

ANALYSIS OF THE IMPACT OF COSTS ON THE TOTAL INVESTMENT AT CHỢ CỒN COMBINED APARTMENT AND SHOPPING MALL PROJECT

/ Ho Van Minh, Pham Phuong Nam, Nguyen Son Lam*

Abstract: The study analyzes the impact of costs on the total investment of Chợ Cồn combined apartment, and shopping mall project in Da Nang City, and figures out the correlation between costs, and total investment. This study also evaluates costs' impact on investment decisions, and proposes solutions to minimize risks, and optimize total investment. The research methods include risk assessment, sensitivity analysis, and correlation assessment between costs, and total investment. The results help project managers better understand the correlation between costs, and total investment, make effective decisions, and propose solutions to reduce risks, and optimize the project. The article also proposes specific solutions to ensure success, and sustainability for Chợ Cồn combined apartment, and shopping mall project. The results, and comments can be applied to similar construction projects, contributing to the development of the field of project management, and investment.

Keywords: Crystal Ball, correlation assessment, risk analysis, Monte Carlo, total investment.

Receive date: 20 January 2024, *Revise date:* 25 February 2024, *Accept date:* 27 March 2024

1. Raising the issue

In construction project research, many international, and domestic studies have focused on the impact of cost overruns on total investment. The paper "The Impact of Cost Overruns on Construction Projects: A Review of the Literature" by Khan, and colleagues [1] is a comprehensive work synthesizing studies on the impact of cost

overruns in global construction projects. However, this paper only focused on analyzing published studies without going into detail about influencing factors, and not mentioning measures to mitigate cost overruns. The study "The impact of cost overruns on construction projects in the United States" by Ford, and colleagues [2] focused on surveying the impact of cost overruns in construction projects in the United States. This paper reported research results on the level of cost overruns, and factors influencing cost overruns but did not mention measures to mitigate cost overruns. The study "The impact of cost overruns on construction projects in the United Kingdom" by Hillson, and colleagues [3] focused on studying the impact of cost overruns on construction projects in the United Kingdom. This paper provided research results on the level of cost overruns, and factors influencing cost overruns but did not discuss measures to mitigate cost overruns. Some domestic papers have also been conducted to understand better the correlation between cost factors, and total construction investment. Among these studies, three papers are notable. The paper "Đánh giá tác động của các yếu tố chi phí lên tổng mức đầu tư xây dựng công trình xanh" by Nguyễn Thị Thu Hương, and colleagues [4] examined all cost factors affecting total investment in green building construction. This paper used a scientific methodological approach combining theoretical, and empirical analysis to evaluate the impact of cost factors. The paper provides useful information for investors, project owners, and construction project managers of green buildings.

However, the scope of research was limited to green buildings in Vietnam, and was not compared with similar studies worldwide. The paper "Phân tích tác động của chi phí vật liệu lên tổng mức đầu tư xây dựng" by Nguyễn Thị Thu Thảo, and colleagues [5] focused on the impact of material costs on total construction investment. This paper used regression analysis methods, and actual data from construction projects in Vietnam. The research results showed that material costs have the greatest impact on total construction investment. However, the paper only considered the impact of material costs on total construction investment, and did not consider the impact of material costs on other factors of construction projects. The paper also did not propose solutions to mitigate the impact of material costs on total construction investment. The paper "Đánh giá tác động của chi phí nhân công lên tổng mức đầu tư xây dựng" by Nguyễn Thị Thu Hương, and colleagues [6] focused on the impact of labor costs on total construction investment. From these studies, it can be seen that the impact of cost overruns on total investment in construction projects is an important issue, and significantly affects the effectiveness, and success of projects. However, current research has not focused on a detailed analysis of influencing factors, and measures to mitigate cost overruns. Therefore, to achieve the research objective of the paper "Analyzing the impact between costs on a total investment of Chợ Cồn combined apartment, and shopping mall project", it is necessary to research factors, and measures related to cost overruns in construction projects.

