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Critical Review on Economic Effect of Renovation Works for Sustainable Office Building Based on Opinions of Real-Estate Appraisers

Kyuman Cho, Jaeyeon Kim and Taehoon Kim *

Department of Architectural Engineering, Chosun University, 309 Pilmun-daero, Dong-gu, Gwangju 61452, Korea; cho129@chosun.ac.kr (K.C.); srjykim@naver.com (J.K.)
* Correspondence: thoonkim@chosun.ac.kr

Abstract: Despite increased renovation work for office buildings to improve energy performance, studies on the appraisal of renovated office buildings (ROB) are scarce. Thus, this study analyzed the perceptions of appraisers regarding renovation work and the effect of renovation work on the economic value of office buildings. Following a reliability evaluation, research results were derived using various methodologies, such as descriptive statistics, Chi-square analysis, analytic hierarchical process, and structural equation modeling, based on the survey results of 118 appraisers. The renovation work was found to positively increase an office building's value, although the existing appraisal methods have low applicability considering the appraisal of ROB. On evaluating the importance of each factor considered in the ROB appraisal process, the factors related to the "location" of ROB were deemed more important than the attributes directly changed as a result of renovation work. Moreover, factors whose attributes were changed (e.g., working environment, green space, lease area, gross area of floors, number of floors, and number of parking spaces) were found to be critical factors affecting ROB value. The results of this study are expected to provide improvement directions for ROB appraisal methods and significantly aid building owners.

Keywords: renovated office building; real estate appraisal; economic effects of renovation work; quantitative research methods

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1. Introduction

With an increase in the period of building usage, buildings deteriorate in terms of physical, social, and economic aspects. To improve such deteriorated performance, various maintenance strategies are available. Renovation (also referred to as rehabilitation) corresponds to large-scale repair work for the renewal of an entire building [1,2]. Because buildings are responsible for a large amount of total energy consumption, sustainable development for existing office buildings is particularly important in the field of energy efficiency of buildings [3]. Moreover, a sustainable renovated office building (ROB) is considered to have an increased physical lifespan, as well as improved work efficiency and rental income.

When determining the level of renovation for non-residential buildings (e.g., office buildings), the functional and operational status (e.g., working environment, frequency, and extent of emergency maintenance, risk of business failure, etc.) is important. According to [4], there are five levels of renovation: light touch/refresh, medium intervention, extensive intervention, comprehensive refurbishment, and demolition. Among these levels, level 2 (i.e., medium intervention) is most commonly used for sustainable office buildings and refers to the whole building or to individual parts, such as floors, installations, equipment, appliances, etc. All higher levels require consideration of the applicable space legislation, while a building permit should be obtained for levels 4 and 5 [4]. The report "Comprehensive Study of Building Energy Renovation Activities and the Uptake of Nearly

Zero-Energy Buildings in the EU" suggests results for achieved renovation rates (below threshold, light, medium, and deep renovations), energy savings, and investment costs for 28 EU member states [5]. In addition to the energy-saving features of sustainable office buildings, the structural performance, the renovation of building elements, and the increase of the usable floor space can be achieved by extending the building [6]. Furthermore, the overall benefits can also be reflected in social and environment effects (e.g., in the quality of living (air quality, thermal, visual and acoustic comfort), aesthetics, and others).

However, during the process of determining the renovation of an office building, the building owner is very sensitive to changes in the value or price of the building following renovation. Moreover, according to [7], it is difficult for project owners to accept the uncertain economic benefits of renovation work [7]. Consequently, there are frequent cancellations of renovation projects if building owners are not convinced with an improvement in the value of buildings following renovation. In particular, according to [8], despite the investment of construction cost for the renovation of an office building, reflecting the construction cost to the appraisal of the renovated office building is challenging, thereby often prompting the owners of old office buildings to cancel the renovation project [8,9].

In general, the selection and application of an appraisal method are the most important aspects in the appraisal of a renovated office building. The appraisal method is traditionally based on the following three methods: cost approach, sales comparison approach, and income capitalization method. For buildings, primarily, the cost approach based on the replacement cost is applied. However, in terms of the appraisal of renovated buildings, there have been no practical and systematic appraisals performed owing to the lack of expertise and understanding of appraisers. Thus, renovated buildings are positively evaluated in terms of profitability because of a decrease in vacancy rate and an increase in rent. However, a majority of them are rendered as undervalued in terms of appraisal. This is because the cost approach is mostly applied owing to problems with the construction of evaluation manuals and data and the establishment and sharing of information systems [10].

Thus, this study aimed to analyze the perceptions of appraisers regarding renovation work and the effect of renovation work on the economic value of office buildings by conducting in-depth interviews with 227 appraisers. The analysis was conducted involving three aspects: (1) examining the perceptions of appraisers who evaluate the value of buildings on renovation work, (2) analyzing factors considered important during the appraisal process of renovated office buildings (ROB), and (3) an attempt to derive critical factors that affect the value improvement of ROB. The results of this study are expected to suggest directions for improving the appraisal of ROB and assure building owners planning on renovation of their renovation projects from an economic perspective.

2. Appraisal of the Renovated Office Buildings

2.1. Appraisal of the Renovated Buildings

Office buildings are appraised based on the following three traditional methods: cost approach, sales comparison approach, and income capitalization method. In the cost approach, the appraisal value can be determined through the subtraction of depreciation from the initial construction cost. However, this approach is applicable only to buildings and is particularly suitable for buildings that are not expected to yield income or revenue, such as schools and infrastructure facilities [11]. In contrast, the sales comparison approach directly applies the evaluation of the market to real estate values, that is, the market values of real estates are evaluated referring to newly traded similar real estates. This approach is based on the premise that the fair market value of a real estate is closely and directly related to the selling prices of comparable competitive real estate [12]. Finally, the income capitalization approach considers that the value of an asset can be reflected as the present value of future income; thus, the value is determined by discounting the future cash flow created from the asset. Therefore, this approach is suitable for profitable real estate and is applied using economic profit, particularly net operating profit [11].

However, despite active renovation work for office buildings in recent years, studies related to the same are scarce, including the ROB appraisal method. Consequently, although renovation work generally improves the profitability of office buildings through an improvement in building performance and vacancy rate, integrating this profitability improvement in the appraisal process using the existing methods (cost and sales comparison approaches) is challenging. In other words, because most buildings to be renovated are old, the cost approach is rendered unsuitable owing to the high depreciation rate and difficulty in securing cost data. In addition, there are insufficient ROB transaction cases, rendering the application of the sales comparison approach for the appraisal of ROB a challenge. This perspective has resulted in uncertainties in the decision-making of building owners who determine the renovation of old office buildings [10].

2.2. Factors Influencing the Price of the Renovated Buildings

Few studies have analyzed factors that affect the value of ROB. Further, certain studies have analyzed attributes that affect the price change of renovated multi-family houses (RMFH) and factors that affect the price of ROB in the price prediction process.

Kim et al. [13] proposed six variables that affect the price of RMFH by analyzing 19 factors that affect the price of typical apartments through literature analysis and conducting correlation analysis between the price of RMFH and the 19 attributes through the analysis of actual RMFH cases. Consequently, they derived six factors that affect the price of RMFH: space area of unit house, gross area of floors, years elapsed since construction, reputation of construction company, number of parking lot, and location.

Kim et al. [8] and Cho et al. [9] analyzed factors that affect the price of ROB and presented four to six factors that determine the price through the process of analyzing the relationship between the price and the attribute value for each collected ROB case. Similar to the factors of RMFH described above, the number of floors, years elapsed since construction, and gross area of floors were included as factors that determine the price. Moreover, in these studies, based on 13 to 15 candidate factors, the relationship between the ROB price and the attribute value of each candidate factor was analyzed through regression analysis for each ROB case, and finally four to six factors that determined the price of ROB were derived.

The above studies on factors that determine the price of RMFH and ROB analyzed attributes that determine the "price", which is a dependent variable. Thus, the primary focus was securing statistical significance through quantitative methodologies, such as regression analysis and correlation analysis, and consequently, certain influence factors were suggested. These influence factors were derived as factors based on which the price of renovated buildings was determined employing a statistical method. However, the manner in which such influence factors actually changed through renovation work and the effect of such changes on the value of renovated buildings has yet to be analyzed. Furthermore, there are no studies on the perceptions of appraisers, who directly evaluate the value of ROB, on such various influence factors and the manner in which they affect the appraisal process.

