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DEVELOPMENT OF FEASIBILITY ANALYSIS MODEL FOR DEVELOPER-REQUESTED HOUSING PROJECTS

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ABSTRACT: While many studies on feasibility analysis for housing projects have been released, the main focus was on economic feasibility and factors related to developers were not clearly identified enough to be used in practice. In order to establish a feasibility analysis model for apartment development projects requested by developers in Korea, 31 driving factors behind projects' success were identified under seven different categories. Criterions of the each factor were also developed, and weight of each factor was assigned by applying the Analytical Hierarchy Process(AHP). Finally, based on the Monte Carlo simulation, the feasibility analysis model was established, providing probability distribution of project's grade. The model was applied to 12 housing projects to verify its reliability, and found that the model properly filtered projects that are unlikely to be profitable, indicating reasonable reliability of the model. The model can be a useful tool for contractors, especially with less experience in analyzing project development feasibility.

Keywords: Housing Development Project, Feasibility Analysis, Factor, Criterion, Analysis Model

1. INTRODUCTION

Due to current construction industry recession in Korea, many construction companies are increasingly promoting housing development projects by themselves. However, housing projects requested by developers still take a large portion. When construction companies and developers proceed housing projects, feasibility analysis is the most crucial for project success. Some large companies have been using their own analysis models to control project-related risks. However, most companies have no enough ability to analyze feasibility and heavily relied on information from developers as well as decision-maker's experience and intuition. Therefore feasibility analysis model, which helps construction companies examine whether they accept orders or not, highly needs to be developed.

This study identified factors behind success of housing development project and established quantitative criterions for each factors to develop a feasibility analysis model which will facilitate main contractors to make right decisions on projects requested by developers. The followings are main procedures of this study.

(1) Review previous studies related to feasibility analysis.
(2) Identify driving factors in the developer-requested housing development project and establish quantitative criterions for each factor.
(3) Calculate weight of each factor by the AHP(Analytic Hierarchy Process) and develop the feasibility analysis model based on the Monte Carlo Simulation.
(4) Apply developer-requested housing development projects completed to the model to verify its reliability.

2. LITERATURE REVIEW

2.1 Feasibility Analysis

Feasibility analysis is to assess possibility of a project execution, including technical possibility, financial feasibility and various social factors. Because outcomes by the construction development are very massive both in scale and investment, it is impossible for them to be revised and redeveloped. In other word, problems occurring in early phase could be easily settled, but those in late phase are hard to be solved and require many efforts and funds. This is why feasibility analysis in the planning phase is very crucial in construction development.

2.2 Previous Studies

Kang mi-seon(1997) suggested a feasibility analysis model based on concept of overall benefit which including social value as well as financial profit. Jeong kyung-hoon(2001) identified factors in a feasibility analysis and examined the correlation between them to establish analysis process model based on the IDEF0 modeling. Joo jae-young(2002) found main factors affecting urban redevelopment projects and suggested objective decision-making method by analyzing project process. Yun seok-heon(2003) identified major categories which have influence on cost of construction development projects and analyzed the change of earning rate with time-based technique. Shin woo-shik(2005) divided analysis factors into qualitative and quantitative ones and calculated weight of quantitative ones by means of survey. He also established criterions of quantitative factors to develop the feasibility analysis model for housing development projects.

3. Research Methodology

3.1 AHP(Analytic Hierarchy Process)

The AHP(Analytic Hierarchy Process) is a structured technique for helping people deal with complex decisions. Decision makers systematically evaluate various elements, comparing them to one another in pairs. In making the comparisons, the decision makers can use concrete data about the elements, or they can use their judgments about the elements' relative meaning and importance. The AHP converts these evaluations to numerical values that can be processed and compared over the entire range of problems.

3.2 Monte Carlo Simulation

The Monte Carlo methods are a class of computational algorithms that rely on repeated random sampling to compute their results. Because of their reliance on repeated computation and random or pseudo-random numbers, they are most suited to calculation by a computer. Monte Carlo simulation methods are especially useful in studying systems with a large number of coupled degrees of freedom, such as fluids, disordered materials, strongly coupled solids, and cellular structures. More broadly, the Monte Carlo methods are useful for modeling phenomena with significant uncertainty in inputs, such as the calculation of risk in business.