*Faculty of Construction, Ho Chi Minh City University of Technology (HUTECH)
Email: phanminh017@gmail.com, pp.namqlxd@gmail.com, ns.lam@hutech.edu.vn

2. Determining the functions, and total investment construction cost of the project

Based on the locality's sustainable development requirements, and the area's actual needs, Chợ Cồn combined apartment, and shopping mall project was formed to meet the demand for quality living space, and comprehensive, convenient services for residents. This article aims to determine the detailed functions, and scales of the project's construction items, and the total estimated investment. This is an important basis for analyzing the impact of costs on the investment efficiency of the project, and proposing solutions to reduce risk to increase implementation effectiveness. The project is at 90 Hung Vuong Street, Hai Chau 1 Ward, Hai Chau District, Da Nang. Residential construction standards are determined according to Vietnamese standard No. 04:2021/BXD set by the Ministry of Construction. [7]. The project is divided into two main areas: the residential area, and the commercial, and service area. The residential area is designed as 12-22 stories high apartment blocks. The commercial, and service areas will be developed with supermarkets, shopping centers, dining areas, gardens,, and parking lots. Combining multiple functions aims to provide convenient, harmonious living environments for residents. The article will be divided into two parts. The first part will list the functions of each area of the project. The second part will estimate the total investment based on the project's technical specifications. The results will be used to analyze the impact of costs on the investment efficiency of the project.

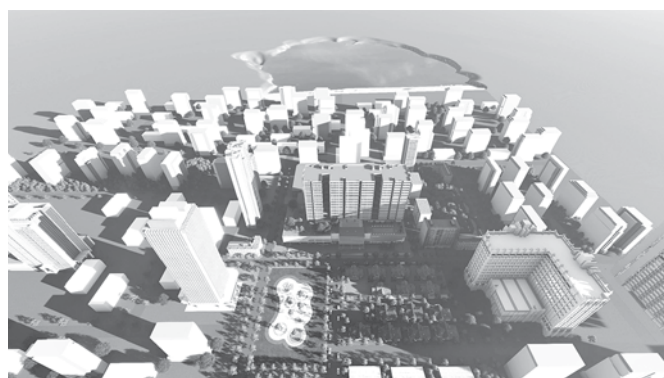


Figure 1 - Overview of residential complex combined with Chợ Cồn commercial center

2.1. Summary of project service functions.

Based on the thorough research of the detailed master layout drawings, this paper will conduct a comprehensive, and accurate analysis, and quantification of the planned functions to serve the project's overall goals. Specifically, the residential area is divided into three different types of apartments based on the bedroom criteria: one-bedroom, two-bedroom, and three-bedroom apartments. For each apartment type, the paper statistically enumerates the number of apartments, and determined the average suitable area. In addition, the commercial, and service area is divided into four main functional areas: supermarket area, food court, shopping area, and entertainment area. For each functional area, the paper also clearly provides the specific construction area allocated to each area (Table

2). Based on the above meticulous analysis, and quantification, this paper will summarize the total construction area of the entire project in detail.

Table 1. Statistical area of each room type by floor

Area	Total area (square meters)	Apartment type (square meters)				Public block (square meters)					
		Three bedroom unit one	Three bedroom unit two	Two bedroom unit one	Two bedroom unit two	Two-bedroom unit three	Commercial service area	Nu and y room area	Community activity area	Car park area	Ancillary area
Basement	21.780									18.200	3.580
Basement floor one	10.890									9.100	1.790
Basement floor two	10.890									9.100	1.790
Building tower block	91.648	7.552	6.048	4.128	12.240	2.752	30.503	300	233	-	27.620
Building base block	38.829	-	-				30.503	300	233	-	7.793
First-floor floor	10.100						9.247	300	233		220
Second-floor floor	6.066						5.125				940
Third floor	7.260						5.917				1.343
Fourth floor	6.762						5.953				809
Fifth floor	6.767						4.259				2.507
Sixth floor	1.874										1.874
Building tower block	52.819	7.552	6.048	4.128	12.240	2.752					19.827
Seventh floor	3.121	472	378	258	765	172					1.076
Eighth floor	3.121	472	378	258	765	172					1.076
Ninth floor	3.121	472	378	258	765	172					1.076
Twentieth floor	3.121	472	378	258	765	172					1.076
Twenty-first floor	3.121	472	378	258	765	172					1.076
Twenty-second floor	3.121	472	378	258	765	172					1.076
Rooftop floor	2.883										
Included in the service, and public trade coefficient	38.829										
Included in the housing coefficient	32.720										
Construction floors do not include basements	91.648										
Construction floors include basements	113.428										