Therefore, this study was planned to examine factors considered important by appraisers during the ROB appraisal process and analyze the primary factors that affected an increase in the value of ROB. As diverse building information was considered for appraisal, factors that affected the price of office buildings were divided into physical, environmental, and transactional attributes based on the analysis of previous studies, including the aforementioned studies; and the candidate factors mentioned in previous studies were classified into each group [14–22]. Subsequently, the perceptions of appraisers regarding these candidate factors were surveyed. The candidate factors for each group are described in detail in Table 1 in Section 2.2.

Table 1. Potential factors influencing appraisal of the ROB.

Group of Factors	ID	Description of Factors
Physical attributes	1-A	Land-use controls
	1-B	Location (ex. Central Business District)
	1-C	Presence of obnoxious facilities
	1-D	Width of frontal road
	1-E	Accessibility of public transport
	1-F	Number of parking space (post renovation)
	1-G	Number of floors (post renovation)
	1-H	Gross area of floors (post renovation)
	1-I	Ground area of property
	1-J	Building footprint
	1-K	Exclusive rate of lease area (post renovation)
	1-L	Years elapsed since construction
	1-M	Interior and exterior design (post renovation)
	1-N	Number of elevators (post renovation)
	1-O	Level of IT equipment (post renovation)
	1-P	Working environment (post renovation)
	1-Q	Floor plan (after renovation)
	1-R	Green space ratio (post renovation)
Environment attributes	2-A	Accessibility to cultural facilities
	2-B	Accessibility to commercial properties
	2-C	Accessibility to medical facilities
	2-D	Accessibility to sports properties
	2-E	Elementary, middle, and high school accessibility
	2-F	University accessibility
	2-G	Kindergarten accessibility
	2-H	Maturity of educational environment
Transactional attributes	3-A	Facilities distribution around the target building
	3-B	Expected lease rate
	3-C	Easy for lease
	3-D	Region preference
	3-E	Level of potential for growth
	3-F	Expected lease income
	3-G	Amount of lease deposit
	3-H	Income of parking space operation
	3-I	Officially assessed land price
	3-J	Public charge and tax
	3-K	Building operation costs
	3-L	Building maintenance costs

3. Design for Reviewing Economic Effects of Renovation Works

Research goals pertaining to three aspects were set to examine the economic effect of renovation work in this study, as shown in Figure 1, and the effect of renovation was

examined considering six aspects to achieve the goals (i.e., ①–⑥ on Figure 1). In other words, examining the perceptions of appraisers regarding the renovation work in the appraisal process was set as the first goal, and this goal was deduced by applying descriptive statistics and chi-squared analysis methods based on survey results. Consequently, basic analysis was conducted to investigate the experience of the survey respondents on renovation work ("①" on Figure 1), and the effect of renovation work on the appraisal of office buildings was examined ("②" on Figure 1). The research outcomes are explained in Section 4.1. The second goal was to examine the perceptions of the main factors that affected the ROB appraisal process. Further, relative importance was evaluated for physical, environmental, and transactional factors ("③~⑤" on Figure 1). This goal was achieved using the analytic hierarchical process (AHP) method based on survey results, and the results and outcomes are explained in Section 4.2. Finally, the critical factors affecting the value improvement of ROB were developed using the results of ② and ③ to ⑤ above ("⑥" on Figure 1). This output was developed using the structural equation modeling (SEM) technique, which is an advanced scientific research methodology; the detailed results are explained in Section 5.

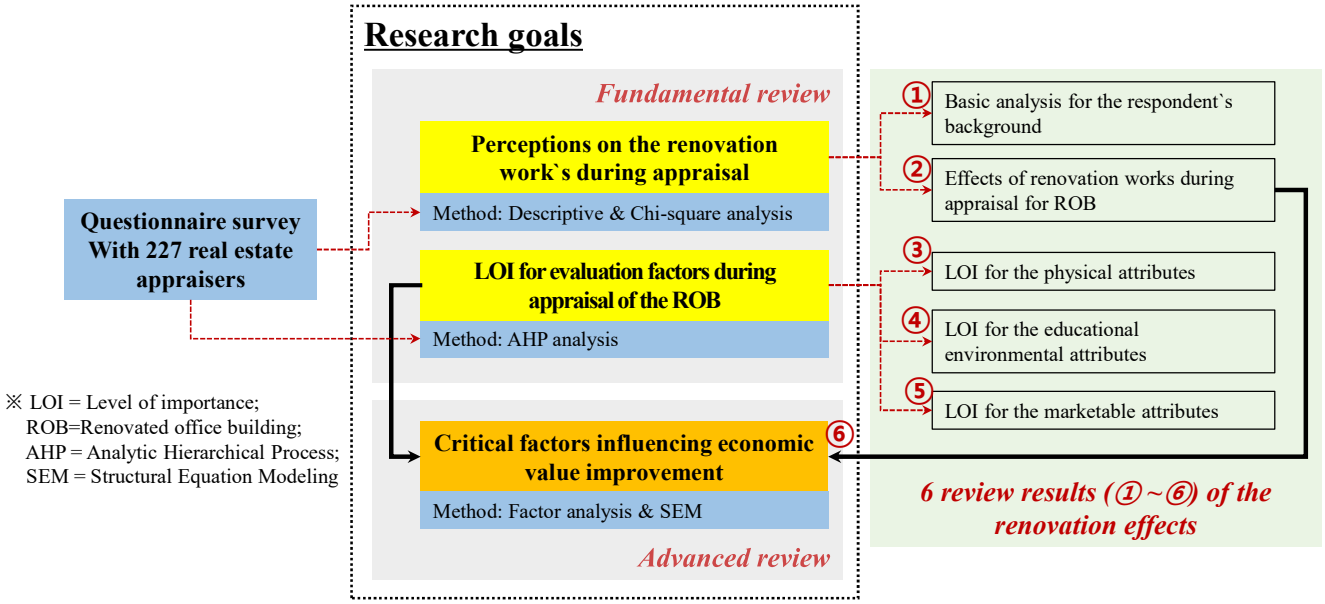


Figure 1. Design of research goals and results.

3.1. Survey Item Development

A questionnaire survey was conducted to investigate the perception of appraisers regarding renovation work, and the research goals were achieved through various analysis techniques (i.e., AHP, SEM, etc.) based on the survey results. The survey comprised three main parts. The first part (Survey Part I), which was a simple survey of the specialized areas of appraisers who participated in the survey, was composed of the following four items: (i) appraisal experience (S1_1), (ii) university major (S1_2), (iii) appraisal experience for renovated buildings (S1_3), and (iv) understanding of renovation of buildings (S1_4).

The second part (Survey Part II), which was a part of the survey of the perceptions of appraisers regarding value evaluation for renovated buildings, was composed of the following six items: (i) necessity and importance of renovation of buildings (S2_1), (ii) the degree of value improvement for renovated office buildings compared to buildings without renovation (S2_2), (iii) the effect of renovation work on the transaction price of an office building (S2_3), (iv) the possibility of evaluating the value of ROB using the existing appraisal methods (S2_4), (v) the error between appraisers during the appraisal of ROB (S2_5), and (vi) the appraisal method suitable for ROB.

The final survey part (i.e., Survey part III) contained survey items related to the calculation of the importance of factors that affected the value evaluation of renovated office buildings. The factors that affected the value of buildings mentioned in various previous studies and analyzed in Section 2 were utilized. Based on such factors, first, 70 factors (45 physical, 13 environmental, and 12 transactional factors) were derived using the qualitative survey method through open interviews with appraisers who had ROB appraisal experience. Thereafter, 38 factors (18 physical factors, 8 environmental factors, and 12 transactional factors) were derived conducting a focus group interview (FGI) with 10 appraisers with more than 5 years of experience as shown in Table 1.

