Cost Structure of Direct and Indirect Cost During Pre-Construction Stage in Construction EPC Project of Built Environment in Indonesia

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ABSTRACT

The construction industry in Indonesia has experienced significant growth, particularly in Engineering, Procurement, and Construction (EPC) projects for the built environment. Efficient management of direct and indirect costs during the pre-construction stage is critical for project success, impacting budget adherence, timelines, and quality standards. This research analyzes the cost structure of direct and indirect costs in Indonesian EPC projects, focusing on the pre-construction phase. By comparing cost components across 116 projects in the mining and data center sectors from 2020 to 2024, the study identifies patterns in cost allocation and key factors influencing cost structure, such as project size, location, industry, and remoteness. The findings reveal that medium-scale projects and those in the mining sector demonstrate optimal direct cost efficiency, while projects in remote areas tend to manage indirect costs more effectively. The research highlights the importance of context, specific strategies in cost management and recommends future longitudinal studies to compare pre-construction estimates with actual costs, development of a weighted remote scale index, and detailed investigation of indirect cost components. These insights aim to support better financial planning, resource allocation, and risk mitigation in future EPC projects in Indonesia.

Keywords: Construction Project, Direct Cost, Indirect Cost, Preconstruction, Cost Management, Cost Efficiency, Project Management

INTRODUCTION

The construction industry in Indonesia has seen a significant increase in recent years, particularly in the EPC (Engineering, Procurement, and Construction) project such as Factory, Data Centre, Mining, Oil and Gas, Energy, and others sectors that support economic sustainability. This industry plays a crucial role in the country's economic development, contributing around 5-10% to Indonesia's GDP and employing over five million workers. However, construction projects in Indonesia and anywhere often face challenges such as cost overruns, delays, and quality issues (Directorat General Bina Konstruksi (2025).

The preconstruction stage, which involves planning, design, and procurement, is a crucial phase where strategic decisions are made that can significantly impact the overall project cost. Project cost management is a critical aspect of construction project management, and understanding the factors that influence direct and indirect costs is essential for project success (Kerzner, 2017).

Direct costs in construction projects refer to the expenses directly attributable to the physical construction of the project, such as materials, labour, and equipment. On the other hand, indirect costs are expenses that are not directly related to the physical construction but are necessary for the project's completion, such as overhead, administrative expenses, and project management fees. Each project may have different factors affecting the direct and indirect costs, which can vary depending on the project type, location, and other contextual factors. in general project owner want to push indirect cost as below as they can due to cost efficiency.

This paper aims to analyse cost structure of direct and indirect cost in construction EPC projects during the preconstruction stage in Indonesia to provide insights into the factors that influence these costs and help project stakeholders make more informed decisions.

LITERATURE REVIEW

Direct And Indirect Cost in EPC Projects During Preconstruction Stage

In construction EPC (Engineering, Procurement, and Construction) projects, understanding the breakdown of direct and indirect costs is important for all stakeholders and project owners. This paper aims to analyse the cost distribution in EPC projects across different sectors and categorized, limited to Data Centres and Mining project with a focus on the preconstruction or tender phase. By looking at costs at this early stage, the paper will explore how these costs differ across industries and highlight key challenges in accurately estimating and managing both direct and indirect costs. This analysis will provide useful insights for project owners in planning and budgeting for construction projects.

Cost Estimation of EPC Project on Preconstruction Stage

At present, there are still some problems in the actual work of EPC project cost management. First, the cost management of most engineering enterprises mainly focuses on the process of project construction, and does not pay enough attention to the cost management in the design stage. The preliminary project construction planning and design is an important factor affecting the formation of project cost and the premise of construction and procurement stage. The progress of preliminary design and procurement directly affects the construction progress (Kejun, 2022).

Since the estimated cost of the object, the construction of which is planned at the expense of budget funds, should not exceed the cost calculated by the end construction price standards (CPS). In order to reliably determine the estimated cost using the collections of the CPS, it is necessary to correctly take into account a significant number of coefficients in accordance with the selected collection and additional costs. Based on the above, it becomes clear that the calculation of the estimated cost of construction for the CPS is a responsible task, which in the final result directly affects the determination of the amount of monetary investment (Dobysheva, 2021).

In recent years, more and more enterprises in China have begun to shift to the EPC model, which transfers many of the risks that should be borne by the owner to the contractor, and the contractor has to deal with more complex and diverse risks. At the same time, more and more enterprises are exploring overseas markets (Liu, et al., 2020)

The cost of construction projects includes not only explicit costs, but also hidden costs that are hard to quantify. The hidden cost is the same as the categorical cost, which is the part of the total cost of the project that cannot be ignored. If project holders do not pay attention to hiding costs and do not control hidden costs, the project holders will lose the benefits of the company to a large extent (Liu, Wu, Yue, & Zhang, 2019).

The minimization and optimization of direct costs of construction are explored by the researches in many different countries, but the increasing of competitiveness through the modelling of indirect costs of construction has not been investigated properly (Zavadskas, Turskis, & Tamošaitienė, 2010). In an environment of free market

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economics, the management of company's expenses constitute a starting point for success. Thus, the effective way to increase the company's competitiveness under highly intense competition in construction market with declining building contractors' profits and shrinking market shares is to control the costs of production and business (Apanavičienė & Daugėlienė, 2011).