2.2. Determining the total investment of the project

After analyzing, and determining the functional use of each area within Chợ Cồn combined apartment, and shopping mall project, along with the total construction area explained earlier, this section will present the process of determining the total investment based on the quantified technical specifications. Specifically, the project's total investment is divided into 7 main cost groups based on Circular No.11/2021/TT-BXD [8], including land cost, construction cost, equipment cost, project management cost, investment, and construction consulting cost, other costs, and contingency costs. Based on detailed design drawings, and cost estimates, the article estimated the specific figures for each cost group mentioned above, and summarized them in (Table 2).

Table 2. Summary of Total Construction Investment

No	Cost Item	Before-tax (billion VND)	Tax (billion VND)	After-tax (billion VND)	Symbol
Four	Project management cost[10]	13,06	0,14	13,20	G _{OLDA}
Five	Investment, and construction consulting cost [10], [11]	24,13	1,93	26,06	G _{IV}
Six	Other costs [12], [13], [14]	34,53	2,76	49,73	G _K
Seven	Contingency cost[8]	130,60	13,06	143,66	G _{DP}
	Total	2.661,55	241,63	2.888,62	V _{TM}

Continuing the presentation of the total construction investment of the Chợ Cồn mixed-use residential, and commercial center project in (Table 1), the article further supplements more detailed information about the investment cost structure by building two charts (Figure 2) (Figure 3).

The two charts (Figure 2) illustrate the percentage breakdown of the total investment allocation according to each cost group of the project, showing that land costs account for the largest proportion at 45.8%, of which construction costs account for approximately 39.86% of total cost, corresponding to Figure 3 which describes land costs more clearly at 1,323 billion VND, and construction costs of 1,151 billion VND. Using illustrative charts has helped readers easily grasp the project's cost structure visually, enabling them to assess the key cost factors that need attention to minimize project risks.

After determining, and summarizing the functional use, and construction area of the main components in the Chợ Cồn mixed-use residential, and commercial center project, the next step of the study is to determine the estimated total investment of the entire project. This provides a quantitative basis for evaluating the impact of cost factors on the total investment. Specifically, the total project investment is calculated based on the typical civil construction price list in Da Nang in 2024, and adjusted according to the region, and type of construction coefficients. For each major construction component, such as structure, infrastructure, fire prevention, and firefighting equipment, costs are calculated based on Table 2, and technical staff serve as the basis for cost analysis in subsequent sections. After noting the main contents in determining the project's total investment, the article will delve deeper into analyzing risks that may affect the total investment using the Monte Carlo simulation risk modeling software Crystal Ball[15]. Specifically, in this section, important variables affecting the total investment, such as material, labor, and construction costs, will have probability distributions constructed, and their impacts assessed through Monte Carlo simulation. This helps evaluate investment risks more comprehensively, proposing appropriate control measures to ensure the overall effectiveness of the project.

3. Risk analysis using Crystal Ball software

In this analysis, the author describes the process of analyzing project risks using Monte Carlo simulation tools in Crystal Ball [15] software. First, a mathematical model is built to reflect the relationship between main cost factors, and total investment by identifying variables, and probability distributions based on actual collected data. Next, the article will apply the Monte Carlo simulation algorithm in Crystal Ball to reproduce the probability distribution of the total investment based on the probabilistic fluctuations of risk factors. The simulation results will be evaluated to examine the volatility of the total investment, and the probability of exceeding the estimated cost in order to adjust more appropriate risk management measures for the project. Below are the parameters used as inputs for the Monte Carlo simulation (Table 3).