3.2. Survey Implementation

The survey was conducted for approximately 75 days from 15 March 20xx to 30 May 20xx. Ninety-five questionnaires were distributed to appraisers from the Korea Real Estate Board and 145 questionnaires to 13 corporate members of the Korea Association of Property Appraisers. Thereafter, of the 240 questionnaires distributed, 227 were recovered (recovery rate of 90.8%).

The survey on the basic information of appraisers and their perceptions of value evaluation for renovated buildings (i.e., Survey part I and II) was conducted using nominal variables. For example, a four-point scale was used for the "university major (S1_2)" in Survey part I (1 = architectural engineering; 2 = architectural design; 3 = business administration; and 4 = others). The nominal scale for each survey item is described in detail in Section 4.1. Further, in Survey part III, the importance of 38 factors was evaluated through pairwise comparison using the AHP technique owing to difficulty to directly evaluate the importance of a number of factors in the domain of human perception according to Thomas Satty [23]. For example, if the experts are asked to observe the two items, "A" and "B", (1) if they conclude A to be much more important than B, it is marked A-3; (2) if they conclude A as more important than B, it is marked A-2; (3) if they conclude that A is slightly more important than B, it is marked A-1; and (4) if A is concluded to be equal to B, it is marked A/B. Consequently, the experts can calculate a weight of each element.

3.3. Reliability Test on Survey Results

The reliability of the survey results was evaluated using the consistency ratio (CR) index, which has been extensively used for evaluating the response consistency of respondents. Essentially, the AHP method adopts the normalized hierarchical orders for the comparative effectiveness of various surveys collected by experts using the pairwise comparison method. The CR is a measurement of the consistency of the pairwise comparison matrix (PCM) and is calculated by Equation (1). The comparison of the random consistency index (CI) shows how essential a respondent is. The CI designates the tolerability of the reciprocal matrix, which is computed with the mean eigenvalue of the PCM (λ_{max}), the random consistency index (RI), and the number of survey items (N), as expressed by Equations (1) and (2) [24,25]. In general, regarding the CR index, the criterion for evaluating the internal consistency varies depending on the size of the PCM, while it differs based on a matrix size of 10 [23].

$$CR = \frac{CI}{RI} \tag{1}$$

$$CI = \frac{\lambda_{max} - N}{N - 1} \tag{2}$$

Thus, in the case of the environmental factors that correspond to a matrix size of 8, the survey results were set to have internal consistency when the CR value of each respondent was lower than 0.1. Whereas, in the case of physical (n = 18) and transactional (n = 12) factors that have a matrix size greater than 10, the criterion of CR was set to 0.2.

Therefore, the survey results not adhering to the CR criterion of each factor were excluded from the data analysis of this study considering that they could lower internal consistency owing to the possibility of inconsistencies existing in the pairwise comparison

matrix. Furthermore, as evident from Table 2, if the results of one survey respondent did not satisfy the CR criteria of any of the three fields (i.e., physical, environmental, and transactional factors), they were excluded from the survey result analysis targets as they could lower internal consistency. Consequently, 109 questionnaires out of 227 were found to not satisfy the CR criteria. Thus, based on the results of the remaining 118 questionnaires, data analysis was conducted to derive research results. The detailed method of calculating the CR value can be found in [23].

Table 2. Reliability test results.

Respondents ID	Consistency Ratio			Decision
	Physical Attributes (Threshold: 0.2)	Enviro. Attributes (Threshold: 0.1)	Transactional Attributes (Threshold: 0.2)	
1	−0.278	−0.180	−0.093	Adopted
2	−0.085	0.021	0.020	Adopted
3	−0.025	−0.173	−0.024	Adopted
4	−0.106	−0.398	−0.229	Adopted
5	0.065	0.880	0.130	Nonadopted
6	0.014	0.260	−0.073	Nonadopted
7	0.447	0.229	0.116	Nonadopted
⋮	⋮	⋮	⋮	⋮
224	0.347	0.725	0.524	Nonadopted
225	−0.219	−0.180	−0.093	Adopted
226	−0.223	−0.215	−0.305	Adopted
227	0.064	−0.074	0.074	Adopted

4. Perception of Appraisers on Renovation Work to Office Buildings

Through the analysis of the results of 118 questionnaires for which reliability was secured statistically, the perceptions of appraisers regarding renovation work were reviewed considering the following two aspects; (i) appraisers' perception regarding the effect of renovation work on value evaluation, and (ii) the importance of each factor considered in the ROB appraisal process. Further, descriptive data analysis, chi-squire analysis, and AHP methodologies were used to achieve the research goals. The details and analysis method of each methodology are described later in this paper.

4.1. Perceptions on the Existing Methods during the Appraisal of ROB

The basic information of appraisers who participated in the survey and the background of renovation were investigated as part of the survey on perceptions of the appraisal of ROB. Table 3 lists the survey items and nominal scales for each of them, while Figure 2 shows the survey results.

Table 3. Basic survey items [1].

ID	Survey Item	Nominal Scale
S1_1	Work experience as appraiser	1 = less than 5 years; 2 = 5~10; 3 = 11~15; 4 = 16~20; 5 = more than 21
S1_2	Majority in university	1 = Architectural Eng.; 2 = Architect (design); 3 = Business; 4 = others
S1_3	Experience in appraising ROB	1 = none; 2 = 1~3; 3 = 4~5; 4 = 6~7; 5 = 8~10; 6 = more than 11 times
S1_4	LOU in renovation works	1 = Excellent; 2 = Good; 3 = Average; 4 = Poor; 5 = Very poor

[1] ROB = Renovated office building; LOU = Level of understanding; LOI = Level of importance.

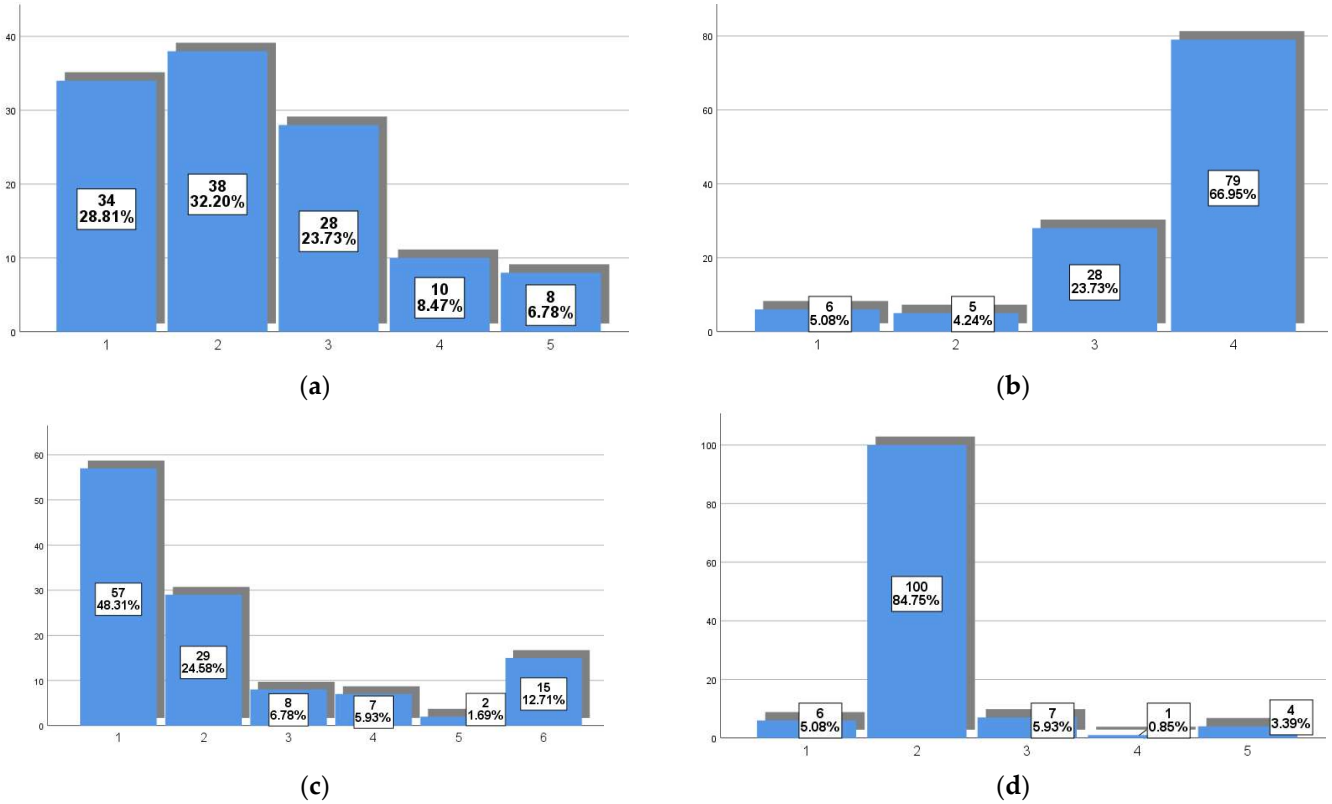


Figure 2. Basic analysis for the respondent's background. (**a**) Frequency of respondents for S1_1; (**b**) frequency of respondents for S1_2; (**c**) frequency of respondents for S1_3; (**d**) frequency of respondents for S1_4.