The direct cost which mainly include material and labour, are chargeable to the end products without difficulty and are thus convenient to handle. The indirect costs also known as overhead which create problems for the cost accountant in determining the accurate product cost. Activity based costing is an upcoming and more refined approach for charging indirect costs to products and computing more accurate product costs (Varadharajan & Senthamilkumar, 2014)

Cost of EPC Construction Project to Estimate Portion of Indirect and Direct Cost

The variation of indirect costs is usually difficult to calculate since they are not directly associated with the physical work of the project. based on that the portion of indirect cost can vary widely even for project with similar scope, but in general the indirect cost is typically lower than the direct cost based on (O'Hara & Suboleski, 1992), the key factors that influence the direct and indirect costs in EPC construction projects in Indonesia include:

- Project type and complexity
- Geographic location and site conditions
- Material and equipment availability
- Labor productivity and availability
- Management and logistical factors
- Legal and regulatory requirements

On the method of estimation of cost during preconstruction (Varadharajan & Senthamilkumar, 2014) make comparison between two method it's call Activity Based Cost (ABC) and Resource Based Costing (RBC). Activity based cost (ABC) management focuses on activity-based cost calculation, on the foundation of the dynamic information provided by activity-based cost calculation analyses and amends all activity-based cost and leads cost management deep into activity based. It eliminates the no-value added activities so as to promote operation efficiency of value-added activities more competitive. Finally, the Level of production and management of the entire value chain will be improved continuously.

On the other hand, the Resource Based Costing (RBC) is method that resources are directly assigned to a cost account (a subproject) in direct costs. Each resource becomes an individual cost account in overhead costs. The term 'Resource-Based Costing' as Opposed to Activity Based Costing. RBC assigns costs directly to sub-projects cost accounts or work packages defined in the work break down structures, as if the costs that arise in the execution of work packages also have their causes in those work packages. This is achieved by finding the overhead cost of the activities and a detailed comparison between ABC & RBC is have different around 3% from total cost, and the method of ABC is less than RBC.

In construction cost estimation, a construction company's overhead costs consist of four main categories: head office expenses (such as expenses of building facilities, clerical, utilities and proceeding taxes and fees), common use transport expenses (costs for amortization, rental and fuel, as well as taxes), and salaries of head office employees and proceeded from them taxes (Apanavičienė & Daugėlienė, 2011). The structure of overhead costs, adopted in Lithuania, is shown in Figure 1.

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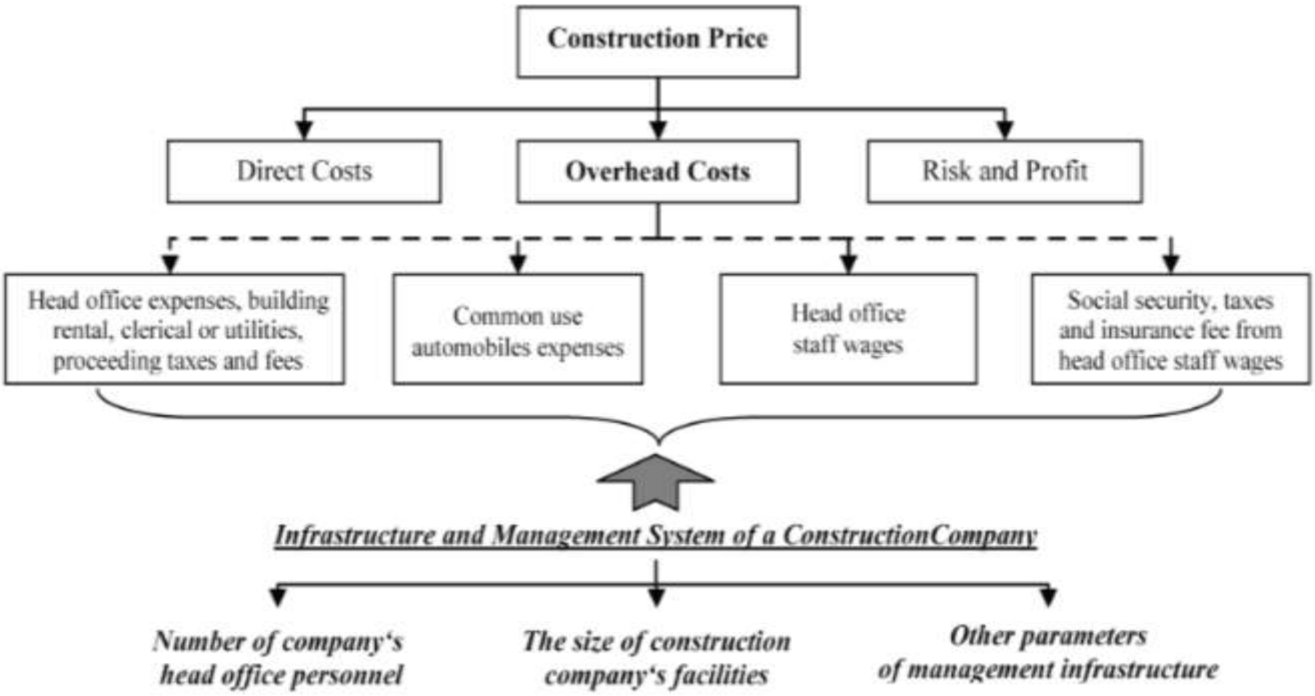
Figure 1 - The structure of a construction company's overhead costs



Source: (Apanavičienė & Daugėlienė, 2011)

The risks on the project will impact the budget cost of project life cycle. Based on (Liu, et al., 2020) one of the risk commons appear during preconstruction stage is errors in bidding prices that could impact total cost around (10%). The others risk that could impact more than 10% are design errors, labour, material and equipment costs increase, and unreasonable construction plans or technical measures.

Cost estimation could have variation between preconstruction to construction stage. (Dobysheva, 2021) find that deviation of cost between estimation to construction have value around -10.55% up to +21.13% with object projects of kindergarten for 220 places and school for 674 places.