Table 3. Cost Parameters for Monte Carlo Simulation

No	Content	Content	Minimum 2%	Maximum 6%	Likeliest
One	Land cost	1.323	1.297	1.402	1.351
Two	Construction cost	1.151	1.128	1.220	1.151
Three	Equipment cost	182	178	193	182
Four	Project management cost	13	13	14	13
Five	Investment, and construction consulting cost	26	26	28	26
Six	Other costs	50	49	53	50
Seven	Contingency cost	144	141	152	144
	Total investment	2.889			2.889

3.1. Risk assessment

Variations in costs are an important factor affecting the initial estimated total costs in construction projects. In this study, the author analyzes project risks based on variations between costs, and their impact on total costs, and project stability, by applying Crystal Ball [15] software. The author uses historical data on cost variations ranging from 2% to 6% deviation, and applies the Monte Carlo simulation method to assess risks, and propose optimal solutions for the project.

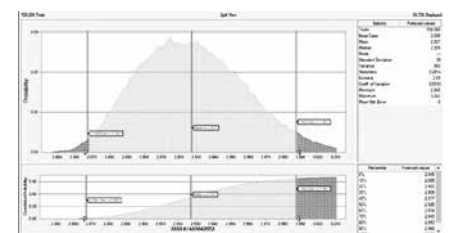


Figure 4 - Risk chart of Chợ Cồn Mixed-use Residential, and Commercial Center Project



Figure 2 - Chart analyzing investment costs (%)



Figure 3 - Chart showing investment cost breakdown (billion VND)

Based on the results of 100,000 Monte Carlo simulations with a 2-6% fluctuation range for cost factors in the investment effectiveness assessment model of the project, the paper collected, and summarized important statistical figures. Accordingly, the base case value of the model was determined to be 2,889 billion VND. The analysis showed that the average value of 100,000 simulations reached 2,927 billion VND, higher than the base value. The standard deviation was only 30 billion VND, reflecting that the level of fluctuation in the simulation results was within the 2-6% limit compared to the base value. The highest, and lowest values also fell within the forecast range. The above results indicate that the project is feasible, and effective when the risk from cost fluctuations is low.

3.2. Sensitivity analysis

Here, the author aims to analyze the sensitivity of each input cost factor to the total result, which is the project's total investment, through the Monte Carlo simulation method. Specifically, the paper will evaluate the impact of a single percentage (%) fluctuation on the three cost factors on the total investment value. By comparing the average value when costs change, the study can determine which factor has the strongest or weakest impact. The analysis results will be presented in tables, and charts, from which the risks of each cost group can be more accurately assessed when the project is implemented.

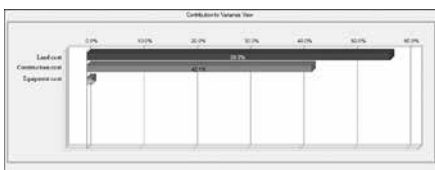


Figure 4 - Sensitivity chart of Chợ Côn Mixed-use Residential, and Commercial Center Project

Cost Factor	Assumptions	Contribution to Variance	Rank Correlation
Land cost		60.75%	0.74
Construction cost		42.10%	0.63
Equipment cost		15.25%	0.25

Figure 4 - Sensitivity data of the Chợ Côn Mixed-use Residential, and Commercial Center Project

Based on the results of implementing the Monte Carlo simulation, and

summarizing the overall results, the report further evaluates the sensitivity of each type of input cost to the final result, which is the project's total investment, through the data analysis provided. Specifically, the "ContributionToVariance" column shows the percentage contribution of each cost item to the variation (variance) of the total capital. The results show that land costs, and construction costs accounted for 56.9%, and 42.1% of fluctuations respectively, which are the two most influential factors. The "RankCorrelation" column analyzes the correlation relationship between cost fluctuations, and total capital fluctuations through the correlation coefficient. Therefore, land, and construction costs have a very strong positive linear correlation with total capital of 0.74, and 0.63, respectively. Thus, the above sensitivity analysis confirms that land, and construction costs play the most important role in influencing fluctuations in the project's total investment.