Upon examining the experience of the appraisers (S1_1), 34 people were found to have less than 5 years of appraisal experience (28.81%), 38 people had 5–10 years of experience (32.20%), and 28 people had 11–15 years of experience (23.73%). Thus, approximately 85% of the respondents had less than 15 years of experience. In addition, approximately 7% respondents had more than 21 years of experience.

Further, regarding the university major of the appraisers (S1_2), 67% of the 118 respondents majored in other fields, such as law and humanities and social science, whereas approximately 9% majored in architectural engineering (nominal scale 1) and architectural design (nominal scale 2), which are expected to increase the understanding of building renovation. Originally, of the 227 survey respondents, the appraisers who majored in architectural engineering and architectural design were 42 (18.50%) and 9 (3.96%), respectively; however, many survey results were excluded as per the results of the reliability test.

Upon examining the appraisal experience of appraisers for ROB (S1_3), the respondents with no experience accounted for 47.31% and the remaining respondents had at least one ROB appraisal experience. In particular, 12.71% of the respondents had 11 or more appraisal experiences. Further, according to the findings obtained during the survey process, ROB appraisal tasks tended to be concentrated on experienced appraisers, which resulted in many appraisers having 11 or more experiences.

Finally, upon examination of the appraisers' understanding of renovation work (S1_4), most of the appraisers were found to have significantly high or good understanding of renovation (106 respondents, approximately 89.83%), while those who had poor understanding represented approximately 4% (5 respondents).

As the next survey on perceptions of ROB appraisal, appraisers' perceptions of the economic value of renovation work were investigated. Table 4 lists the survey items and nominal scales for each of them, while Figure 3 shows the survey results.

Table 4. Survey items from appraiser's perception on ROB during appraisal [1].

ID	Survey Items	Nominal Scale
S2_1	LOI of renovation works	1 = very high; 2 = high; 3 = normal; 4 = low; 5 = very low
S2_2	Value improvement post renovation	1 = less than 10%; 2 = 11~20%; 3 = 21~30%; 4 = 31~40%; 5 = 41~50%, 6 = more than 51%; 7 = inability to judge
S2_3	Level of reflect of renovation work during appraisal	1 = reflected considerably; 2 = reflected slightly; 3 = not reflected at all
S2_4	Availability of existing methods for appraising ROB	1 = evaluated perfectly; 2 = evaluated slightly; 3 = evaluated insufficiently; 4 = evaluated very poor
S2_5	Range of error among appraisers in appraising ROB	1 = less than 5%; 2 = 6~10%; 3 = 11~20%; 4 = 21~30%; 5 = more than 31%
S2_6	Appropriate appraisal method for ROB	1 = cost approach; 2 = sales comparison approach; 3 = income capitalization approach; 4 = combined approach

[1] LOI = Level of importance; ROB = Renovated office building.

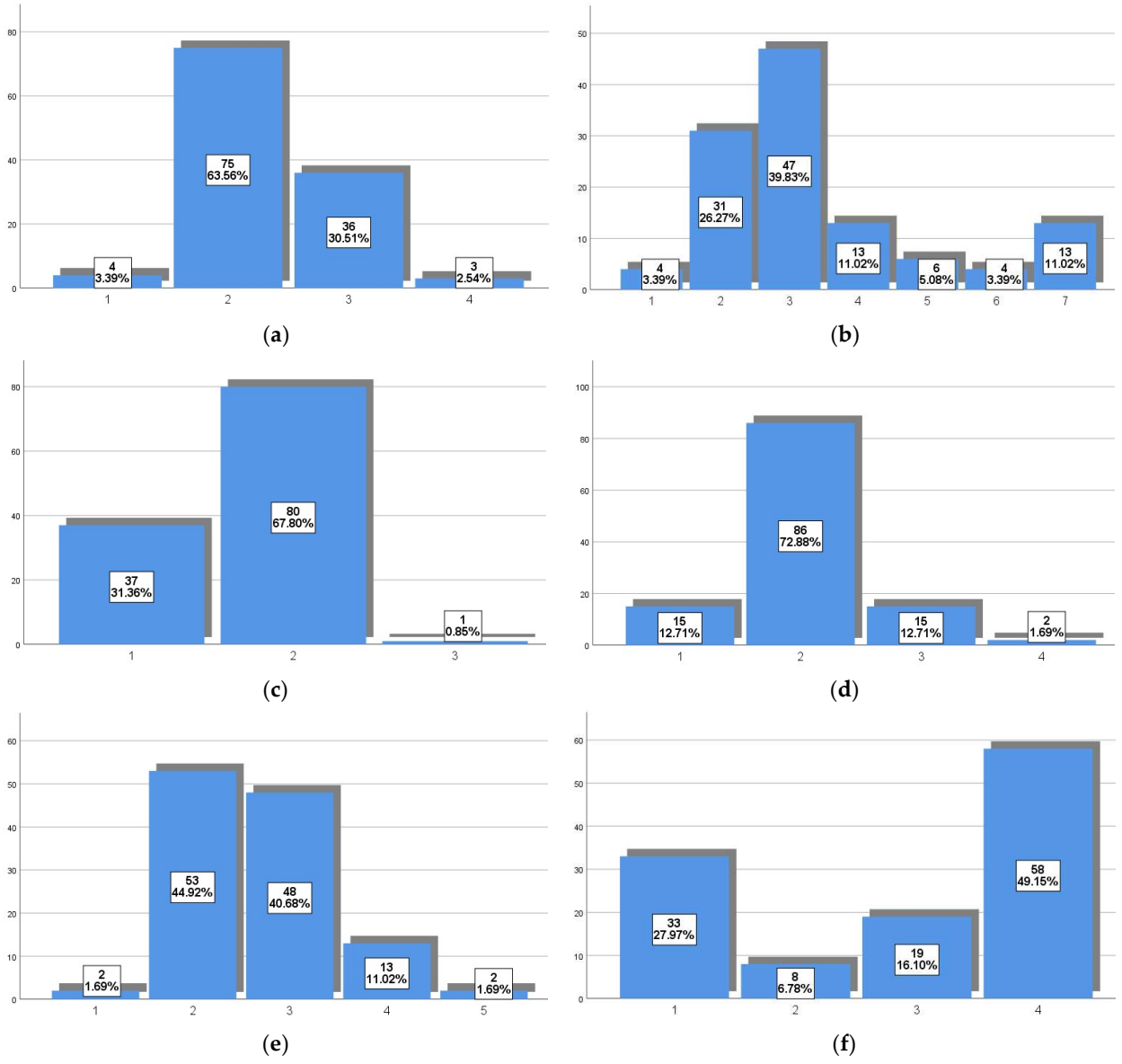


Figure 3. Appraiser's perception on ROB during appraisal. (**a**) Frequency of respondents for S2_1; (**b**) frequency of respondents for S2_2; (**c**) frequency of respondents for S2_3; (**d**) frequency of respondents for S2_4; (**e**) frequency of respondents for S2_5; (**f**) frequency of respondents for S2_6.

