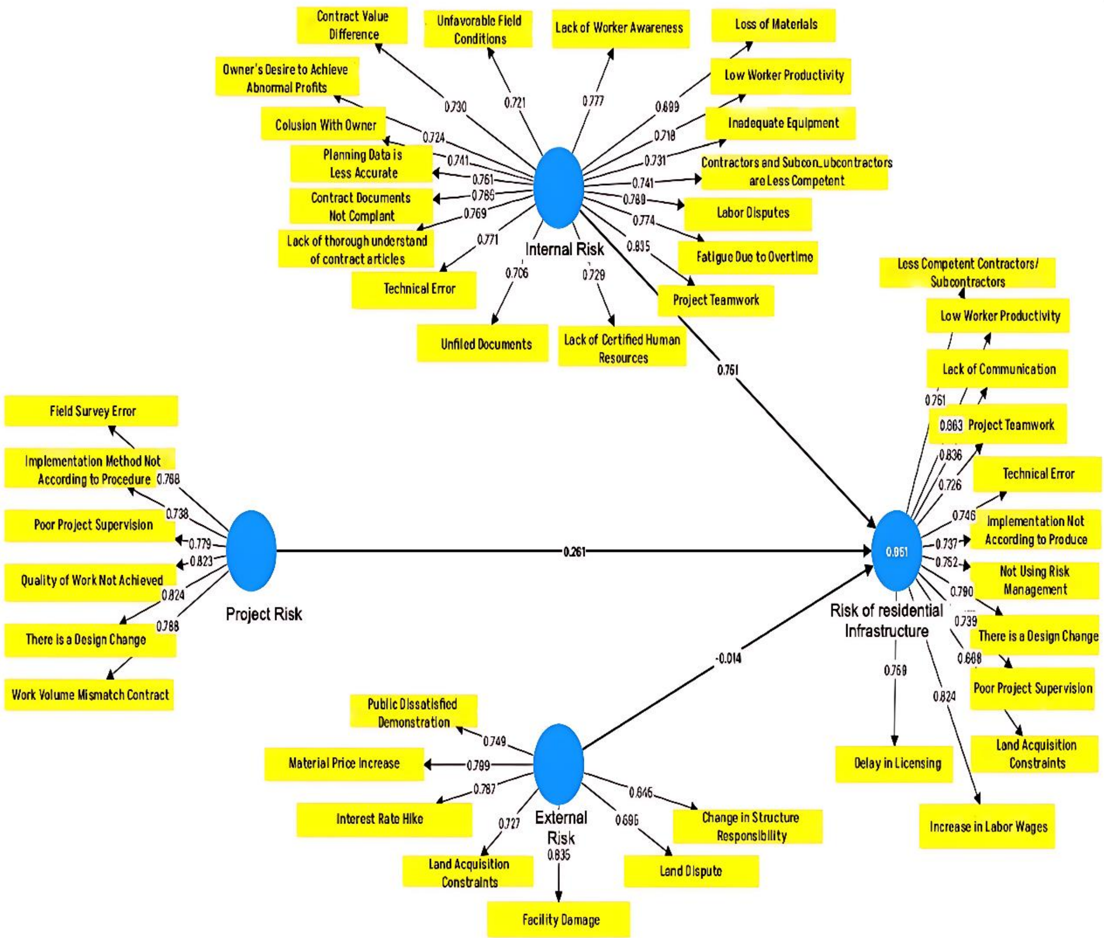

Figure 4.
Path diagram risk of residential infrastructure.

Figure 4 above illustrates that there are three dimensions of risk, namely internal risk (X1) consisting of 18 factors, project risk (X2) consisting of 6 factors, and external risk (X3) consisting of 7 factors. Statistical tests using SEM-PLS show that all factors meet the criteria with loading factors above 0.7. External risks include factors such as public demonstrations, material price increases, interest rate increases, and obstacles in land acquisition. Facility damage and land acquisition constraints have a high correlation with the overall external risk variable.

Table 2.
Path coefficient value.

Risk Criteria	External Risk	Internal Risk	Project Risk	Risk of residential Infrastructure
External Risk				-0.014
Internal Risk				0.751
Project Risk				0.261
Risk of residential Infrastructure				

Table 2 above illustrates that External Risk has a very small impact on the Risk of Failure of Residential Infrastructure, with a path coefficient of -0.014. This indicates that external factors such as rising material prices, land acquisition constraints, or public demonstrations do not significantly increase the risk of infrastructure failure. This is because road infrastructure projects in Bekasi Regency have a short timeframe, whereas external risks typically impact projects with a long duration. Meanwhile, Internal Risk has a very strong influence with a path coefficient of 0.751, indicating that factors such as a lack of understanding of contracts, labour disputes, and a lack of worker awareness significantly increase the likelihood of failure in residential infrastructure projects.