3.3. Correlation analysis

Following the previous sensitivity analysis of each input cost, section 3.3 evaluates the interactive relationships between these costs through statistical data processing methods. Specifically, the study will apply the Pearson correlation coefficient (r) to quantify the level of linear correlation between pairs of costs. The results will identify cost pairs with positive or inverse correlations, and evaluate correlation strength. Principal component analysis is also applied to explain the variation of total investment through the contribution of each cost factor. Assessing the relationships between costs will provide a scientific basis for evaluating the stability of the project when input factors fluctuate in different directions.

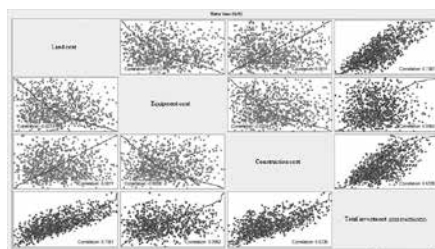


Figure 5 - Correlation chart of the Chợ Côn Mixed-use Residential, and Commercial Center Project

From the correlation chart, and analysis of the information presented in the figure, a clear correlation between cost items, and the project's total investment can be seen. In particular, land, and construction costs are determined to be the factors with the direct, and most important impact on total investment, accounting for 60-75% of total capital. This indicates that controlling land costs, and construction costs is very important, as fluctuations in them will directly impact the project's total budget. Secondly, equipment costs account for 15-25% of the total, in second place contributing to total investment. Fluctuations in these costs will also affect the total expenditure budget. Other costs still influence the total costs of the project. This shows that these costs have a linear correlation, and are dependent on each other. Strict control of the two largest cost items will make an important contribution to determining an effective investment option, and ensuring maintenance of the original capital level for the project.

4. Conclusions, and Recommendations

4.1. Conclusions

Through the process of researching, and applying statistical analysis methods, Monte Carlo simulation on Crystal Ball [15] software to evaluate the impact of cost factors on the total investment of the project, the study has come to the following main conclusions: Land cost, and construction cost are the two main cost factors that have the strongest influence on the total investment of the project, accounting for a large proportion, and having the highest level of fluctuation. These two costs have a very strong linear correlation with the total investment, with correlation coefficients of 0.74, and 0.63, respectively. The results of the Monte Carlo simulation show that the risk due to fluctuations in cost factors is within the allowable threshold, affirming the project's feasibility. In addition to the above conclusions, the study also drew the following additional points: Land, and construction costs have a strong impact on the total investment, and intersect very closely with each other. When one-factor

changes, it will lead to a change in the other factor. This requires strict control of both factors during project implementation. The Monte Carlo simulation method gives relatively stable results but only reflects a preliminary risk assessment. It is necessary to thoroughly study the cost factors, and project implementation stages to provide a more accurate risk assessment. The statistical analysis methods, and simulation methods applied in the study were preliminary, and need further development of research methods to evaluate the impact of costs on project investment effectiveness more comprehensively.

4.2. Recommendations

Based on the results of the analysis, and evaluations in this study, the author would like to put forward the following recommendations: It is necessary to develop strict control plans for land costs, and construction costs, the two main cost factors affecting the total investment. Applying measures such as contract adjustments, and strict monitoring of payment schedules... helps limit fluctuations in these two factors. Continue researching the interaction of land, and construction costs, analyzing the impact of fluctuations in one factor on the other to have appropriate response scenarios. Supplementing the content of assessing risks arising during project implementation will give a better basis for improving the risk management plan, and applying more advanced analytical methods to produce more accurate, and effective results in assessing the impact of costs on the degree of project success.