The cost model based on a new-build data center in a single-storey, warehouse-type construction in the Greater London and Home Counties area. The total net technical area (NTA) is 2,000m^2 (comprising two data halls of 1,000 m^2 NTA each) with typically other areas of 300 m^2 for network operations center/security room and offices, 350 m^2 of ancillary space and 1,000 m^2 of internal plant areas. The total gross internal area is 3,650 m^2. Power and cooling to technical spaces is designed to 1,500W/m^2 of NTA = 3,000kW of IT load on cost model data centers with pricing assumes competitive procurement based on a lump-sum tender find the indirect cost has portion of 16.1% from total cost that include main contractor preliminary allow (14%), main contractor overheads and profit allow (5.5% from Cost of work/direct cost and preliminary cost) and risk allowance 4.8% of total cost (Cagney, 2021).

Lean construction management emphasizes reducing waste in both direct and indirect costs throughout the construction process to maximize client value. By focusing on value flow theory, lean management creates a cost management chain that closely integrates all parties, minimizing indirect costs like supervision, coordination, and delays, while optimizing direct costs such as materials, labor, and equipment. This approach enhances cost information sharing through a common platform, allowing contractors to quickly access project data and make informed decisions to manage both direct and indirect costs effectively. Lean construction also involves continuous cost monitoring, adjusting for deviations in capital expenses in real-time, which supports accurate cost accounting and efficient resource use. By coordinating the entire cost management process, lean construction ensures that materials, funds, and labor are allocated as needed, reducing waiting time and enhancing work reliability, ultimately minimizing waste in both direct and indirect costs across each project

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stage (Kejun, 2022).

Analysis of Cost Structure Epc Construction Project

Cost efficiency in construction projects is generally defined as the ability to achieve desired project outcomes at the lowest possible cost, without compromising quality. In quantitative terms, true cost efficiency is measured as the ratio of output to input (e.g., MW built per dollar, tons processed per dollar). However, due to the lack of output data in this study, the analysis focuses on the cost structure, specifically the proportion of direct and indirect costs relative to total pre-construction costs.

$$Cost\ Efficiency = \frac{Output\ or\ Benefit}{Cost\ Incurred}$$

In EPC (Engineering, Procurement, and Construction) projects, direct costs are those directly attributable to project execution, such as materials, labor, and equipment. Indirect costs, by contrast, include overheads and administrative expenses necessary for project completion but not directly linked to construction activities. Understanding the allocation between these cost categories is essential for effective project management and financial planning.

The findings from this study indicate that, on average, direct costs constitute the majority of pre-construction expenditures in Indonesian EPC projects, with indirect costs forming a smaller but significant portion. A higher percentage of direct costs typically suggests that a larger share of the budget is allocated to productive project activities, which may reflect better cost management and resource utilization. However, it is important to note that a high direct cost ratio does not inherently equate to efficiency, it could also result from overspending on direct items. Therefore, the metric used in this study is best interpreted as a measure of cost structure or overhead intensity.

The analysis reveals notable patterns across project categories:

- Project Size: Project size in construction management refers to the scale of a project, typically measured by total contract value, budget, or resource requirements. Projects are often categorized as small, medium, large, or mega, with thresholds varying by context. For example, Flyvbjerg (2014) defines megaprojects as those costing more than US$1 billion, while other studies use lower thresholds for small and medium projects (Harrison, 2024).

- Industry Sector: Industry sector refers to the primary field or economic activity in which a construction project is undertaken. In construction, common sectors include residential, commercial, industrial, infrastructure, and institutional. Each sector has unique characteristics, regulatory requirements, and operational challenges (Foulkes, 2003).

- Geographic Location: Geographic location in construction refers to the physical site or region where a project is executed. This factor influences project planning, cost estimation, logistics, regulatory compliance, and resource availability. Location can be defined by coordinates, addresses, or broader regions (e.g., urban, rural, island, province) (Cagney, 2021).

- Remote Scale: Remote scale (or remoteness index) is a composite measure used to quantify the degree of remoteness of a project site. It typically incorporates factors such as distance to urban centers, access to infrastructure, transportation availability, communication networks, and service accessibility. Higher remoteness scores indicate greater logistical and operational challenges (Zangeneh, 2019).

In summary, understanding the distribution of direct and indirect costs during the pre-construction stage of EPC projects provides valuable insights for project stakeholders aiming to optimize resource allocation and improve financial planning. By systematically examining cost structures across different project sizes, industry sectors, geographic locations, and degrees of remoteness, this study highlights the importance of context-specific strategies in cost management. These findings can inform decision-making for investors, contractors, and project

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owners, supporting more effective budgeting and risk mitigation in future EPC projects. Continued research and refinement of cost analysis methods will further enhance the ability to achieve cost-effective outcomes in the dynamic landscape of construction project management.

METHODOLOGY

This study investigates the cost structure of direct and indirect costs during the pre-construction stage of EPC (Engineering, Procurement, and Construction) projects in Indonesia. The research is based on a dataset comprising 116 projects executed between 2020 and 2024, spanning the mining and data center sectors.

Project data were collected from completed EPC projects across Indonesia, with each project providing information on total cost, direct cost, and indirect cost during the pre-construction phase. Projects were categorized by:

- Industry sector (Mining & Data Center)
- Project size (Small: < $1M, Medium: $1–10M, High: $10–100M, Mega: > $100M)
- Geographic location (Java, Sulawesi & Maluku)
- Remote scale (an index reflecting remoteness, infrastructure access, and logistical complexity)

The primary metric analyzed is the cost structure, defined as the proportion of direct and indirect costs relative to total pre-construction costs. This approach provides insight into how resources are allocated before construction begins, but does not measure cost efficiency in terms of output per unit cost (e.g., MW built, tons processed). The study focuses on descriptive statistics, including averages and percentages, to summarize cost structures across categories.

Descriptive statistics (mean, percentage) are used to compare cost structures across project categories. No inferential statistical tests (e.g., ANOVA, regression) were applied in this study. Thus, observed differences between categories should be interpreted as indicative rather than statistically significant. The absence of inferential analysis is a limitation, and readers are cautioned against over-interpreting small differences, especially in categories with limited sample sizes.