Project risk also has a positive relationship with the risk of failure of residential infrastructure, with a path coefficient of 0.261. This indicates that factors such as errors in field surveys, poor project oversight, and design changes can increase the risk of project failure. However, their impact is not as significant as internal risks. From these results, it can be concluded that internal risk has the most significant impact on residential infrastructure failure, followed by project risk. In contrast, external risk has a very small or even negative impact. Therefore, efforts to mitigate the risk of residential infrastructure project failure should focus on internal risk management through improved planning, supervision, and workforce management.

Table 3.
Construct reliability and validity value.

Risk Criteria	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
External Risk	0.881	1.000	0.900	0.563
Internal Risk	0.954	0.955	0.959	0.563
Project Risk	0.877	0.879	0.907	0.620
Risk of residential Infrastructure	0.929	0.931	0.939	0.564

Table 3 above illustrates that the construct reliability and validity values for all variables in this study demonstrate good levels of reliability and validity. The Cronbach's alpha value for each variable exceeds 0.7, indicating that the instrument has high internal consistency. Internal Risk has the highest Cronbach's alpha at 0.954, followed by Housing Infrastructure Failure Risk at 0.929, External Risk at 0.881, and Project Risk at 0.877.

Furthermore, the Composite Reliability (rho_c) values also show strong results, with all variables having values above 0.9, indicating that the indicators within each construct have high reliability. The Average Variance Extracted (AVE) values for all variables are above 0.5, ranging from 0.563 to 0.620, indicating that the constructs can explain more than 50% of the variance in their indicators, thus being considered convergently valid.

Table 4.
Heterotrait-monotrait ratio (HTMT) – Matrix.

Risk Criteria	External Risk	Internal Risk	Project Risk	Risk of residential Infrastructure
External Risk				
Internal Risk	0.118			
Project Risk	0.139	0.878		
Risk of residential Infrastructure	0.137	1.019	0.959	

Table 4 in the Heterotrait-Monotrait Ratio (HTMT) analysis, most of the correlation values between constructs are within acceptable limits, namely below 0.9, which indicates that the constructs in this model have good discriminant validity. The HTMT value between External Risk and Internal Risk is 0.118, between External Risk and Project Risk is 0.139, and between External Risk and Risk of Settlement Infrastructure Failure is 0.137.

Table 5.
Fornell-Larcker criterion.

	External Risk	Internal Risk	Project Risk	Risk of residential Infrastructure
External Risk	0.750			
Internal Risk	-0.122	0.750		
Project Risk	-0.138	0.807	0.787	
Risk of residential Infrastructure	-0.141	0.963	0.868	0.751

Table 5 above is the Fornell-Larcker Criterion analysis. The square root value of AVE for each construct is higher than the correlation between other constructs, except for Internal Risk and Risk of Residential Infrastructure (0.963), and Project Risk and Risk of Residential Infrastructure (0.868).

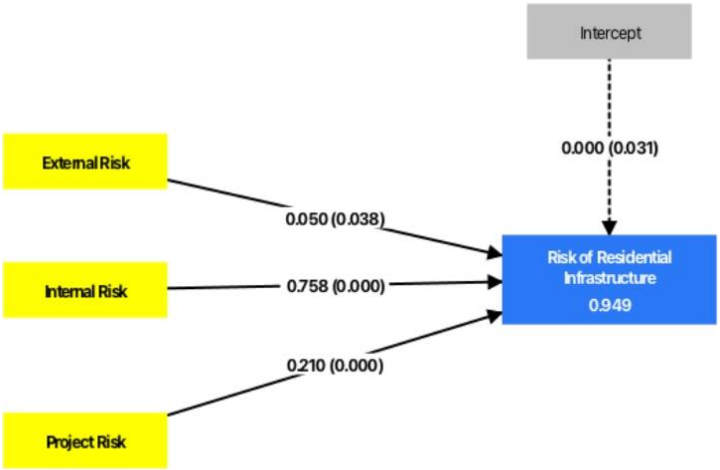

Figure 5.
Regression analysis.