4. Feasibility Analysis Factors and Criterions

In order to establish factors and criterions for each factor, a total of 5 expert meetings were held and factors from previous studies were discussed and assessed. The member of the experts includes one development company representative director and five construction company employees who have more than 15-year experience in development-related work. In the first meeting, the process and major considerations of housing development projects were discussed. In second, third and fourth meetings, factors and criterions were selected and revised to their improvement. In fifth meeting, the final factors and criterions were established.

Table 1. Summary of the expert meetings

	Summary
1st	The process of housing development projects (Figure 1), Major considerations in projects
2nd	Review of analysis factors from previous studies, Establishment of preliminary factors, Setting guidelines of the criterion development
3rd	Review of 2nd meeting, Improvement of analysis

	factors, Establishment of criterions
4th	Review of 3rd meeting, Improvement of analysis factors and criterions
5th	Establishment of final analysis factors and criterions

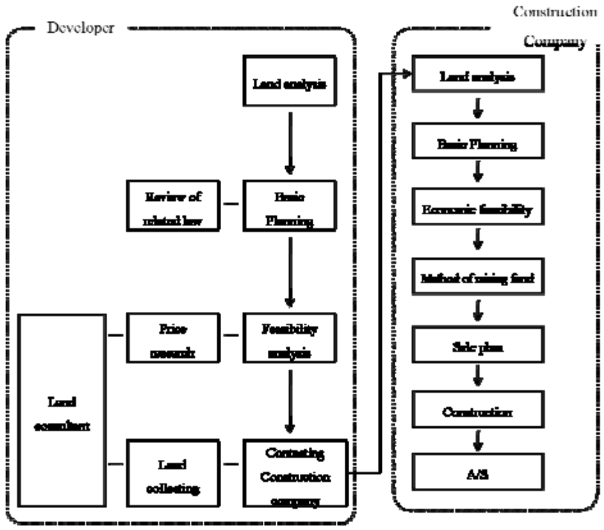


Figure 1. Process of housing development projects

4.1 Analysis Factors

Expert meetings recognized that factors from previous studies have been rarely used in practice, because they were overly break-downed and researched only in theoretical process. In this study, therefore, the factors subdivided in the past studies were merged to their simplicity to easily and synthetically evaluate them.

Also, related studies suggested the discounted cash flow method using NPV and IRR, but because housing development projects are completed in short term period, considering discount rate is not necessarily needed. Hence, the non-discounted cash flow method was applied to this research.

Meanwhile, the previous studies lacked researches on methods of raising fund, contracting type, developer-related factors. Therefore, this study newly included a few factors such as 'method of raising fund', 'contracting type' and 'developer', and the factors of previous studies were reclassified and unified with those factors according to the project process to establish the feasibility analysis factors(table 2).

Table 2. Feasibility analysis factors

Level 1	Level 2	Level 3
1. Project site	1.1 Land condition	1.1.1 Land shape
		1.1.2 View
		1.1.3 Daylight
		1.1.4 Ground condition
	1.2 Site utility	1.2.1 Residential environment
		1.2.2 Transportation
		1.2.3 Education facility
		1.2.4 Convenient facility
2. Basic Planning	2.1 Architectural planning	2.1.1 Floor planning
		2.1.2 Site planning
		2.1.3 Exterior
		2.1.4 Floor area ratio
	2.2 Project preparation period	
	2.3 Policy	2.3.1 Housing policy
		2.3.2 Land policy
		2.3.3 Finance policy
3. Economic feasibility	3.1 Cash-Flow	
	3.2 Gross profit margin (construction company)	
	3.3 Gross profit margin (developer)	
4. Salability	4.1 Development environment	
	4.2 Price	
	4.3 Brand value	
	4.4 Specialty	4.4.1 Interior
		4.4.2 Exterior
		4.4.3 Landscape
		4.4.4 Community facility
5. Method of raising fund		
6. Method of contracting		
7. Developer	7.1 number of conducting projects	
	7.2 Land collection	
	7.3 Authorization condition	

4.2 Establishment of the criterions

The criterions as well as the analysis factors were established in the expert meetings(table 3). The differences in score between contiguous levels were set differently because factors which have negative effects on projects had better be assessed to much lower score to surely filter projects unprofitable(Shin woo-shik). The criterions make each factor be scored easily and the criterion for 'the number of conducting projects' is exemplified in table 4.