For the necessity and importance of renovation work for old office buildings (s2_1), approximately 67% of the appraisers (79 people) responded with the importance being very high or high. For the question regarding the increase in monetary value following renovation (S2_2), the response that the value increases by 21–30% exhibited the highest proportion (39.83%), followed by value will with an increase of 11–20% (26.27%). Further, approximately 11% of the respondents expected an increase in value of greater than 51%. These results indicate that the appraisers generally judged that renovation has a positive impact on the increase in the value of buildings.

Despite the positive impact of renovation, the opinion of renovation work being reflected only partially represented approximately 68% for the question on the reflection of renovation work to appraisal (S2_3). Further, regarding the question on the applicability of the existing appraisal methods to ROB appraisal (S2_4), 72.88% of the appraisers responded as them being applied in a limited manner. Furthermore, for the question on the error between appraisers during the appraisal of ROB (S2_5), approximately 85% of the respondents responded with the error between appraisers ranging from 6 to 20%.

Finally, regarding the question on the appraisal method being suitable for ROB (S2_6), the opinion that the mixing of the existing methods is suitable accounted for 49.15%, followed by the opinion that the cost approach is suitable (27.97%).

Thus, based on the above results for the two survey parts, the difference in the appraisers' perceptions of renovation work, depending on their background, was derived. That is, the difference in response to the economic value of renovation work was analyzed using cross tabulation analysis according to the experience, university major, ROB appraisal experience, and understanding of renovation of the appraisers. Further, cross tabulation analysis was conducted through the independence test for testing whether two variables with different classification criteria are independent and the homogeneity test for testing whether the proportions of each category are the same. In addition, statistical testing was performed through chi-square. In other words, the determination of accuracy was expressed through a chi-square statistic in cross tabulation analysis, and the *p*-value was used to determine whether the results were statistically significant. In general, statistical insignificance is determined if the *p*-value is higher than a significance level of 0.05, provided there is no consistency in evaluation; statistical significance is determined if it is lower than 0.05 [26].

Table 5 shows the cross-tabulation analysis results, wherein differences in response to the questions on the effect of renovation during appraisal depending on the characteristics of the respondents are evident. No differences in the response tendency to whether renovation work is reflected to the appraisal price (S2_3) and whether renovation work increases the value of an office building (S2_2), depending on the characteristics of the respondents (i.e., experience, major, ROB appraisal experience, and understanding of renovation work), were observed. In other words, statistically significant results could not be obtained because the *p*-value of each analysis case exceeded 0.05.

Table 5. Cross tabulation analysis result 1.

Respondent's Characteristics	Effects of Renovation Works during Appraisal of ROB			
	S2_3 (Level of Reflection in Price)		S2_2 (Value Improvement)	
	χ^2 Value	*p*-Value	χ^2 Value	*p*-Value
S1_1 (Experience)	7.902	0.443	30.406	0.172
S1_2 (Majority)	0.699	0.995	14.117	0.721
S1_3 (ROB appraisal experience)	6.696	0.754	31.986	0.368
S1_4 (LOU in renovation works)	6.803	0.558	23.693	0.479

In a similar manner, perceptions regarding the existing appraisal methods according to the characteristics of the respondents were examined as shown in Table 6. The perceptions

of the possibility of the existing appraisal methods during ROB appraisal (S2_4), the error range during appraisal (S2_5), and an appropriate appraisal method (S2_6) were examined according to the characteristics of the respondents.

Table 6. Cross tabulation analysis result 2.

Respondent's Characteristics	Perception for the Existing Appraisal Methods during Evaluating ROB					
	S2_4		S2_5		S2_6	
	χ^2 Value	*p*-Value	χ^2 Value	*p*-Value	χ^2 Value	*p*-Value
S1_1 (Experience)	11.651	0.474	25.606	0.060	11.009	0.528
S1_2 (Majority)	12.107	0.207	21.201	0.048 *	11.576	0.238
S1_3 (ROB appraisal experience)	30.527	0.010 *	45.245	0.001 **	19.936	0.174
S1_4 (LOU in renovation works)	21.404	0.045 *	5.457	0.993	10.514	0.571

* $p < 0.05$, ** $p < 0.01$; S2_4 = availability of existing methods for appraising ROB; S2_5 = range of error among appraisers in appraising ROB; S2_6 = appropriate appraisal method for ROB.

In contrast to the previous cross tabulation analysis results, differences in perceptions of the existing appraisal methods were observed depending on the characteristics of the respondents. Thus, the perceptions of the possibility of the existing appraisal methods (S2_4, χ^2: 360.527, *p*-value: 0.010) and the error range during appraisal (S2_5, χ^2: 45.245, *p*-value: 0.001) were observed to vary depending on the ROB appraisal experience. In addition, there were differences in perceptions of the error range of the appraisal results (S2_5) and the applicability of the existing appraisal methods (S2_4), depending on the major (S1_2) and understanding of renovation (S1_4), respectively.

Upon examining the perceptions of the existing appraisal methods according to the ROB appraisal experience, the opinion that ROB can be appraised to a certain extent using the existing methods increased with an increase in the ROB appraisal experience. Thus, as the response to the ROB appraisal experience increased from 1 to 2, 3, 4, and 6, the proportions of selecting "nominal scale 2" in S2_4 were 82.46% (47/57), 44.83% (13/29), 75% (6/8), 57.12% (4/7), and 93.33% (14/15), respectively. Subsequently, with the increase in the ROB appraisal experience, the error of the ROB appraisal results was concentrated in the 6–10 and 11–20% ranges; that is, with the increase in the response to the ROB appraisal experience from 1 to 2, 3, 4, and 6, the proportions of selecting "nominal scales 2 and 3" in S2_5 were 84.21% (48/57), 58.62% (17/29), 100% (8/8), 71.42% (5/7), and 80% (12/15), respectively.

In addition, a difference in the applicability of the existing methods depending on the understanding of renovation was observed. With an increase in understanding regarding renovation, the applicability of the sales comparison approach increased. Among the 106 respondents who responded that they understood renovation, 86 (81.32%) judged that the sales comparison approach is applicable.

4.2. Level of Important Factors during Appraisal of the ROB

In this section, the results of evaluating the importance of the factors affecting the value evaluation of ROB listed in Table 1 are described. As described earlier, the importance of the 38 factors was evaluated through pairwise comparison using the AHP technique. Thus, the 227 appraisers who participated in the survey evaluated the relative importance of each factor in three groups (i.e., 18 physical factors, 8 environmental factors, and 12 transactional factors) through pairwise comparison. Each respondent evaluated a_{ij} in the pairwise comparison matrix $A = (a_{ij})$, i, j = 1, 2, ... n as the relative importance of i compared to j using a seven-grade scale, and the relative importance of each factor by the respondent can be evaluated by normalizing the eigen vector of the largest eigenvalue of the matrix [23]. Subsequently, the average of the relative importance values of each factor evaluated by the respondents was calculated based on the survey results of the 118 respondents. Consequently, internal reliability was proven through reliability analysis

using the CR value, and the importance of each factor was finally calculated. For example, for the 18 physical factors in Table 1, the appraisers evaluated the importance of each factor aij (i and j = 1–18) performing pairwise comparison, and calculated the relative importance of each factor using the eigen vector of the largest eigenvalue of the matrix. Thereafter, the importance of each factor was estimated by calculating the average relative importance of each factor based on the survey results of the 118 respondents.

Figure 4 shows the importance evaluation results for the 18 physical factors (1-A to 1-R). It is evident that the relative importance of factor "1-B" was highest (importance: 0.113), followed by "1-E" (0.080), "1-A" (0.076), and "1-C". The importance results show that the factors determined by the location of ROB ("1-B", "1-E", and "1-A") were considered as more important than the physical factors changed by renovation. Moreover, among the factors changed by renovation, "1-K" was evaluated to be the most important, followed by "1-F" and "1-P". It was found that the increase in lease area and parking space as well as the working environment improvement caused by renovation are considered important during appraisal.