Figure 5 above illustrates a model of the relationship between various risks and infrastructure failure. The value of 0.949 in the model is likely the coefficient of determination (R^2), indicating that the variables in the model can explain 94.8% of the variability in infrastructure failure.

Table 6.
R Square value.

	Risk of residential Infrastructure
R-square	0.949
R-square adjusted	0.948

Table 6 shows an R-squared value of 0.949, indicating that the independent variables in the model can explain 94.9% of the variability in infrastructure failure. This result indicates that the model has very high predictive ability. Furthermore, the standard deviation (STDEV) value of 0.008 indicates that the R-squared estimate is relatively stable. The very high T-statistic value of 122.831, along with a P-value of 0.000, confirms that this result is statistically significant. Thus, this model is strongly capable of explaining the relationship between risk factors and infrastructure failure.

Table 7.
Variance Inflation Factor VIF.

Risk Criteria	VIF
External Risk	2.210
Internal Risk	3.364
Project Risk	3.190

Table 7 shows a Variance Inflation Factor (VIF) analysis indicating that the External Risks variable has a VIF value of 2.210, which suggests no multicollinearity issues. Meanwhile, the Internal Risk and Project Risk variables have VIF values of 3.364 and 3.190, respectively, which are still within reasonable limits as they are below the critical threshold of 10.

Table 8.
Standardized Coefficients.

	Unstandardized coefficients	Standardized coefficients	SE	T value	P value
External Risk	0.057	0.050	0.027	2.090	0.038
Internal Risk	0.462	0.758	0.018	25.543	0.000
Project Risk	0.401	0.210	0.055	7.266	0.000
Intercept	1.520	0.000	0.701	2.168	0.031

Table 8 is an analysis of standardized coefficients showing that the Internal Risk variable has the most dominant influence on the model, with a T-statistic value of 25.543. A P-value of 0.000 confirms that its influence is statistically significant. Meanwhile, the Project Risk variable also contributes to the model, although with a smaller influence than Internal Risk. The T-statistic value is 7.266 and a P-value of 0.000, indicating strong significance. On the other hand, the External Risks variable has a T-statistic value of 2.090, with a P-value of 0.038. So, the model of Y is as follows:

Y=1.520+0.462X1+0.401X2+0.057X3+ε

Where:

Y	= Infrastructure Failure Risk
X1	= Internal Risk
X2	= Project Risk
X3	= External Risk
1.520	= Intercept
ε	= Error term

The model interpretation in this Study is presented as follows:

- Internal Risk (X1) has the largest influence on infrastructure failure with a coefficient of 0.462, meaning that the higher the internal risk, the greater the likelihood of infrastructure failure.
- Project Risk (X2) also has a positive influence, although smaller than Internal Risk, with a coefficient of 0.401.
- External Risks (X1) have a significant positive influence, as its coefficient is 0.057 with a p-value of 0.038.
- The intercept value (1.520) indicates a relatively small contribution of the constant in the model.
- The R-squared of 0.949 indicates that the independent variables in the model can explain 94.9% of the variability in infrastructure failure, demonstrating that the model has very high predictive ability.

5. Discussion

From the analysis above, all variables in the internal, project, and external risk dimensions influence the risk of infrastructure development failure in Bekasi Regency, West Java. However, internal risks are significantly more substantial, considering that they are related to the contractor team's readiness to prepare the project, including resources such as finance, human resources, materials, and understanding of the contract. Failure to anticipate internal risks will result in failure in project preparation and planning. Project risks are related to site success, design changes managed by other entities, and weak project supervision that hinders communication and information flow. Project risks involve internal and third parties, requiring coordination, partnering, and effective communication. External risks are related to third parties and the environment. External risks are often uncontrollable and must be accepted by the contractor. Some risks can be transferred to third parties, but often risks must be accepted, and their impact must be anticipated to be minimized. Zavadskas et al. [6] stated that micro and macro analysis is needed to resolve risks in construction projects.