Results are presented in tables summarizing the distribution of direct and indirect costs by project type, industry, location, and remote scale. All referenced figures and tables are included to ensure transparency and reproducibility.

A statistical analysis is used to determine the correlation between cost efficiency and project categories, including project size (Small, Medium, High, Mega) by comparing the direct and indirect cost percentages. This method will be applied to assess the proportion of direct and indirect costs across various types of EPC projects by analyzing historical data. It allows for a data-driven approach to estimate cost distribution, helping to identify patterns and trends in how costs are allocated. By comparing cost proportions across different project categories, such as data centers and mining, this analysis aims to highlight the distinct cost characteristics of each type. The conclusions drawn from these comparisons will provide valuable insights into the typical cost structures of EPC projects, supporting better cost management and decision-making in future projects (Zhao, Mbachu, & Domingo, 2017).

Data Analysis

In this context, cost structure refers to the proportion of direct and indirect costs to total costs in a project. A higher percentage of direct costs indicates that a larger portion of the budget is spent directly on project execution rather than on overhead or indirect expenses. This often reflects better cost management and resource utilization. Table 1 shows the data of projects for this study.

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Table 1 - Data of Projects

Project Categorized	Number of Projects	Total Cost (USD)	Average Direct Cost (%)	Average Indirect Cost (%)
- Type - Industry - Location - Remote Scale	116	$ 5,103,545,121	85.4%	14.6%

Total data project used for the research is 116 projects can be seen at Table 1, it's including mining (92 projects) and Data center (24 projects). The location of project based in Indonesia (Sulawesi, Java and Maluku) with each location has remote area scale. All project has range year construction at 2020 – 2024, with project types are mega project (> 100 million USD), high project (10-100 million USD), medium project (1-10 million USD) and small project (< 1 million USD). **Table *2*** - Summary Cost Structure by Types of ProjectsTable 2 shows the summary cost structure by types of projects.

Table 2 - Summary Cost Structure by Types of Projects

Project Type	Number of Projects	Total Cost (USD)	Average Direct Cost (%)	Average Indirect Cost (%)
Mega	13	$ 4,159,491,856	84.85%	15.15%
High	26	$ 851,956,302	84.01%	15.99%
Medium	22	$ 76,800,129	86.71%	13.92%
Small	55	$ 15,296,835	85.67%	14.33%

Figure 2 show the cost structure analysis categorized by types of projects.

Figure 3 – Cost Structure Analysis Categorized by Types of Projects.

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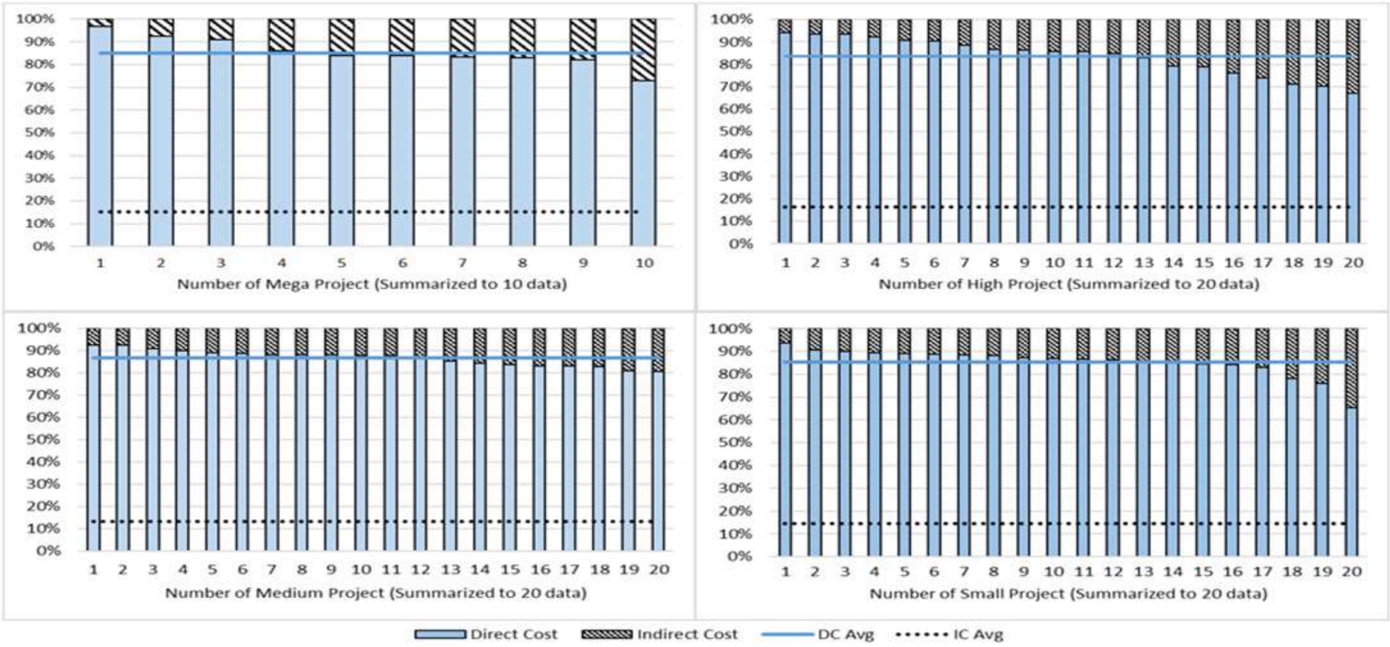

Based on the summary of data project types that show in Table 2 and Figure 2 medium and small projects have a relatively high average direct cost (86.71%) and indirect cost (13.92%), indicating good cost efficiency due to economies of scale. High Projects have a lower average direct cost percentage compared to Mega Projects, suggesting higher indirect costs and potentially less cost efficiency. Table 3 show the summary by industry of projects.