Based on the initial research results on evaluating the impact of costs on the total project investment, I propose some directions for further research to expand,

and deepen the issue: Conducting investigations, and field surveys of project owners, and construction contractors to collect more detailed data on fluctuations in factors affecting costs. Developing mathematical models that more clearly describe the intrinsic relationships between cost factors, and the project implementation process. Studying the evaluation of risk management effectiveness by comparing different cost control measures at actual projects. Applying advanced simulation methods such as dynamic system simulation to study the long-term impacts of risks. Expanding the scope of research to other construction investment sectors such as transportation, energy...

Luong Tra (BD)

References:

[1] A. I. M. A., and M. A. Asif Khan, "The impact of cost overruns on construction projects: A literature review," *Construction Engineering, and Management*, 2022.

[2] C. W. I., and T. D. K. James A. Ford, "The impact of cost overruns on construction projects in the United States," *Construction Engineering, and Management*, 2008.

[3] J. K., and P. H. David Hillson, "The impact of cost overruns on construction projects in the United Kingdom," *Management, and Economics*, 2003.

[4] T. T. T. Nguyễn Thị Thu Hương, "Đánh giá tác động của các yếu tố chi phí lên tổng mức đầu tư xây dựng công trình xanh," *Công nghệ Xây dựng*, 2022.

[5] N. T. T. H. Nguyễn Thị Thu Thảo, "Phân tích tác động của chi phí vật liệu lên tổng mức đầu tư xây dựng," *Khoa học và Công nghệ Xây dựng*, 2022.

[6] N. T. T. T. Nguyễn Thị Thu Hương, "Đánh giá tác động của chi phí nhân công

lên tổng mức đầu tư xây dựng," *Khoa học và Công nghệ Xây dựng*, 2022.

[7] Bộ Xây dựng, "Quy chuẩn kỹ thuật quốc gia về nhà chung cư," Việt Nam, Dec. 2021.

[8] Bộ Xây dựng, "Hướng dẫn một số nội dung xác định và Quản lý chi phí Đầu tư Xây dựng," Việt Nam, 11/2021/TT-BXD, Aug. 2021.

[9] Bộ Xây dựng, "Công bố suất vốn đầu tư xây dựng công trình và giá xây dựng tổng hợp bộ phận kết cấu công trình năm 2022," Việt Nam, 510/QĐ-BXD, May 2023.

[10] Bộ Xây dựng, "Ban hành định mức Xây dựng," Việt Nam, 12/2021/TT-BXD, Aug. 2021.

[11] Chính phủ, "Quy định chi tiết thi hành một số điều của Luật Đấu thầu về lựa chọn nhà thầu," Việt Nam, 63/2014/NĐ-CP, Jun. 2014.

[12] Bộ Tài chính, "Hướng dẫn thực hiện một số điều của Nghị định số 119/2015/NĐ-CP ngày 13 tháng 11 năm 2015 của Chính phủ quy định bảo hiểm bắt buộc trong hoạt động đầu tư xây dựng và Nghị định số 20/2022/NĐ-CP ngày 10 tháng 3 năm 2022 sửa đổi, bổ sung một số điều của Nghị định số 119/2015/NĐ-CP ngày 13 tháng 11 năm 2015 của Chính phủ quy định bảo hiểm bắt buộc trong hoạt động đầu tư xây dựng," Việt Nam, 50/2022/TT-BTC, Aug. 2022.

[13] Bộ Tài chính, "Quy định mức thu, chế độ thu, nộp, quản lý và sử dụng phí thẩm định dự án đầu tư xây dựng," Việt Nam, 28/2023/TT-BTC, May 2023.

[14] Bộ Tài chính, "Quy định mức thu, chế độ thu, nộp, quản lý và sử dụng phí thẩm định thiết kế kỹ thuật, phí thẩm định dự toán xây dựng," Việt Nam, 27/2023/TT-BTC, May 2023.

[15] Decisioneering, "Crystal Ball." 1997.

