

# THE ADAPTIVE INDICATORS AND WEIGHTING SYSTEM FOR THE REUSE OF INDUSTRIAL HERITAGE

Shyh-Huei HWANG\*, Yi-Fen CHANG\*

\* Graduate School of Design, National Yunlin University of Science & Technology, 123 University Road, Section 3, Yunlin, Taiwan

**Abstract:** Today's, Taiwan attach great importance to the preservation, revitalization and reuse of the industrial heritage space. Therefore, the adaptability and reuse of industrial heritage space becomes the main issue for the Taiwanese government. The purpose of this study is to construct an adaptive indicator and weight system for reusing industrial heritage space. Hence, in some previous study, the Delphi method has been used to examine items with professional and consistent views. Therefore, this paper is based on that, and further applied Analytic Hierarchy Process (AHP) to obtain relative weight value of the indicators, and the consistency verification and analysis, based to establishment of the "Industrial Heritage Space Reuse Adaptability indicators", its framework structure includes 4 main criteria and 22 sub-criteria. The results of the study are as follows: 1) Establish the weight of 4 main criteria of the space reuse adaptability; 2) Establishing the weights, rankings, and overall order for each sub-criterion within the 4 main criteria; 3) The indicators are used to test 2 industrial heritage cases, and the results of the assessment confirm the availability of the indicators; and 4) The rationality of the applied results shows the indicator system is effective.

**Keywords:** *The Reuse of Industrial Heritage, Adaptive Indicator, Analytic Hierarchy Process (AHP), Weighting*

## 1. Introduction

### 1.1 Background and motivation

Taiwan contains a rich and diverse culture heritage, including such as Jinguashi, Jiufen, Ruifan, etc.; in the culture heritage industrial many industries are built for its own purpose. For example, Taiwan railways industries are built for forestry, such as Alishan Forest Railway, Nantou Checheng Forestry, etc.; salt villages had been developed by the salt industry; various sugar factories have been developed due to the sugar industry; also various industrial due to industrial development arisen, including steel plants, cement plants, power plants, etc. Douglas [1] indicates that adaptive reuse can extend the service life of buildings with industrial heritage. Therefore, in the face of these industrial heritages, Taiwan's current practices have shifted from rescue and preservation to active reuse, according to Article III, Chapter 4 Legal Protection of the Nizhny Tagil Charter for the Industrial Heritage, "Sympathetic adaptation and re-use may be an appropriate and a cost-effective way of ensuring the survival of industrial buildings." [2] In other words, reuse is based on the preservation and development needs of industrial heritage,

the introduction of new functions, the conversion into another innovative space use, and the reuse of historical value and local features.

### 1.2 Research purpose

This research constructed a set of systematic and practical adaptive indicators for industrial heritage space reuse through collecting a group of experts' decisions methods. Based on this, the research purposes are as follows:

- (1) Use the adaptive indicators for the reuse of the industrial heritages that developed from the research to explore the relative weight and the order of the 4 main criteria and 22 sub-criteria of the industrial heritage space, examine the coherence of the experts' opinions to construct a complete adaptive reuse indicator weight system, and provide a reference for the industry, government, and university as the evaluation tools for reuse of industrial heritage space.
- (2) Through the case study, to test and verify the industrial heritage space reuse adaptive indicators developed from the research.

## 2. Literature Review

### 2.1 Adaptive Reuse

The “Reuse of the Architecture” means that to design a new way to use the old buildings. In different contexts, western scholars and architects vary from one another. Among them, “adaptive reuse” can best express the concept of new use of old houses, generally referred to as “reuse” [3]. In recent years, the “adaptive reuse” has become a widely used method. Therefore, this research uses adaptive reuse as the name of the discussion to analyze the reuse of the industrial heritage space and the evaluation criteria for different phases.

The Heritage Council of Victoria (HCV) [4] proposes that the new adaptability should respect the value of the site now and the meaning behind it. Therefore, respecting the history of industrial heritage and maintaining the industrial civilization left behind, including material and non-material aspects such as architecture, materials, processes, production activities, etc., have become the highlighting values of the industrial heritage represented in the contemporary era.