Table 3 - Summary by Industry of Projects

Project Industry	Number of Projects	Total Cost (USD)	Average Direct Cost (%)	Average Indirect Cost (%)
Mining	92	$ 2,948,892,073	86.01%	13.99%
Data Center	24	$ 2,154,653,048	83.74%	16.26%

Figure 4 – Cost Structure Analysis by Industry of Projects.

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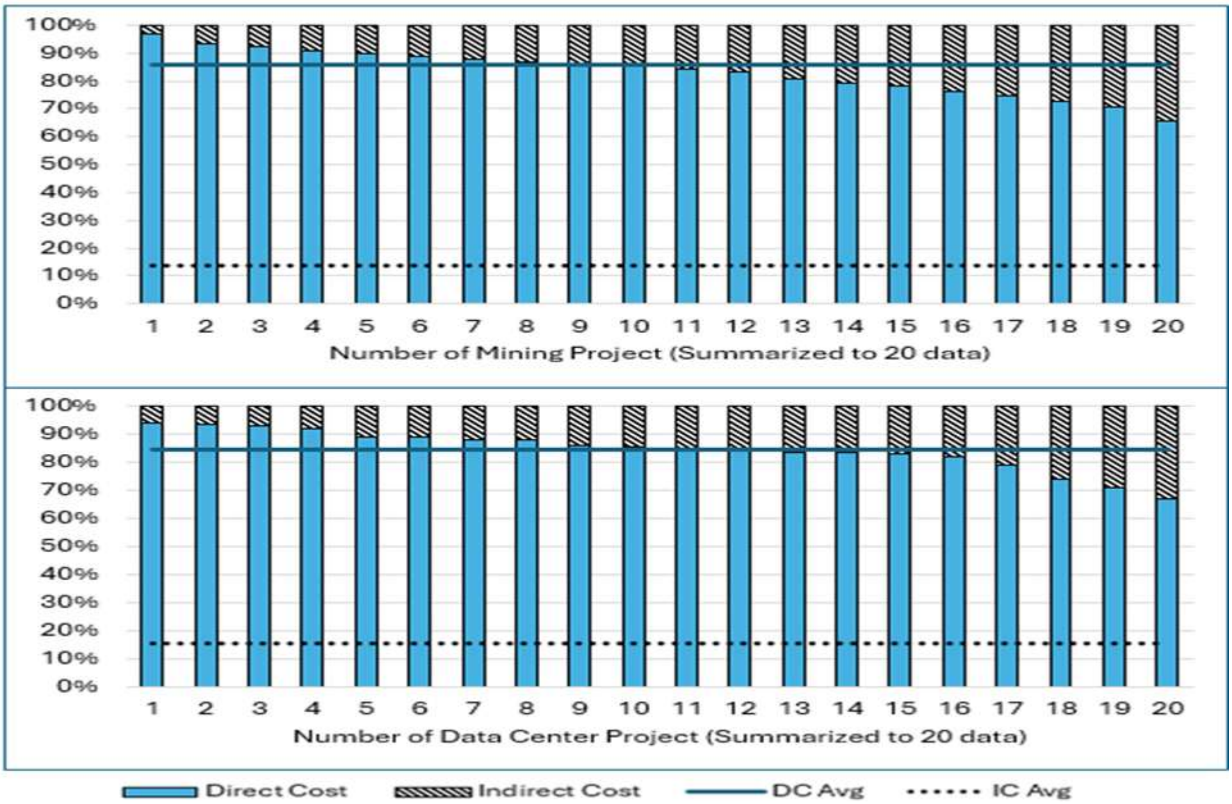

Based on the summary of data project industry that show in

Table **3**, showing the mining industry stands out with a high proportion of direct costs (86.01%) and relatively low indirect costs (13.99%), indicating strong cost management and operational efficiency. The data center industry has a reasonable direct cost percentage (83.74%) and indirect costs (16.26%).

Table 4 show the summary by location of projects.

Table 4 - Summary by Location of Projects

Project Location	Number of Projects	Total Cost (USD)	Average Direct Cost (%)	Average Indirect Cost (%)
Java	59	\$ 2,297,302,587	85.72%	14.28%
Maluku	10	\$ 259,539,215	82.70%	17.30%
Sulawesi	47	\$ 2,546,703,318	85.78%	14.22%