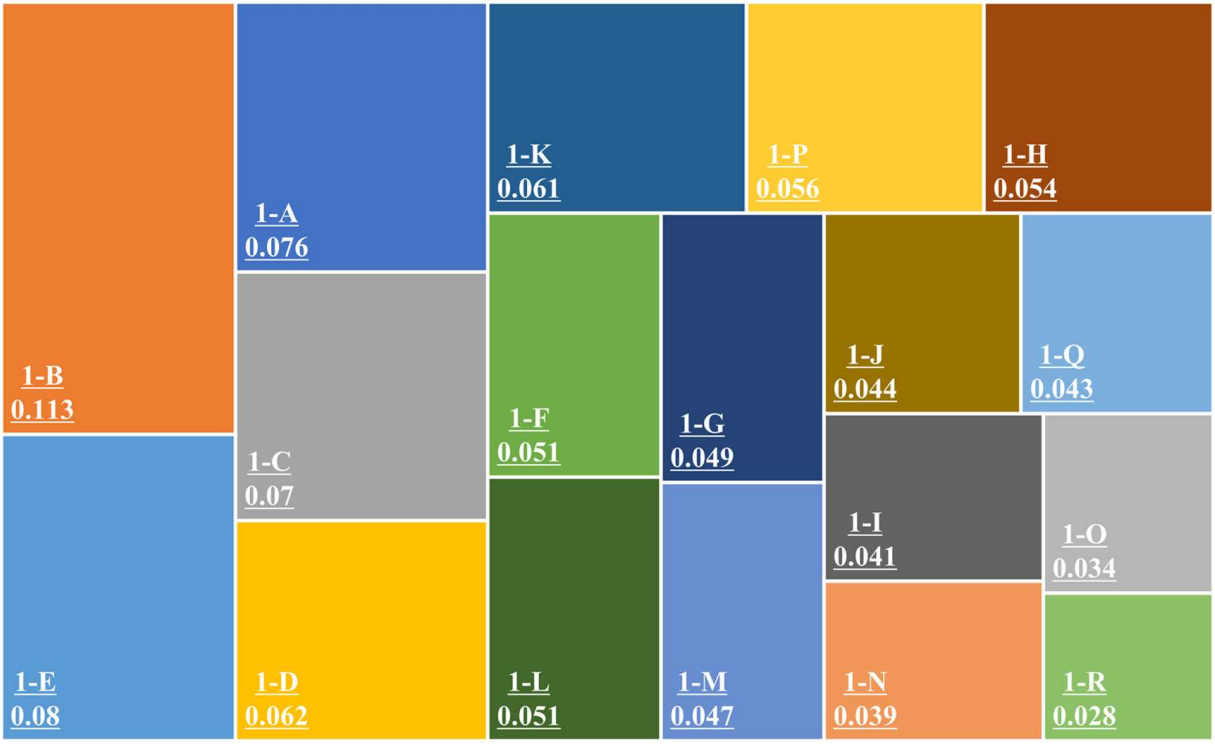
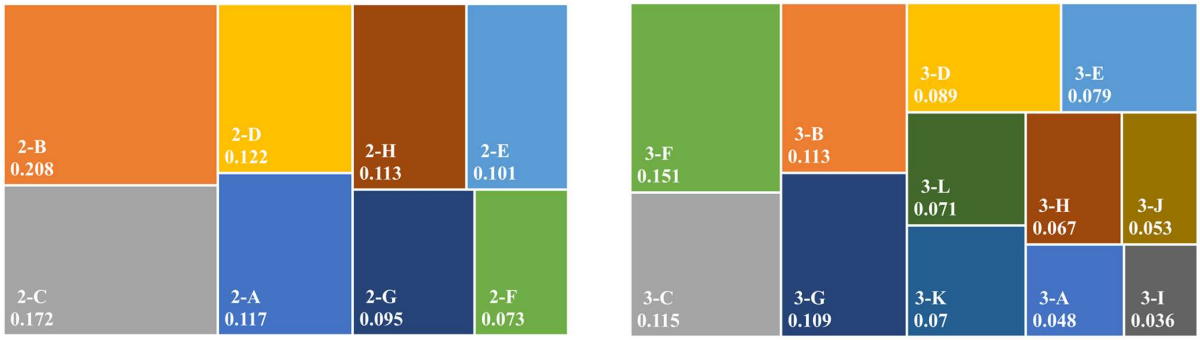


Figure 4. Level of importance for 18 physical attributes during appraisal of ROB.

Figure 5a,b shows the results of calculating the importance of environmental and transactional factors, respectively. Among the eight environmental factors, "2-B" was discovered to be the most important (0.208), followed by "2-C" (0.172), "2-D" (0.122), and "2-A". Further, environmental factors that were evaluated to be important were accessibilities to commercial, medical, sports, and cultural facilities, which are highly related to the "location" evaluated to be important in physical factors. Thus, owing to the expectation that the importance of the environmental factors mentioned above will be evaluated to be high for office buildings located in central districts, the survey results were interpreted as relatively consistent results. As evident from Figure 5b, among the 12 transactional factors, "3-F" was found to be the most important, followed by "3-C" (0.115), "3-B" (0.113), and "3-G". In addition, most are related to the office building rental income, and it is expected that the value of office buildings with the high rental income potential will be high.



(**a**) (**b**)

Figure 5. Level of importance for environmental and transactional attributes during appraisal of ROB. (**a**) LOI for the environmental attributes; (**b**) LOI for the transactional attributes.

Consequently, the factors related to the location are considered important in physical and environmental aspects. In particular, favorable appraisal is expected for office buildings located in central districts, because the evaluation scores of the physical, environmental, and transactional factors are likely to be high. In relation to renovation work, it was confirmed that the renovation factors affecting the rental income (i.e., an increase in lease area and parking space as well as an improvement in working environment) are considered more important during appraisal than renovation in terms of performance and convenience.

5. Critical Factors Influencing Economic Value Improvement of ROB

As a final step for examining the effect of renovation work on appraisal, factors that affect the price increase of office buildings following renovation were analyzed using 38 factors in three fields. Thus, based on the results of the 118 appraisers for the two survey parts: "importance of 38 factors by respondent" and "perceptions of the value increase by respondent for S2_2 (degree of the value increase after renovation)", critical factors affecting the value increase of office buildings following renovation were analyzed by applying factor analysis and the SEM methodology.

The SEM methodology is effective in identifying the relationships between various independent and dependent variables. SEM is similar to multi-variates regression analysis, but favorable in expressing the overall relationship that includes the maximum number of variables possible using the covariates of independent and dependent variables, which is in contrast to regression analysis that removes independent variables to increase the accuracy of the model [26]. Figure 6 shows the structure of SEM consisting of measurement and structural components [27]. As evident, the measurement component is a characterized model that measures exogenous variables with observed variables, whereas the structural component is a characterized model of the causal relationship between the exogenous and endogenous variables. In general, the measurement component in SEM is derived through factor analysis. Consequently, the structural component is derived using the SEM technique, and subsequently, the SEM model is finally constructed. A more detailed SEM application method can be found in [14].

Latent variables were set by conducting exploratory factor analysis for each factor based on the survey results of 118 respondents derived through reliability analysis. Factor analysis is a statistical analysis method wherein the degree of influence on each variable and the characteristics of the group are identified through the extraction of the correlations among variables with a small number of factors and thereafter determining the common factors of all variables. Thus, it is a multivariate statistical analysis method that explains the target proposition through the determination of factors that cause the actual result. Subsequently, a structural equation model that shows the factors affecting the value increase of ROB among the 38 attributes described in Table 1 was constructed using the AMOS25 software.

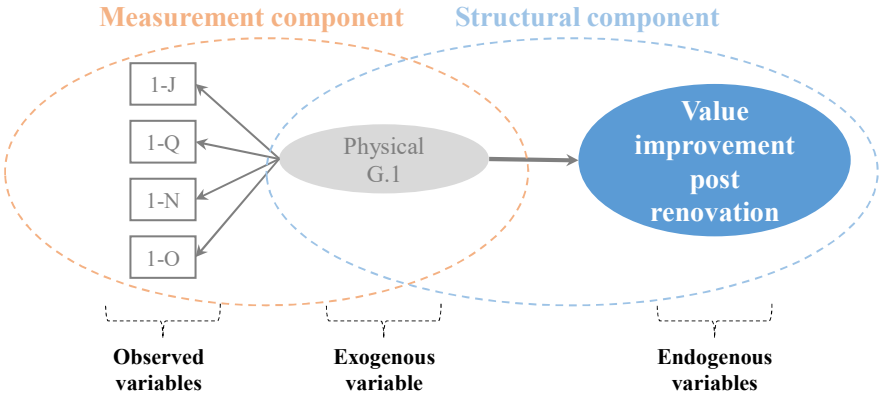


Figure 6. Fundamental logic of SEM.