The adaptive reuse is not just a matter of maintaining the structure or appearance of a building. Hung [5] proposes a complete preservation of the industrial heritage of the buildings and facilities, can highlight the unique cultural elements of the industrial heritage, and has an important significance of inheritance. Appropriate reuse provides a way to preserve the appearance, space and place of the industrial heritage.

## 2.2 The checking items of the adaptability of the industrial heritage reuse

As the international community actively develops the reuse of industrial heritage space, the “adaptability” of the effectiveness of space reuse needs to establish a systematic checklist. The previous study of this paper aims to specify the checkpoints for evaluating “adaptability” of industrial heritage space reuse. The previous study was divided into 3 phases (Table 1).

**Table 1. Previous study process**

First phase	In-depth interviews with experts (experts comment on the adaptability of industrial heritage space reuse.)
Second phase	The initial review of the adaptability of the industrial heritage reuse evaluation dimensions and sub-items ( open coding 、 3-round KJ method )
Third phase	Establish the framework of checking items (3-round Delphi method expert survey )

In first phase, in-depth interviews of 7 experts in reuse of industrial heritage space from industry, government and academia were conducted; their opinions were then encoded and analyzed. The second phase, was open-coded and 3-round KJ method (classification, induction, labeling) as the initiate structure of the Delphi method. The third phase according to

the operation procedure from 14 experts and continued 3-round of expert survey to reach the agreement in expert’s opinions, and finally constructing the checking items.

Based on Huang and Chang’s [6] research on framework of checking items of adaptability of industrial heritage space reuse (Table 2), there are 4 evaluation dimensions and 22 sub-items. While conducting the reuse of the industrial heritage, this previous research findings and outcomes can be provided as a reference to check whether the value is presented, the benefits of the stakeholders are emphasized, and whether the plan and the management policy is well-organized.

**Table 2. The framework of checking items, 4 evaluation dimensions and 22 sub-items of adaptability of industrial heritage space reuse**

<b>A. The value of reuse</b>	<b>C The planning of reuse</b>
a1 Sustainable value	c1 Research study
a2 Historical value	c2 The positioning of the reuse function
a3 Educational value	c3 The evaluation prior to the repair of the reuse
a4 Societal value	c4 The innovative principles of the reuse
a5 Economical value	c5 The implementation planning of the reuse
<b>B The stakeholders of reuse</b>	<b>D The management of reuse</b>
b1 Central government	d1 Integration of organization and human resources
b2 Local government	d2 Research and development of service
b3 Professional coordinators	d3 The condition of reuse business feedback
b4 Assets managers	d4 Marketing
b5 Assets operators	d5 Financial plan
b6 Local residents	d6 Engagement and application of social capital

## 3. Research methodology

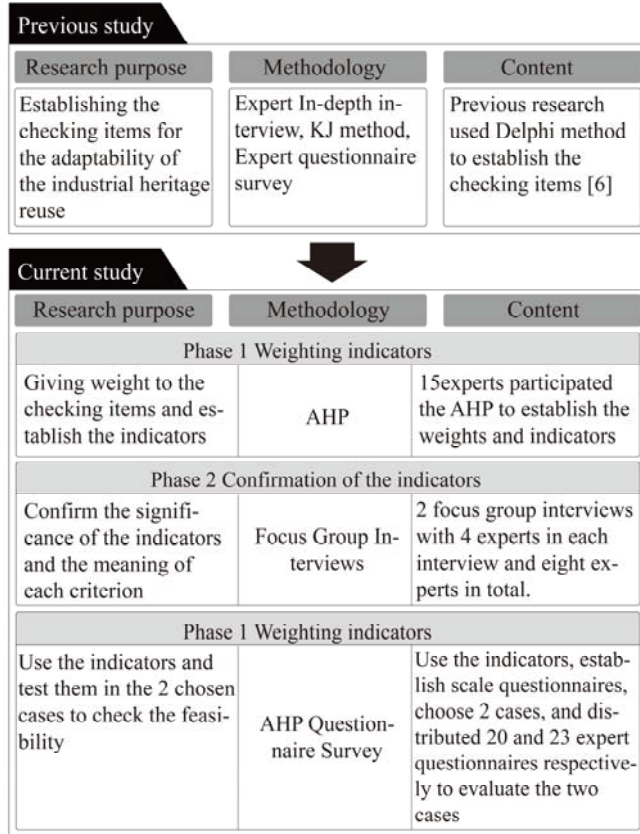
### 3.1 Research procedure

The previous research applied Delphi method to screen out the industrial property space for the professional and consistent view of the reusability of the appropriate items, and obtained 4 evaluation dimensions and 22 sub-items, which can be provided as government, scholars, professional coordinators, asset manager, asset operators and local residents as a reference while conducting the reuse of the industrial heritage. Based on the previous research outcomes, this research is divided into 3 phases, as illustrated in Figure 1.