Figure 5 – Cost Structure Analysis by Location of Projects

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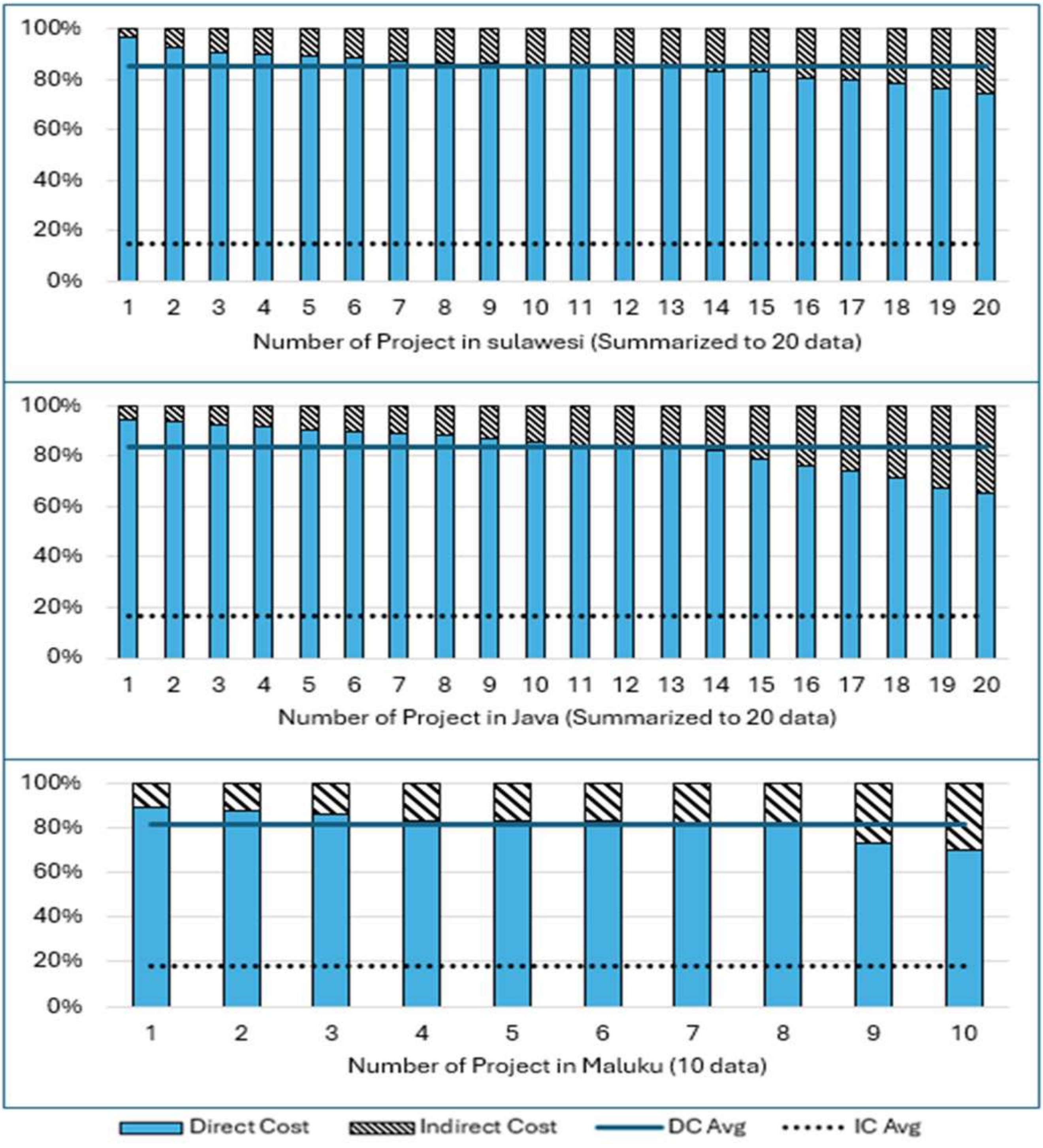

In terms of cost structure based on **Table 4**Table 4, Java and Sulawesi demonstrate the highest levels of direct cost, with the majority of expenses allocated to direct costs (85-86%). In contrast, Maluku, although managing fewer projects, exhibit higher proportions of indirect costs (17.30% respectively), suggesting a lower in controlling overhead costs.

Table 5 show the summary by remote scale of projects. Figure 5 show the cost structure analysis by remote scale of construction projects.

Table 5 - Summary by Remote Scale of Projects

Project Remote Scale	Number of Projects	Total Cost (USD)	Average Direct Cost (%)	Average Indirect Cost (%)

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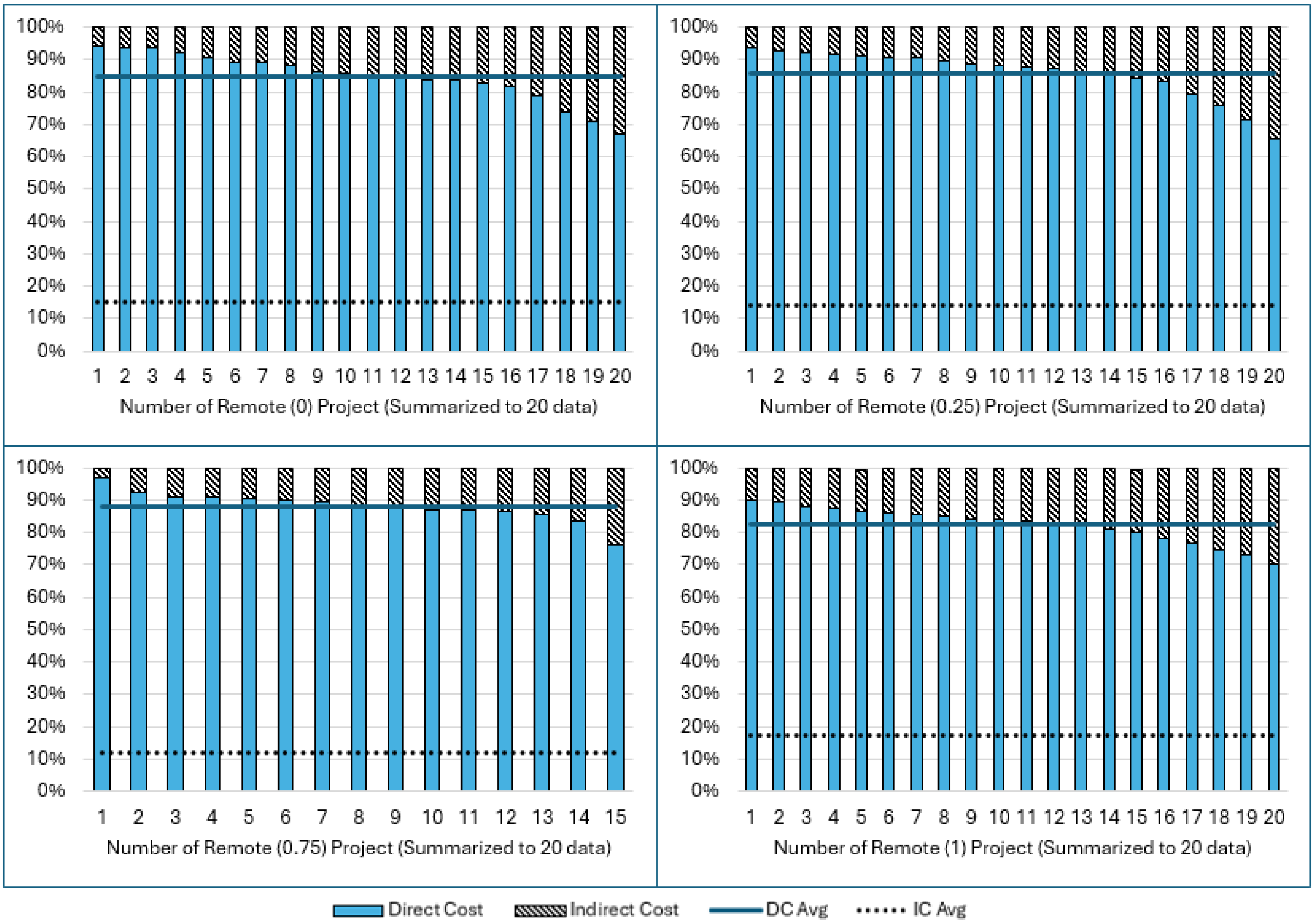
0	26	$ 2,197,843,885	84.21%	15.79%
0.25	34	$ 99,664,298	86.97%	13.03%
0.75	18	$ 2,420,389,781	87.90%	12.10%
1	38	$ 385,647,157	83.63%	16.37%