To evaluate the goodness-of-fit of the developed SEM of the absolute fit index, which indicates the degree of reflection of input data by the research model using a value, and the incremental fit index, which identifies the degree to which the goodness-of-fit of the research model is higher compared to the null model (a model that assumes that all measured variables are not related to each other) [14,26], were employed. In this study, the goodness-of-fit was evaluated using χ^2/df (degree of freedom), the goodness-of-fit index (GFI), and the root mean square error of approximation (RMSEA), which are absolute fit indices. In addition, the comparative index (CFI), an incremental fit index, was used as well. Regarding the absolute fit index, χ^2/df, the model was judged to be suitable provided it ranged between one and two. Moreover, the model was also judged to be suitable if GFI was 0.9 or higher, while RMSEA was less than 0.08 or 0.1. In addition, if CFI was 0.9 or higher, the model was also judged to be suitable. However, in case the goodness-of-fit does not reach a satisfactory level, it must be improved through model modification, which can be performed by removing paths and variables with low correlations or via the addition of a new path and covariance between errors using the modification index provided by AMOS25 [28–30]. In this study, the final model was developed by improving the goodness-of-fit using both methods.

Table 7 shows the results of exploratory factor analysis for the 18 physical factors, which were extracted using the Varimax method, and subsequently classified into five groups. The cumulative explanatory power of the grouping was found to be 64.634%. In this instance, the goodness-of-fit of the factor analysis results was examined by conducting a sphericity test of Kaiser–Meyer–Olkin (KMO) and Bartlett. The grouping results showed that six, five, three, one, and three variables were included in Physical groups 1, 2, 3, 4, and 5, respectively. Therefore, based on this exploratory factor analysis, the measurement component composed of observed variables and exogenous variables described in Figure 6 can be established. Similarly, the environmental factors were classified into four groups (i.e., environmental groups 1–4) and the transactional factors into five groups (i.e., transactional groups 1–5).

Thereafter, a basic SEM model was developed based on the measurement part for each variable above. The final SEM model was derived through the process of improving the goodness-of-fit of the developed initial SEM model (i.e., removal of paths and variables with low correlations). Figure 7 shows the final SEM model. As evident, four factors were included in physical group 1 following the removal of "1-E" and "1-B", which were evaluated to exhibit low correlations in the goodness-of-fit improvement process, although six factors were included in the group for the initial SEM model. Consequently, the goodness-of-fit of the three SEMs satisfied the cutoff criteria, except for GFI of SEM for physical attributes, as presented in Table 8. Although a GFI that could not satisfy the criterion was confirmed, it is difficult for all indices to yield satisfactory results in the structural equation model [26]. However, as the cutoff criteria were mostly satisfied, no problem was judged for the analysis.

Table 7. Factor analysis results for the physical attributes.

Factors	Factor Loading	Variance Explained (%)	Cumulative Variance Explained (%)	Components (Exogenous Variables)
1-O	0.848	20.802	20.802	Physical group 1
1-Q	0.805			
1-J	0.700			
1-N	0.673			
1-E	−0.623			
1-B	−0.571			
1-M	0.721	13.066	33.868	Physical group 2
1-D	0.673			
1-K	0.571			
1-P	−0.519			
1-R	0.499			
1-F	0.722	11.523	45.391	Physical group 3
1-A	0.708			
1-G	0.470			
1-H	0.839	9.825	55.215	Physical group 4
1-I	0.741	9.419	64.634	Physical group 5
1-C	0.724			
1-L	−0.559			

Table 8. Goodness of fit measurements for SEM.

GOF	Cutoff Criteria for GOF Indices	SEM for Physical Attributes	SEM for Environmental Attributes	SEM for Transactional Attributes
χ^2/df	from 1 to 2	1.701	1.350	1.275
GFI	over 0.9	0.891	0.968	0.960
CFI	over 0.9	0.910	0.980	0.986
RMSEA	below 0.1	0.077	0.055	0.048

In the final SEM model, the number at the end of each arrow was similar to the regression coefficient value of regression analysis, and thus explained the level of influence. Table 9 presents the pathways for the relationships between physical groups and factors in the final SEM model, and the standardized coefficient values and *p*-values for each path. As evident, the reliability of pathway H1 was low because the significance level cannot satisfy 95%. Therefore, it was blurred in the final model as shown in Figure 7. Path analysis for the three groups was completed through the above SEM process.

Table 9. Estimates of meaningful relationship between physical attributes and value improvement of ROB.

Pathway	Coefficient Value	Standardized Coefficient	Standard Error	*p*
H1: Physical G. 1 → Value improvement of ROB	−92.303	−0.649	−1.841	0.066 $^{N/S}$
H2: Physical G. 2 → Value improvement of ROB	144.656	0.875	2.020	0.043
H3: Physical G. 3 → Value improvement of ROB	24.952	0.344	2.553	0.011
H4: Physical G. 4 → Value improvement of ROB	35.714	0.564	3.176	0.001
H5: Physical G. 5 → Value improvement of ROB	13.432	0.508	2.249	0.025
H6: Physical G. 3 → 1-N	0.296	0.466	6.421	***
H7: Physical G. 4 → 1-G	0.422	0.507	6.018	***

$^{N/S}$ = Not significant; *** = $p < 0.001$.

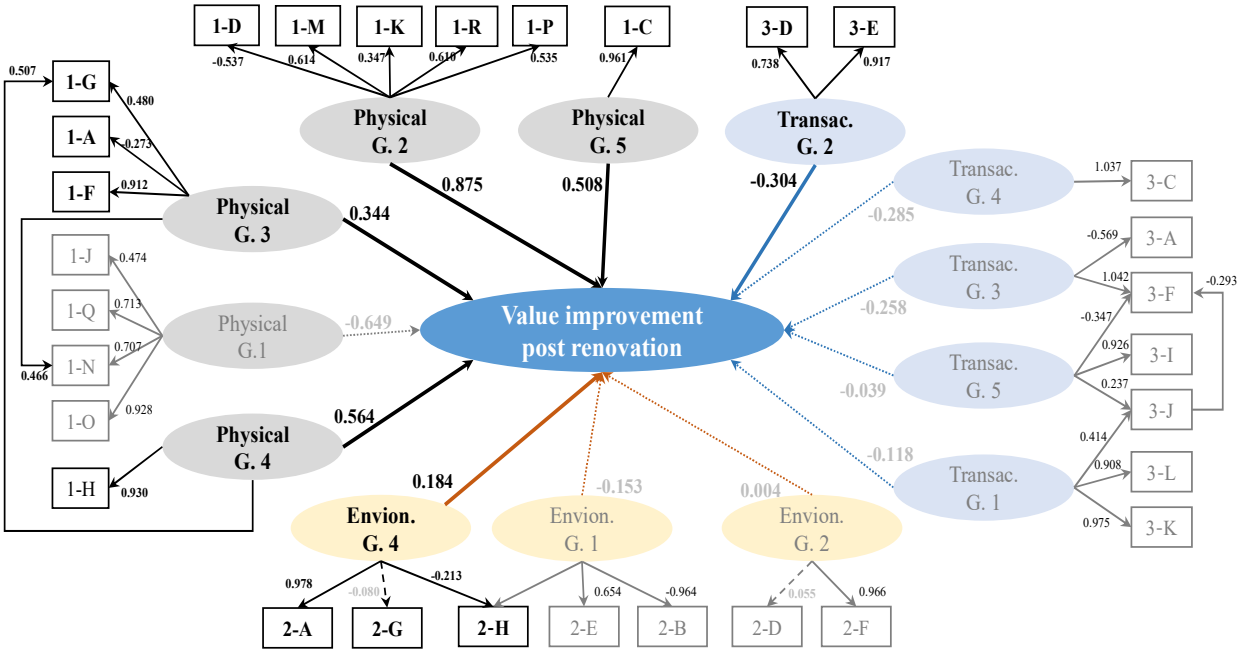


Figure 7. Final SEM for the critical factors influencing the value improvement of the ROB.