The phase 1 is to weight indicators and the Analytic Hierarchy Process (AHP) [7] is applied. There are 15 experts participated in the AHP relative weight questionnaire survey. Take the checking items of the adaptability of the industrial heritage reuse as the tool to obtain the relative weight for the adaptive reuse indicators and the coherence check. Based on the results, the research established the weight system for the indicators of the industrial heritage reuse. The indicator framework system established by this research can divide into 2 levels: The main criteria of the reuse adaptability and the sub- criteria of the reuse adaptability.

The phase 2 is the confirmation of the indicators. The research has conducted 2 expert focus group interviews. There

are 4 experts in each interview with 8 experts in total. The research has made the qualitative interview into transcript and used open coding to obtain the significant sentences from the experts' interview. The second phase has gone through the expert focus group interviews and grounded theory to validate the importance of the indicators and the meaning of each sub-criterion, and applied the qualitative cross validation.



**Figure 1. The illustration of research process**

The phase 3 is the testing phase. In order to test the feasibility of the adaptability of the reuse indicators established by the research, the research chose 2 industrial heritage reuse cases to test. One is the Ten Drum Cultural Creative Park (used to be Ren-De Sugar Factory) and another is Tsung-Yeh Arts and Cultural Center (used to be Tsung-Yeh Sugar Factory). The research has distributed 20 and 23 expert questionnaires respectively, and 43 answers collected. The research then evaluated the adaptability of the space reuse of the 2 cases based on the 22 sub-criteria. In the end, adding the weight value of the AHP into the 2 cases to identify the effectiveness of the adaptive reuse.

### 3.2 Phase 1: weighting indicators by AHP

The phase 1 is weighting indicators. The research invited 15 experts to participate in the AHP relative weight questionnaire survey. The time of the survey was from May 6, 2016 to June 26, 2016. There were 15 questionnaires distributed and 15 collected. The response rate is 100%.

### 3.2.1 The selection of the group expert

In the selection criteria section of the expert sample, this study considers that the field of the industrial heritage is quite diverse. Therefore, this study considers it necessary to include the opinions of multiple experts.

Therefore, according to Meltsner[8], Weimer and Vining[9], Shan and Ho[10], based on the perspective of “analysis techniques” and “politic techniques”, the experts was divided into 3 groups: 1. Technical-type policy experts are one have high analysis techniques, and generally refers to intellectuals. In this research, the researchers from the industrial heritage and the space design field were invited. 2. Entrepreneur-type policy experts are who have high analysis and politic techniques. In this research, it focuses on operators who actually manage the reuse of the industrial heritage space were invited. 3. Official-type policy experts are who have high politic techniques. In this research, the officials from central and local governments that deal with the reuse of the industrial heritage were invited. Finally, the small group of experts involved in this research including 7 professional technical experts, 5 enterprise policy experts, and 3 official policy experts.

### 3.2.2 Questionnaire design

Based on the research results of the preliminary study of this study, the “checking items of adaptability of industrial heritage space reuse”, there are 22 items that can be categorized (Table 2).

In this research, the expert AHP method was first used to compile the “Investigation Questionnaire for the Relative Weight of Industrial Heritage Space Reuse Adaptability indicators”, and the weight analysis was carried out for each level of facet. Following the way of Saaty [11], the expert judges the pairwise comparison between the facets. After the matrix operation, the priority vector of each level is obtained as the relative weight of the indicators.

### 3.3 Phase 2: confirmation of the indicators with focus group interviews

In the phase 2 of the research, the “Confirmation Phase”, a focus group of interviews were conducted to those who are currently engaged in industrial heritage space reuse related industries, relevant positions of government departments, and experts and scholars within reuse of related industrial heritage space. A total of 2 sessions, 4 experts in each session, a total of 8 experts, each session for about 1.5 to 2 hours, the conference members are coded according to the background, in order to facilitate the subsequent qualitative data collection, analysis, 2 focus group expert group basic information (Table 3).