Table 3. Criterion structure

Level	Score	Criterion
A	10	1. According to the criterion of each factor 2. Assume probability distribution of score based on the criterion of each factor
B	9	
C	7	
D	4	
E	0	

Table 4. Criterion for the number of conducting projects

Analysis Factor	Condition	Level	Score
the number of conducting projects (7.1)	More than 3	A	10
	More than 1	C	7
	0	E	0

5. Development of the feasibility analysis model

In order to develop the feasibility analysis model, the factors and criterions were established in several expert meetings. Meanwhile, each factor has deferent impact on project feasibility and it is unreasonable to evaluate each factor in same condition. Therefore, to calculate weight of the factors, experts' opinions were converged and converted into the value of weight by using the AHP. Finally, based on the Monte Carlo method(using Crystal Ball 7 software), the feasibility analysis model was finally developed.

5.1 Calculation of the weights by using AHP

To calculate the weight of the each factor, experts participating in establishing analysis factors and criterions converged their opinions and compare factor on the same level in pairs according to the criterion of importance comparison in pairs(table 5).

Table 5. Criterion of importance comparison in pairs

important <--------				equally important	--------> important			
5	4	3	2	1	2	3	4	5

Table 6 shows the comparison in pairs of level 1 factors by the experts and this was converted into the value of weight of level 1 factors(table 7). Factors such as 'Salability' and 'Economic feasibility' were analyzed to have high weight compared with other factors.

Table 6. Comparison in pairs of level 1 factors

	Project site	Basic Planning	Economic feasibility	Salability	Method of raising fund	Method of contracting	Developer
Project site	1	2	1/2	1/2	1	3	3
Basic Planning	1/2	1	1/2	1/3	1/2	2	2
Economic feasibility	2	2	1	1/2	2	3	3
Salability	2	3	2	1	2	5	5
Method of raising fund	1	2	1/2	1/2	1	3	3
Method of contracting	1/3	1/2	1/3	1/5	1/3	1	1/2
Developer	1/3	1/2	1/3	1/5	1/3	2	1

Table 7. Weights of level 1 factors

	Project site	Basic Planning	Economic feasibility	Salability	Method of raising fund	Method of contracting	Developer
weight	0.149	0.092	0.206	0.296	0.149	0.049	0.059

Also, the factors of level 2 and level 3 were compared in pairs and each weight were calculated(table 8).

Table 8. Weights of level 1, 2, 3 factors

Level 1	Weight	Level 2	Weight	Level 3	Weight
1. Project site	**0.149**	1.1 Land condition	**0.333**	1.1.1 Land shape	**0.163**
				1.1.2 View	**0.363**
				1.1.3 Daylight	**0.326**
				1.1.4 Ground condition	**0.148**
		1.2 Site utility	**0.667**	1.2.1 Residential environment	**0.397**
				1.2.2 Transportation	**0.232**
				1.2.3 Education facility	**0.232**
				1.2.4 Convenient facility	**0.139**
2. Basic Planning	**0.092**	2.1 Architectural planning	**0.626**	2.1.1 Floor planning	**0.294**
				2.1.2 Site planning	**0.183**
				2.1.3 Exterior	**0.106**
				2.1.4 Floor area ratio	**0.417**
		2.2 Project preparation period	**0.238**		
		2.3 Policy	**0.136**	2.3.1 Housing policy	**0.540**
				2.3.2 Land policy	**0.163**
				2.3.3 Finance policy	**0.297**
3. Economic feasibility	**0.206**	3.1 Cash-Flow	**0.194**		
		3.2 Gross profit margin (construction company)	**0.496**		
		3.3 Gross profit margin (developer)	**0.310**		
4. Salability	**0.296**	4.1 Development environment	**0.246**		
		4.2 Price	**0.299**		
		4.3 Brand value	**0.209**		
		4.4 Specialty	**0.246**	4.4.1 Interior	**0.456**
				4.4.2 Exterior	**0.141**
				4.4.3 Landscape	**0.141**
				4.4.4 Community facility	**0.263**
5. Method of rasing fund	**0.149**				

Level 1	Weight	Level 2	Weight	Level 3	Weight
6. Method of contracting	**0.049**				
7. Developer	**0.059**	7.1 number of conducting projects	**0.162**		
		7.2 Land collection	**0.491**		
		7.3 Authorization condition	**0.347**		

5.2 Development of Feasibility Analysis Model

The feasibility analysis model developed in this study draws not a single score but a score probability distribution through the Monte Carlo simulation. This is to provide decision-makers comprehensive information to make a reasonable judgment. The weight of each level factors shown in table 8 were substituted for the formula 5.1, drawing the weight of the evaluating factors.