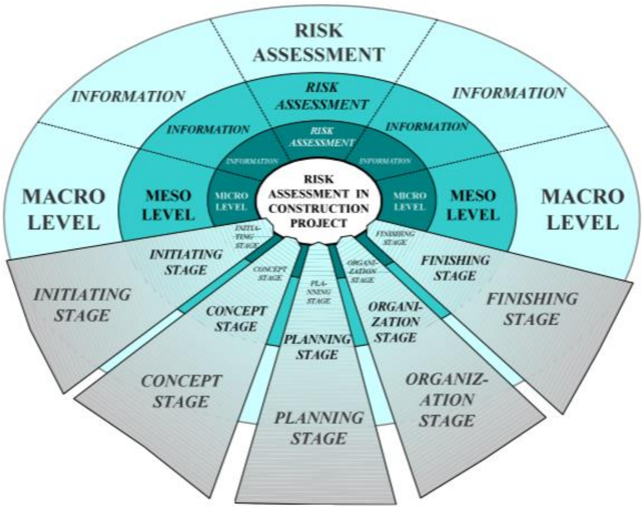

Figure 6.
Risk assessment is divided according to the object life cycle environment
Source: Zavadskas et al. [6].

Figure 6 above illustrates that in the project initiation phase, internal risks and projects are carried out at a micro level to obtain a detailed risk overview as part of risk identification and assessment. Meanwhile, in the meso-level phase, project risk mapping begins to involve third parties, such as site acquisition, project supervision, etc. At the same time, the macro level is intended to map external risks that are influenced by third parties and cannot be controlled by the contractor and owner. In mitigating external risks, it is necessary to involve third parties, such as insurance, mergers, and business diversification, according to needs [6]. The ability to avoid, minimize, monitor, and control the possibility of risks occurring is the highest priority for contractors in project risk management. This ability must be supported by proper risk identification, especially those related to external risks [10].

In the results of in-depth interviews conducted with seven experts focusing on external risks that occurred in the infrastructure development project in Bekasi, West Java, each group of experts had different views on the project's external risks as follows:

- Government (owner): The infrastructure development project in Bekasi, West Java, has a short duration of less than one year, so anticipation, such as material inflation and public demonstrations, can be predicted well. Indonesia's relatively safe and stable political conditions mean that the government, as the owner, can carry out infrastructure work according to the budget managed annually. Land disputes also rarely occur because the government does not carry out road acquisitions, such as toll roads. The issue that must be anticipated is damage to facilities caused by infrastructure development, because different agencies do not simultaneously manage various infrastructure plans [13, 32, 33].
- Contractors: An external risk often faced by contractors is the unequal increase in material prices during tender preparation and implementation. Project implementation decisions often ignore material price increases, forcing contractors to adjust to the increased material prices [33, 34]. A strategy that contractors can use is to collaborate with building material suppliers to fix prices from the time the tender is drawn up [1, 2, 35]. Another risk is damage to facilities that requires contractors to repair the damage that occurs; this usually reduces the planned profit. The accuracy of the location survey when preparing the tender is important to include the risk coefficient of facility damage. Weather and environmental conditions, such as flooding in Bekasi, must be anticipated because it is a potential flood area due to the river catchment area. In road projects, this condition is a major loss for contractors. Partnering solutions and exceptions in the contract in the event of a disaster are very important because the handover is limited by time [27, 36, 37].
- Academics: External risks are risks that cannot be predicted by the contractor from the time the tender is entered into. Contractors, based on experience, must be able to predict external risks that will occur. Support from Human Resources, who have competence in tender document planning, is very important so that risks can be properly identified [38]. External risk management is usually outsourced to third parties with insurance coverage when it comes to natural disasters. Rising material prices can be anticipated through mergers and partnerships to achieve stable prices [38].

6. Conclusions

From the research findings above, the risks in projects related to the failure of infrastructure development in Bekasi, West Java, are influenced by internal, project, and external risks. Internal risks have a very high significance, indicating the need for attention in project preparation by reducing potential internal risks such as a lack of skilled human resources, internal collaboration issues, worker fatigue, labor disputes, incompetent subcontractors, inadequate equipment, low worker productivity, inappropriate work contracts, and technical errors in the project. Contractor readiness in preparing the project is crucial to anticipate internal risks that may occur. Meanwhile, project risks such as design changes, errors in surveys, work implementation not in accordance with procedures, and failure to achieve work according to targets are effects of unmanaged internal risks caused by the lack of competence of human resources owned by the contractor. External risks that occur are the effects of unpredictable external environments. In the case of infrastructure development failure in Bekasi, the influence is considered less significant because of the short duration of the project and the possibility of long-term external risks. Identifying and addressing external risks in a project requires risk transfer to a third party and in-depth partnering from the project planning stage so that external risks can be minimized and, if accepted by the contractor, prevent contract disputes due to delays in the handover of work. External risks are rare but have a significant impact when they occur, thus categorizing them as very high risk. Accurate prediction of external risks will result in achievable project performance and help the contractor achieve its planned objectives.

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