Based on the final SEM, factors that affected the price increase of office buildings following renovation were examined among the 38 factors in three fields. First, regarding the physical factors, it was found that physical groups 2, 3, 4, and 5 affected the price increase of ROB. In contrast, most of the environmental and transactional factors were found to have no significant influence on the price increase of ROB, with only a few factors (i.e., environmental group 4 and transactional group 2) found to be significant.

Physical group 2 (standardized coefficient = 0.875, p = 0.043), which includes "1-P (working environment)", "1-R (green space ratio)", "1-K (exclusive rate of lease area)", "1-M (design (interior and exterior))", and "1-D (width of frontal road)", was found to exert the largest influence on the value increase of ROB, followed by physical group 4 (standardized coefficient = 0.564, p = 0.001), which includes only "1-H (gross area of floors)", physical group 5 (standardized coefficient = 0.508, p = 0.025), and physical group 3 (standardized coefficient = 0.344, p = 0.011). Moreover, among the 18 physical factors, most of the factors whose attributes were changed as a result of the renovation were found to be the primary factors affecting the price increase of ROB. In particular, the working environment, green space, exclusive rate of lease area, gross area of floors, number of floors, and number of parking spaces, whose performance was improved through the renovation of old office buildings, were found to be critical factors affecting the value increase of ROB. In addition, it was found that certain location-based attributes (e.g., 1-A, and 1-D) were still affecting the value increase of ROB.

In terms of environmental attributes, only group 4, which includes "2-A (accessibility to cultural facilities)", "2-G (kindergarten accessibility)", and "2-H (Maturity of educational environment)", was found to affect ROB (standardized coefficient = 0.184, p = 0.048), while the other factors did not influence the price increase caused by renovation. In terms of the transactional factors, only group 4, which includes "3-D (region preference)" and "3-E (level of potential for growth)", was found to have a "negative" impact on the value increase of ROB (standardized coefficient = −0.304, p = 0.022). This indicates that an increase in value can be expected when office buildings in areas with low region preference and growth potential are renovated.

Overall, the physical factors whose performance was directly changed by renovation were found to affect the value increase of ROB. In particular, the working environment, green space, lease area, gross area of floors, the number of floors, and the number of parking spaces were found to be factors that resulted in an increase in the ROB value. However, the

location-related factors (1-A, 1-D, 2-A, 2-G, and 2-H) whose attributes were not changed as a result of the renovation were found to still affect the value increase of ROB, although they were small in size. This implies that the value of office buildings at better locations can be evaluated to be higher when the same renovation is performed. Thus, it appears that a larger increase in value can be expected when office buildings in areas with low region preference and growth potential are renovated.

6. Discussion

In this study, the factors affecting the appraisal of ROB were derived based on the perceptions of appraisers. Subsequently, the derived results were compared with the results of the related previous studies.

The three previous studies mentioned in Section 2.2 [8,9,13] were conducted based on the actual renovated cases. In these studies, factors affecting the price change of renovated offices or apartments were analyzed by collecting renovation cases as well as the price change prior to and following renovation for each case, changes in various attributes, and by analyzing the significant relationship between the price change and the attribute change. Table 10 presents the factors affecting the value increase of renovated buildings mentioned in previous studies. It is evident that the gross area of floors, years elapsed since construction, and number of parking spaces were commonly mentioned as factors affecting the price in the previous studies. Further, factors related to the officially assessed land price, reputation of construction company, number of underground floors, and location were different depending on the building type and research methodology.

Table 10. Comparison of influencing factors in the existing research.

[8]	[13]	[9]	This Research
• Gross area of floors • Number of underground floors • Years elapsed since construction • Officially assessed land price	• Space area of unit house • Gross area of floors • Years elapsed since construction • Reputation of constr. Company • Number of parking lot • Location	• Gross area of floors • Site area • Number of parking spaces • Number of floors • Years elapsed since construction • Officially assessed land price	• Working environment • Green space ratio • Exclusive rate of lease area • Gross area of floors • Number of floors • Number of parking space • Land-use controls • Width of frontal road

1. [8], Predicting the monetary value of office property post renovation work, J. of Urban Planning and Development, ASCE, 144(2): 04018007.
2. [13] Factors determining the price of remodeled multi-family housing, KJCEM, 17(3), 13–22.
3. [9] Decision support method for estimating monetary value of post-renovation office buildings, Canadian J. of Civil Engineering, 46(12): 1103–1113.

On comparing the results of this study with those of previous studies, it was found that increasing the attributes of "gross area of floors", "number of floors", and "number of parking space", which were commonly found to affect the value of renovated buildings in actual cases, through renovation affected the value based on the perceptions of the appraisers. Further, in the analysis based on the case data, the location-related factors that were not directly changed through renovation, that is, "officially assessed land price" and "location", were also analyzed as factors that exerted significant influence. In addition, in this study, it was found that "land-use controls" and "width of frontal road" were also perceived as important factors by the appraisers.

However, the appraisers did not consider "years elapsed since construction", which was evaluated as an important factor in the analysis of the case data and is important in the ROB appraisal process. It was evaluated to be the eighth most important in Figure 4, where the relative importance of the 18 physical factors is shown. As it was also evaluated to exhibit a low correlation in the application process of SEM, which analyzed the factors affecting the price increase of ROB, it was excluded from the process of developing the final model. Moreover, the improvement of the working environment as a result of renovation, which is a rather qualitative factor, was judged to affect the value based on the perceptions of the appraisers.

7. Conclusions

Studies that have analyzed the effect of renovation work on the price of office buildings are insufficient. Therefore, this study analyzed the effect of renovation on the appraisal of old office buildings through a survey on the perceptions of appraisers who are directly involved in evaluating the price of office buildings. The renovation of aging office buildings is being actively attempted as a way to achieve sustainable cities and society. On the other hand, due to a lack of confidence in the economic performance of the renovation, it is openly reported that the project's owners are hesitant to perform the renovation. From the viewpoint of this background, this study was carried out to analyze whether renovation work affects the economic value of a building, and to analyze what types of renovation factors affect the value increase of the renovated office building. In the process of identifying these research questions, a survey by appraisers who are in charge of determining the value of a building was conducted, and based on the survey results that went through the reliability verification test, various scientific analysis techniques were used to achieve the objective of the study.

This study was conducted to achieve the following three goals: (i) analysis of perceptions of renovation work in the appraisal process, (ii) calculation of the importance of various factors that are considered in the renovated office building (ROB) appraisal process, and (iii) derivation of critical factors that affected the value improvement of ROB. A survey was conducted with 227 appraisers, and the survey results of 118 respondents were finally obtained following a reliability test conducted on the survey results. Subsequently, the research results were derived using various methodologies, such as descriptive statistics, cross tabulation analysis, analytic hierarchical process (AHP) analysis technique, and structural equation modeling (SEM).

According to the research results, first, the appraisers generally judged that renovation work has a positive influence on the value increase of office buildings; however, the majority of them reported that renovation work was only partially reflected during appraisal. Their perceptions also revealed that the existing appraisal methods were limited in terms of the appraisal of ROB, and thus errors between appraisers is expected. Certain perceptions were also found to be different depending on the characteristics of the respondents. Second, on evaluating the importance of 38 physical, environmental, and transactional factors in the ROB appraisal process, it was found that factors related to the location of office buildings were considered more important than changes in various attributes as a result of renovation. Further, in relation to renovation work, it was confirmed that renovation factors that affected the rental income (i.e., an increase in lease area and parking space as well as an improvement in working environment) were perceived as more important factors during appraisal than renovation in terms of performance and convenience. Finally, factors whose attributes were changed as a result of renovation, such as the working environment, green space, lease area, gross area of floors, the number of floors, and the number of parking spaces, were found to be factors that resulted in an increase in the ROB value. Moreover, the location-related factors whose attributes were not changed as a result of the renovation were found to still affect the ROB value, although they were small in size.

The results of this study are expected to provide improvement directions for ROB appraisal methods. Furthermore, they will be significantly helpful for building owners planning on renovation in determining the renovation and its directions.

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