Weight of evaluation factor
= weight of level 1 × weight of level 2 ×
weight of level 3 × 10 (Formula 5.1)

For example, the weight of the evaluation factor such as ‘Land Shape’ was calculated by multiplying the weight of ‘Project site’ by ‘Land condition' by ‘Land shape’ by 10. The reason why it is multiplied by 10 is to make the perfect evaluation score 100points.

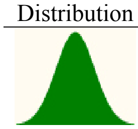
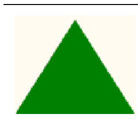
Table 9 is the feasibility analysis model suggested in this study and according to the each criterion, each evaluation factor is to be scored. The score of evaluation factor can also be assumed in probability distribution (table 10) according to project’s condition. Based on inputted probability distribution data of each evaluation factor, The Monte Carlo simulation program conducts random sampling, and sample of each evaluation factor is multiplied by each weight and the results are added together to present total score. The feasibility analysis model repeats this process for 5,000 times to giving the probability distribution of total score(figure 2).

Table 9. Feasibility analysis model

Level 1	Level 2	Level 3	weight	Probability distribution					
				Distribution	Mean or score	Standard deviation	Min	Likeliest	Max
1. Project site	1.1 Land condition	1.1.1 Land shape	**0.081**						
		1.1.2 View	**0.180**						
		1.1.3 Daylight	**0.162**						
		1.1.4 Ground condition	**0.073**						
	1.2 Site utility	1.2.1 Residential environment	**0.395**						
		1.2.2 Transportation	**0.231**						
		1.2.3 Education facility	**0.231**						
		1.2.4 Convenient facility	**0.138**						
2. Basic Planning	2.1 Architectural planning	2.1.1 Floor planning	**0.169**						
		2.1.2 Site planning	**0.105**						
		2.1.3 Exterior	**0.061**						
		2.1.4 Floor area ratio	**0.240**						
	2.2 Project preparation period		**0.219**						
	2.3 Policy	2.3.1 Housing policy	**0.068**						
		2.3.2 Land policy	**0.020**						
		2.3.3 Finance policy	**0.037**						
3. Economic feasibility	3.1 Cash-Flow		**0.400**						
	3.2 Gross profit margin(construction company)		**1.022**						
	3.3 Gross profit margin(developer)		**0.639**						
4. Salability	4.1 Development environment		**0.728**						
	4.2 Price		**0.885**						
	4.3 Brand value		**0.619**						

Level 1	Level 2	Level 3	weight	Probability distribution: Distribution	Mean or score	Standard deviation	Min	Likeliest	Max
	4.4 Specialty	4.4.1 Interior	**0.332**						
		4.4.2 Exterior	**0.103**						
		4.4.3 Landscape	**0.103**						
		4.4.4 Community facility	**0.192**						
5. Method of rasing fund			**1.490**						
6. Method of contracting			**0.490**						
7. Developer	7.1 Number of conducting project		**0.096**						
	7.2 Land collection		**0.290**						
	7.3 Authorization condition		**0.205**						

Table 10. Probability distributions

Distribution	Conditions	Applications
 normal	- Mean value is most likely. - It is symmetrical about the mean. - More likely to be close to the mean than far away.	Natural phenomena.
 triangle	- Minimum and maximum are fixed. - It has a most likely value in this range, which forms a triangle with the minimum and maximum.	When you know the minimum, maximum, and most-likely values, useful with limited data.
 uniform	- Minimum is fixed. - Maximum is fixed. - All values in range are equally likely to occur.	When you know the range and all possible values are equally likely.