Figure 6 – Cost Structure Analysis by Remote Scale of Construction Projects



Based on the summary of remote scale projects that show in Table 5 and Figure 5, projects with a remote scale of 0.75 show the highest average direct cost percentage (87.90%) and the lowest average indirect cost percentage (12.10%). Projects with a remote scale of 0.25 exhibit the highest direct cost ratio (86.97%) and relatively low indirect costs (13.03%), which also points to efficient cost management, though slightly less efficient than the 0.75 remote scale projects. On the other hand, projects with a remote scale of 1 have the lowest direct cost percentage (83.63%) and the highest indirect cost percentage (16.37%), it happens because the location of project has more challenging than the other. The 0 scale projects also display a balanced direct cost percentage (84.21%) but with higher indirect costs (15.79%) than the 0.25-0.75 scale.

The classification of categorized remote scale can be seen in Table 6.

Table 6 – Classification of Remote Scale of Construction Projects From this Study

Project Remote Scale	**0**	**0.25**	**0.75**	**1**

Public Infrastructure	Complete	Moderate	Minimum	No Public Access
Distance to the city	< 50 km	> 50km-100km	100 - 200 km	>200 km
Access Transportation	Public	Public	Public Connect with private	Private
Flight	1	1	1 - 2	> 2
Communication	> 3 Provider	1 - 2 Provider	1 provider	Private provider
Social Issue	No Issue	Moderate	Minimum	With Officer Protection

Cost Management Principle to Mitigate Cost Efficiency and Minimize Cost Overruns of EPC Project

Based on the analysis for type projects categorized the project that has optimum direct cost is medium project with average direct cost (86.71%) and indirect cost (13.92%) this indicate in Indonesia project management approach commonly aligned with medium project. Mega and High project has average direct cost around (84.5%) and indirect cost (15.5%) that show estimating cost during preconstruction or tender stage for high and mega project is challenging in Indonesia.

Furthermore, for industry projects categorized the project that has optimum direct cost is Mining project with direct cost portion average (86%) and indirect cost average (14%). Data Center industry has a reasonable direct cost percentage (83.74%) but slightly higher indirect costs (16.26%) compared to Mining, suggesting potential areas for improving cost efficiency in managing administrative and overhead expenses. Overall, the Mining industry exhibits better than Data Center industries could benefit from optimizing indirect cost management.

On the other hand, for location project categorized Java and Sulawesi exhibit a high of direct cost, with the majority of project costs allocated to direct costs (85-86%), suggesting streamlined operations. However, Maluku despite having fewer projects, show higher indirect costs 17.30%, which could indicate less cost efficiency in managing overheads. Java and Sulawesi contribute to the largest total costs, while Maluku reflect smaller-scale projects with a higher proportion of indirect expenses, highlighting opportunities for improving cost efficiency in these regions.

In Indonesia, most skilled workers for construction projects come from Java, even if the project is located outside the island. The analysis shows that projects in Sulawesi have a direct cost average similar to those in Java. This suggests that Sulawesi follows a similar approach to managing and executing projects during the construction phase as Java does, even though they are in different locations.

As a result, for remote scale of project categorized a remote scale of 0.75 are the highest direct cost, exhibiting the highest direct cost average (87.90%) with the lowest indirect cost average (12.10%). This suggests an optimal allocation of resources, focusing on direct project expenses. Projects with a remote scale of 0.25 also demonstrate good direct cost management, though slightly less so than those with a 0.75 remote scale, with direct costs at (86.97%) and indirect costs at (13.03%). In contrast, projects with a remote scale of 1 face more challenges due to their location, resulting in the lowest direct cost percentage (83.63%) and the highest indirect cost percentage (16.37%). Projects with a 0 scale show a balanced direct cost percentage (84.21%) but have slightly higher indirect costs (15.79%) compared to the 0.25 scale projects.

In light of these findings, projects located in well-developed public infrastructure areas, close to cities, with full access to public transportation, and fewer social issues (reflected by a 0 remote scale) tend to have a larger proportion of indirect costs compared to projects with a 0.25 to 0.75 remote scale. This suggests that projects located in public/urban area, despite having easier access to resources and infrastructure, incur more complex overhead costs due to factors such as higher administrative demands, regulatory requirements, and coordination efforts. In contrast, projects in more remote areas, while logistically more challenging, may face simpler organizational structures and fewer bureaucratic hurdles, leading to a relatively lower share of indirect costs. Thus, the nature of the project's location plays a significant role in determining the complexity and scale of indirect costs. Overall, remote scale significantly impacts cost distribution, with the 0.75 scale projects.