**Table3 : The basic information of the 2 expert focus group interviews**

Session/Date	Case	Code	Professional Background
Session 1/ 2017.03.08	Ten Drum Cultural Creative Park	R1	Design and plan for the industrial heritage space
		R2	The preservation, reuse and space design of the cultural heritage
		R3	The operator of the cultural creative park
		R4	The business, management and space design for the cultural creative park
Session 2/ 2017.03.15	Tsung-Yeh Arts and Cultural Center	R5	Art village administration, Operation and management
		R6	Art village administration, Operation and management
		R7	Art village administration, Operation and management
		R8	The preservation of the cultural heritage and local culture and history



The framework of the checking items of the adaptability of the industrial heritage reuse was provided prior to the interview, and 2 industrial heritage reuse cases were chosen: one is the Ten Drum Cultural Creative Park and another is Tsung-Yeh Arts and Cultural Center. The experts discussed the 2 cases during the focus group interviews. Each of them shared their opinions on each indicator on the 2 cases, and the application in the 4 main criteria and the connotations in the 22 sub-criteria. After the focus group interview, the researchers organized the qualitative data to conduct the qualitative cross validation.

### 3.4 Phase 3: indicators test phase with the AHP questionnaire assessment

In phase 3, “*indicators test phase*”, in order to test the feasibility of the indicators for the adaptive reuse of the industrial heritage, 2 cases of the industrial heritage reuse that are currently running were chosen. (Table 4).

TD is the Ten Drum Cultural Creative Park and TY is the Tsung-Yeh Arts and Cultural Center. The questionnaires distributed from December 12, 2017 to January 14, 2018. There were 20 and 23 expert questionnaires sent to the 2 cases respectively with a-total of 43 responses. Based on the 22 sub-criteria, this research assessed the adaptability of the 2 cases. The point ranged from 1 to 10, the highest number means that the better effectiveness of the adaptive reuse.

**Table 4. The adaptability evaluation samples of the reuse of the industrial heritage space**

	Case TD (Ten-Drum)	CaseTY (Tsung-Yeh)
Photo		
Current use	Ten Drum Cultural Creative Park	Tsung-Yeh Arts and Cultural Center
Business Units	Ten Drum Cultural Creativity Co., LTD	Cultural Affairs Bureau, Tainan City Government

## 4. The establishment of the adaptive indicators of industrial heritage space and weighting system

### 4.1 The results and analysis of the relative weighting of adaptive indicators of industrial heritage space

In addition to establishing hierarchy framework of the adaptive indicators of industrial heritage, the main purpose of this study is to find the relative weights between the 4 main criteria and the 22 sub-criteria, and to explore the subordinates under the main criteria. In the indicators weighting phase, the research uses the results of the previous research to reconstruct the hierarchy framework of checking items of adaptability of industrial heritage space reuse (Table 2), and the results of assessment of the adaptive indicators by the experts, and then used the Expert Choice to conduct the statistics (Table 5).

### 4.2 The comparative analysis of the relative weight of the overall criteria indicators

#### 4.2.1 The weight analysis of each of the 4 criteria

The consistency indicators of the 4 main criteria of the adaptive reuse indicators of the industrial heritage space is 0.01, the value is smaller than 0.1, which is acceptable according to Saaty. [11] According to the assessment results, the relative importance of the 4 main criteria, a) value of reuse comes the first, with the weight value of 0.453, which means that the relative weight among the 4 main criteria is 45.30%, and then c) plan of reuse comes the second, with the weight value of 0.214, the relative weight is 21.40%, the d) management of reuse comes the third, with the weight of 0.212 and relative weight 21.20%, and the last one is b) stakeholders of reuse, with the weight of 0.120, and the relative weight of 12.00% (Table 5). From the relative weight sorting of the 4 main criteria, the experts think that the cores of ensuring the adaptive reuse are the confirmation of the value and the plan of the effective preservation reuse. Second comes the actual management and the last one is the related stakeholder.