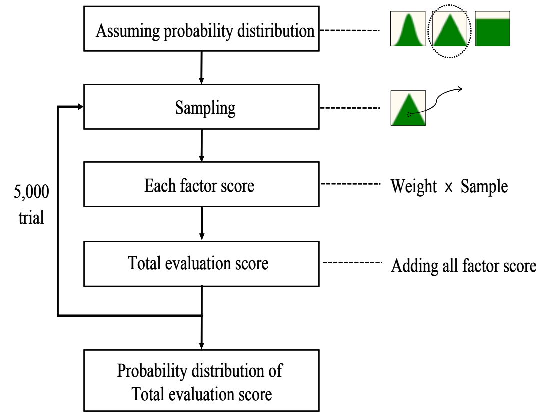


Figure 2. Simulation process of the model

6. Reliability Verification

6.1 Projects Selection

To verify reliability of the feasibility analysis model, 12 housing projects, seven for successful projects and five for abandoned projects, in Youngnam region conducted by B construction company were selected, applied to the model and assessed by means of the Monte Carlo simulation, drawing the probability distribution of total score.

6.2 Projects Assessment

Based on the criterions, the feasibility analysis model assessed 12 projects by Monte Carlo simulation. For more precise assessment, three experts with more than 15-year experience converged their opinions to input score or probability distribution of the evaluation factor and Table 11 shows inputted data of P1. After 5,000 times simulation, the model gave each project's statistical values and the probability distribution of total score. Table 12 is statistical values of 12 projects, showing that P1 has the highest mean value with 83.13 points and P12 has the lowest mean value with 57.76 points. Figure 3 is the 12 projects' probability distribution of total score, presenting probability and frequency of total scores.

Table 11. Inputted data of P1
∩: normal ∧: triangle ⊓: uniform

Level 1	Level 2	Level 3	Weight	Probability distribution: Distribution	Mean or score	Standard deviation	Min	Likeliest	Max
1. Project site	1.1 Land condition	1.1.1 Land shape	**0.081**	∧	-	-	4	7	9
		1.1.2 View	**0.180**	∧	-	-	7	9	10
		1.1.3 Daylight	**0.162**	∧	-	-	7	9	10
		1.1.4 Ground condition	**0.073**	∧	-	-	0	4	4
	1.2 Site utility	1.2.1 Residential environme	**0.395**	-	4	-	-	-	-

Level 1	Level 2	Level 3	Weight	Probability distribution					
				Distribution	Mean or score	Standard deviation	Min	Likeliest	Max
		nt							
		1.2.2 Transportation	**0.231**	-	7	-	-	-	-
		1.2.3 Education environment	**0.231**	-	7	-	-	-	-
		1.2.4 Convenient facility	**0.138**	-	9	-	-	-	-
2. Basic Planning	2.1 Architectural planning	2.1.1 Floor planning	**0.169**	∩	9	2	-	-	-
		2.1.2 Site planninh	**0.105**	∩	7	2	-	-	-
		2.1.3 Exterior	**0.061**	∩	7	2	-	-	-
		2.1.4 Floor area ratio	**0.240**	-	9	-	-	-	-
	2.2 Project preparation period		**0.219**	∧	-	-	9	10	10
	2.3 Policy	2.3.1 Housing policy	**0.068**	∧	-	-	5	7	9
		2.3.2 Land policy	**0.020**	∧	-	-	5	7	9
		2.3.3 Finance policy	**0.037**	∧	-	-	5	7	9
3. Economic feasibility	3.1 Cash-Flow		**0.400**	∩	10	1	-	-	-
	3.2 Gross profit margin(construction company)		**1.022**	∩	7	2	-	-	-
	3.3 Gross profit margin(developer)		**0.639**	∩	10	1	-	-	-
4. Salability	4.1 Development environment		**0.728**	∧	-	-	0	4	7
	4.2 Price		**0.885**	∩	7	2	-	-	-
	4.3 Brand value		**0.619**	-	9	-	-	-	-
	4.4 Specialty	4.4.1 Interior	**0.332**	∩	9	1	-	-	-
		4.4.2 Exterior	**0.103**	∩	9	1	-	-	-
		4.4.3 Landscape	**0.103**	∩	9	1	-	-	-
		4.4.4 Community facility	**0.192**	∩	7	2	-	-	-
5. Method of rasing fund			**1.490**	-	10	-	-	-	-
6. Method of contractin			**0.490**	-	10	-	-	-	-
g									
7. Developer	7.1 Number of conducting project		**0.096**	-	10	-	-	-	-
	7.2 Land collection		**0.290**	-	10	-	-	-	-
	7.3 Authorization condition		**0.205**	-	10	-	-	-	-