Beside of the mitigate cost efficiency, cost overruns often occur in project implementation. Effective project management is essential for construction projects, as it aims to avoid or reduce various emerging risks, including optimizing direct costs to achieve project cost efficiency as per Rauzana (2022).

Cost overruns can occur in any phase of project development. The most common causes for cost overruns are: (Kerzner, 2017)

Proposal Phase

- Failure to understand customer requirements
- Unrealistic appraisal of in-house capabilities
- Underestimating time requirements

Planning Phase

- Inaccuracy of the work breakdown structure
- Omissions
- Misinterpretation of information (Risks, major cost element, etc)

Contractual Phase

- Proposal team different from project team
- negotiation team that must “win this one”
- Contractual discrepancies

Design Phase

- Accepting customer requests without approval
- Problems in design review meetings
- Problems in customer communications channels and data items

Procurement Phase

- Excessive material costs
- Long Lead Items miss arrived
- Manufacturing and engineering disagreement

Construction Phase

- Low Productivity
- Bad interface management between parties (GC/Subies/Owner/Consultant/etc)
- Miss sequence of critical activities

For future research, it would be valuable to compare the preconstruction data with the actual costs incurred during or after the construction phase. By analyzing this gap between estimated and actual costs, particularly for both direct and indirect expenses, deeper insights can be gained into cost efficiency and accuracy in budgeting. Such comparisons could reveal discrepancies that may arise due to unforeseen challenges during construction, such as changes in project scope, delays, or fluctuations in material costs as per Pujitha & Venkatesh (2020).

To advance the understanding of cost management in EPC construction projects, future research should conduct a longitudinal study comparing pre-construction cost estimates with final actual costs. This approach will enable a rigorous analysis of estimation accuracy and reveal the true drivers of cost overruns by tracking deviations across project phases and identifying where and why discrepancies arise. Additionally, the analysis of the "remote scale" can be deepened by developing a weighted, multi-criteria index that incorporates factors such as infrastructure availability, distance to urban centers, transportation access, communication networks, and social issues. Validating this index with empirical project data will provide a more nuanced understanding of how remoteness impacts both direct and indirect costs.

Furthermore, a detailed investigation into the specific components of indirect costs such as logistics, camp facilities, security, and administrative overhead will help clarify which elements most significantly contribute to cost increases in remote or complex projects. By disaggregating indirect costs and analyzing their behavior across different project contexts, stakeholders can develop targeted strategies to optimize cost efficiency and mitigate overruns.

Understanding these variances would allow for more precise cost estimation models and improve the accuracy of future cost predictions. Additionally, this analysis could uncover patterns that highlight areas for cost optimization and more effective resource allocation, ultimately leading to enhanced project management strategies and better cost control in future construction projects.

CONCLUSION

The analysis highlights several key insights regarding cost structure in various construction projects in Indonesia. Medium-scale projects are found to be the most direct cost efficient, with an optimal balance between direct costs average (86.71%) and indirect costs average (13.92%), indicating that the project management approach for medium projects is generally well-aligned with industry best practices. In contrast, mega and high-scale projects face greater challenges during the preconstruction and tender phases, as evidenced by the slightly lower direct cost percentage (84.5%) and higher indirect cost percentage (15.5%). These projects may struggle with accurate cost estimation due to their complexity and scale.

Among industry categories, the Mining sector stands out as the most direct cost efficient, with an average direct cost of (86%) and indirect costs of (14%). The Data Centre sector has a reasonable direct cost percentage (83.74%) but slightly higher indirect costs (16.26%), suggesting that there is room for improvement in managing overhead costs. Overall, the Mining sector demonstrates the best cost management, while Data Centre projects could benefit from better indirect cost optimization.

Geographically, Java and Sulawesi exhibit higher cost efficiency, with the majority of project costs allocated to direct expenses (85-86%). In contrast, Maluku have higher indirect cost percentages (17.30%), indicating inefficiencies in overhead cost management despite fewer projects in these regions. This highlights the need for improved cost management strategies in remote areas.

Additionally, the analysis of remote scale projects reveals that projects with a remote scale of 0.75 are the most direct cost efficient, with the highest proportion of direct costs (87.90%) and the lowest indirect costs (12.10%). In comparison, projects with a remote scale of 1 face more logistical challenges, resulting in higher indirect costs (16.37%). Projects located in well-developed urban areas (0 remote scale) tend to have higher indirect costs due to the complexity of managing regulatory requirements, administrative demands, and coordination efforts.

From the perspective of investors, contractors, and project owners, projects valued at less than 10 million USD are the most direct cost efficient in Indonesia, especially those located in Java or Sulawesi. The mining industry remains a popular sector for development in the country. Projects in remote areas with a remote scale of 0.25 to 0.75 tend to allocate direct costs more efficiently compared to projects in urban/industry areas (with a 0 scale remote area). Even though projects in Java with a 0 scale remote area have higher indirect costs, indicate remote area projects manage their indirect costs more effectively. Based on these findings, investors and project owners can use this information to make better decisions about which projects are likely to be the most cost-efficient in the cost structure.

In light of these findings, this analysis underscores the importance of location, project scale, and industry type in determining cost structure. Effective project management, especially in the preconstruction and tender stages, is crucial to minimizing cost overruns during construction phase. To enhance cost efficiency in the projects, we can focus on maximizing direct costs, ensuring that each expenditure directly contributes to productive work. Minimize indirect costs, particularly administrative or operational inefficiencies. Use benchmarking against similar projects to track efficiency improvements over time.

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