There are 3 interpretations from the results above. Firstly, the main criteria, a) value of reuse, assessed as the most important criterion, which means that confirming the value of the industrial heritage is the most basic work. The following

**Table 5. The weight analysis table of the adaptive indicators of the industrial heritage space**

Main criteria	Weight of main criteria	Order of main criteria	Sub-criteria	Weight of sub-criteria	Order of sub-criteria	Overall weight	Overall order	CI, CI <sub>≤</sub> 0.1
a: The value of reuse	0.453	1	a2 Historical value	0.283	1	<b>0.126</b>	<b>1</b>	0.02
			a1 Sustainable value	0.221	2	<b>0.099</b>	<b>2</b>	
			a3 Educational value	0.216	3	<b>0.096</b>	<b>3</b>	
			a5 Economical value	0.150	4	<b>0.067</b>	<b>4</b>	
			a4 Societal value	0.131	5	<b>0.059</b>	<b>6</b>	
b: The stakeholders of reuse	0.120	4	b3 Professional coordinators	0.237	1	0.034	12	0.01
			b5 Assets operators	0.220	2	0.031	15	
			b2 Local government	0.161	3	0.023	17	
			b6 Local residents	0.157	4	0.022	19	
			b4 Assets managers	0.114	5	0.016	20	
			b1 Central government	0.111	6	0.016	20	
c: The planning of reuse	0.214	2	c2 The positioning of the reuse function	0.306	1	<b>0.060</b>	<b>5</b>	0.02
			c1 Research study	0.250	2	<b>0.049</b>	<b>8</b>	
			c3 The evaluation prior to the repair of the reuse	0.164	3	0.032	13	
			c4 The innovative principles of the reuse	0.163	4	0.032	13	
			c5 The implementation planning of the reuse	0.117	5	0.023	17	
d :The management of reuse	0.212	3	d1 Integration of organization and human resources	0.273	1	<b>0.059</b>	<b>6</b>	0.02
			d2 Research and development of service	0.205	2	<b>0.044</b>	<b>9</b>	
			d5 Financial plan	0.197	3	<b>0.043</b>	<b>10</b>	
			d6 Engagement and application of social capital	0.167	4	0.036	11	
			d4 Marketing	0.111	5	0.024	16	
			d3 The condition of reuse business feedback	0.047	6	0.009	22	

plan, execution, and management would be made after confirming the value. The result concurs with the Nizhny Tagil Charter [2] for the industrial heritage, which mentioned that the industrial heritage is the witness of the industrial activities that has a profound influence on the following decades. The motivation of protecting the industrial heritage lies in the universal value of this historical legacy, not just the uniqueness. Most important, industrial heritage must clearly demonstrate its value. The public must clearly understand the reasons and values that these heritages should be preserved. The value of industrial heritage should be recognized by local people and make people feel the locality. [12] °

Secondly, the success of the reuse relies on the management. After the investment on the restoration and all the related facilities, the appropriate management is the key to the sustainable running, keeping the charm of the industrial heritage and delivering the value of the cultural heritage. Thirdly, main criteria of b) stakeholders of reuse which ranked the fourth does not mean that it is least important; instead, it just showed that compared to the other 3 main criteria, it is slightly less important than the others. Newman [13] pointed out that preservation should be based on reuse, to find out the balance of interests between developers, owners and preservation advocators, so the participation of stakeholders is an important matter.

The analysis of the overall relative weight of the 22 sub-criteria, the CI value, is 0.02, which is less than 0.1. According to Saaty [11], the consistency is acceptable. The a2) historical

value under the main criterion a) value of reuse has the highest weight, 0.126; second comes a1) sustainable value, with the weight of 0.099, and the third one is a3) educational value with the weight of 0.096 (Figure 2).

The result from above shows that the purpose of the adaptive reuse is to conserve the historical value of the industrial heritage as the main mission, and shows that the historical value is the most important adaptive reuse indicator of the industrial heritage. The result concurs with the Adaptive Reuse of Industrial Heritage: Opportunities & Challenges published by the HCV [4], which mentions that “*Industrial heritage consists of the remains of industrial culture which are of historical, technological, social, architectural or scientific value.*”

In addition, the industrial heritage can provided as the educational materials, which align with the idea in the Nizhny Tagil Charter [2] for the industrial heritage and Huang and Chang’s [6] idea of industrial heritage as the witness of the industry development, and is a practical industrial educational material. At the meantime, all the 15 experts agreed that the main criteria of a) value of reuse is significantly important, and therefore the sub-criteria under it are comparatively important. When discussing the reuse of the industrial heritage space, it is recommended to examine the adaptability of the 5 sub-criteria under the category of a) value of reuse.