Table 12. Statistics

	Mean	Median	Maximum	Minimum	Standard deviation
P1	83.18	83.30	72.51	91.05	2.76
P2	78.07	78.07	68.42	88.16	2.92
P3	76.89	76.96	68.06	84.16	2.40
P4	74.31	74.30	64.54	84.98	2.86
P5	85.93	85.98	79.74	91.71	1.78
P6	76.15	76.23	64.74	85.44	2.92
P7	68.82	68.92	56.93	78.63	3.25
P8	58.30	58.32	45.07	68.41	3.27
P9	59.23	59.21	49.60	68.21	2.72
P10	58.33	58.30	48.16	70.22	2.88
P11	57.89	57.93	48.12	66.71	2.59
P12	57.76	57.77	48.50	65.65	2.49

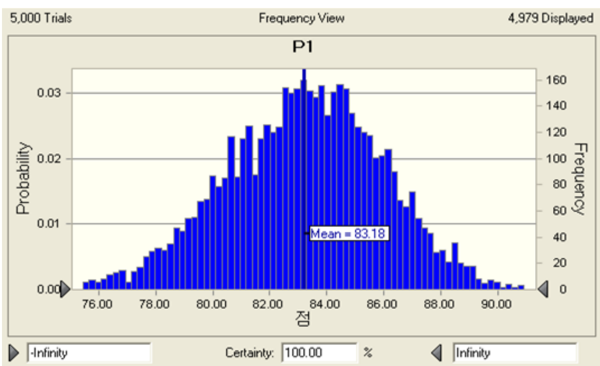


Figure 3. Probability distribution of total score(P1)

6.3 Assessment Result

Twelve projects selected were accessed by the model, showing all projects had normal distribution in the probability distribution of total evaluation score. Projects completed successfully had total evaluation scores from 69 to 86 (mean value) and projects abandoned had average 20 lower scores than successful projects, ranging from 58 to 59. Figure 4 is overlay chart of the 12 projects, showing that distributions of projects completed are clearly separated from those of projects abandoned at approximately 64 points.

Officials from construction companies express positive opinions on the model, and evaluate that the analysis factors were well categorized in practice and the model would be a useful tool for construction companies with less project experiences. Also, because the model gives not a single total evaluation value but probability distributions, it helps decision-makers to consider risks. Officials said, however, in order to increase its practical use and improve its reliability, more projects of other construction companies should be evaluated by the model and more quantitative criterions should be established to assess some qualitative analysis factors more easily and objectively.

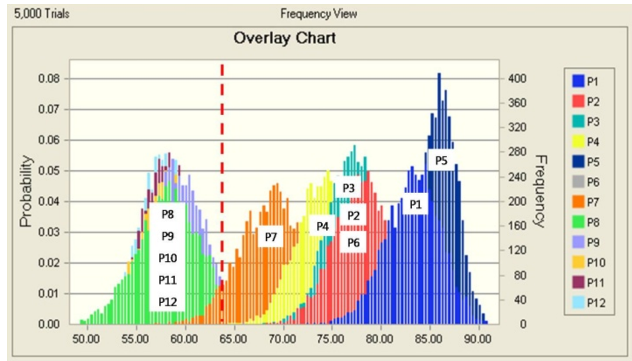


Figure 4. Overlay Chart

7. Conclusions

The analysis factors behind success of housing development project were identified and quantitative criterions for each factor were established, developing a feasibility analysis model which will facilitate main contractors to make right decisions on projects requested by developers. The followings are main conclusions.

First, factors possibly driving project success were selected in several expert meetings and they were categorized into three levels(level 1, 2, 3). Criterions of each analysis factor were established in order to evaluate projects objectively.

Second, among weights of the factors calculated by means of the AHP, weight of 'salability', 'economic feasibility', 'site location' and 'method of raising fund' were relatively high, which means they are important factors for project success.

Third, the model was applied to 12 housing projects performed in Busan (seven for successful projects and five for abandoned projects) to verify its reliability. The application results reported that the model properly filtered projects that are unlikely to be profitable, indicating reasonable reliability of the model

Finally, consulting to experts, the model developed in this study would be a useful tool for contractors, especially with less experience in analyzing project development feasibility.

In order to increase its practical use and improve its reliability, more projects of other construction companies should be evaluated by the model and more quantitative criterions of some qualitative analysis factors should be established to assess more easily and objectively. Also, models that can evaluate other type of project also need to be developed.

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