The main criteria of c) planning of reuse ranked as the second highest weight among the 4. Among this main criteria, the c2) positioning of the reuse function was ranked as fifth in

all the 22 sub-criteria, and c1) research study as the eighth. The d1) integration of organization and human resources from d) management of reuse that ranked as the third among the 4 main criteria, was ranked as the sixth among the 22 sub-criteria, d2) Research and development of service as ninth, d5) Financial plan as tenth. The 5 criteria mentioned above were ranked in top 10 among the 22 sub-criteria even though they are in the group of the main criteria that ranked as the second and the third. Especially, c2 ranked as the fifth, and d1 and a4 both ranked as the sixth, which shows that the 5 sub-criteria should be viewed as crucial assessment indicators while considering the adaptive reuse.

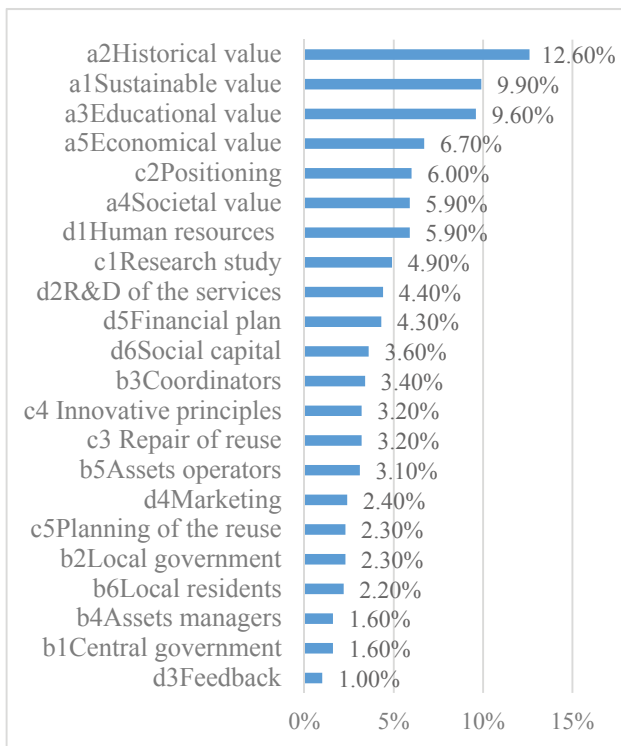


Figure 2. The ranking chart of relative weight of 22 sub-criteria

#### 4.2.2 The relative weighting and meaning of 22 sub-criteria

This session explains the results of the AHP quantitative statistics analysis from the 15 experts in the weighting phase, the qualitative analysis of indicator confirming phase that has 2 focus group interviews with each had 4 experts participated. The results are shown as follows:

##### (1) The comparison of relative weight of the sub-criteria under the main criteria, a) the value of reuse

According to the statistical results, in the main criterion, a) value of reuse, a2) historical value has the highest weight value, 0.283, and follows a1) sustainable value with the weight of 0.221, the third one is a3) educational value with the weight of 0.216. The order then comes a5) economic value with the weight of 0.150, a4) societal value with the weight of 0.131

(Table 5).

Compared the statistic results above with the focus group interviews, the qualitative analysis shows that the sustainable value of the industrial heritage lies in having the chance to show the historical industrial context in the contemporary time, and the changing meaning in the generations (R8, R6). The aesthetic value of industry from different age can be seen from the industrial heritages (R1). When conduct the reuse, it will correspond with the nature and essence of the original industries (R8). Discovering the uniqueness of the architecture space of the industrial heritage, the aesthetic mechanism, the ecological environment, the shared memories, the historical context and so on will establish the exceptional sustainable value, especially when connected to the geographical context (R7). Prior to the execution of the reuse project, the detailed research study of the background and history of industrial heritage is necessary, including the geographical factor, the location and the community connection. Collecting the correct historical and cultural records and documents, and also the first hand information of the industrial heritage, and then from the difference of each industrial heritage to establish the niche of the reuse, conduct the adaptive reuse, and so that the real historical value of the industrial heritage can be carried out (R2, R3). The industrial space includes the space, the structure, and the mechanism, after the conservation, can present the industrial aesthetics of the early 20th century (R1). At the same time, through the speculation from the relics, the industrial history, the procedure, people's daily life, and the local connection showed and included in the historical value (R6). The organizations that manage the industrial heritages would have various styles; therefore, the industrial heritage has the educational value that has multi-facets. In addition to the educational value of the cultural heritage and environmental education, the local conscious and the action record while striving for the conservation for the industry heritage are the non-physical educational value (R6). The physical value of the organization of the industrial heritage includes the mechanism, the space and so on; and the non-physical value such as the cultural and historical materials, the production procedure, and documents. Applying the concept of the eco-museum to conduct the reuse of the industrial heritage will achieve the purpose of the sustainable, historical and educational value (R1, R2).

##### (2) The comparison of relative weighting of the sub-criteria under the main criteria, b) the stakeholders of reuse

According to the statistics, under the main criterion, b) stakeholders of reuse, b3) professional coordinators under the

b) stakeholders of reuse has the highest weight, 0.237; the second one is the b5) assets operators with the weight of 0.220; the third one is b2) local governments with the weight of 0.161, and the following are the b6) local residents with the weight of 0.157, b4) assets managers with the weight of 0.114, and b1) central government with the weight of 0.111 (Table 5).

Compared the statistic results above with the focus group interviews, the qualitative analysis showed as follows: the industrial heritage reuse needs the participation from cross-field professional coordinators, including cultural and historical study, the preservation of the cultural material, the restoration of the space, the architecture design, the urban plan and the public safety, etc.; and all the professional coordinators need to understand the cultural and historical content of the industrial heritage (R2). The asset operators are the crucial stakeholders because they are one who will influence the direction and the future vision of the industrial heritage reuse (R5, R7). The asset operators need to coordinate and communicate with the professional coordinators, government sectors, and the asset managers and then build up the common consensus (R3). The asset operators need the resolution to undertake the outcome of the reuse (R3). The higher autonomy the asset operators have, the more flexible the reuse. The asset operators (R2, R3) should decide the role of the government plays in the reuse project. Moreover, the local government needs to establish administration support system on the execution aspect, and locate the public resources evenly. It will benefit the protection of the integrity and authenticity of the industrial heritage. The local government should support but not interfere, and respect the way that the professional coordinators and asset operators conduct (R3). The more autonomy that the local government shoulders, and adds on the resource from the central government, it will benefit better the outcome of the reuse (R6).

### **(3) The comparison of relative weight of the sub-criteria under the main criteria, c) the planning of reuse**

According to the statistics, under the main criterion, c) planning of reuse, c2) positioning of the reuse function under the c) planning of reuse has the highest weight, 0.306, and follows the c1) research study with the weight of the 0.250; and the third one is the c3) evaluation prior to the repair of the reuse with the weight of 0.164. The following are c4) innovative principles of the reuse with the weight of 0.163, c5) implementation planning of the reuse with the weight of 0.117 (Table 5).

Compared the statistic results above with the focus group interviews, the qualitative analysis showed as follows: the positioning of the industrial heritage reuse need to adjust in

response to the time change, and the ratio of the positioning is also crucial. The reuse should appropriately play the roles of culture conservation and the business display, and meet the need of the contemporary time to arouse the resonance from the young generation (R2, R3, and R5). The beginning of the reuse project should conduct a detailed and comprehensive research study that includes history, architecture, ecology, and environment and people (R1, R2, and R3), so that it can represent the features of the industrial heritage and the adaptive reuse. The restoration assessment of the reuse should respect the original space structure, form of the industrial heritage, keeping the original atmosphere and architecture (R1, R6). The sustainability and the economic value after the reuse are the 2 major factors of restoration assessment.

### **(4) The comparison of relative weight of sub-criteria under the main criteria, d) the management of reuse**

According to the statistics, under the main criterion, d) management of reuse, d1) integration of organization and human resources under the d) management of reuse has the highest weight, 0.273, and follows the d2) research and development of service with the weight of the 0.205; the third one is d5) financial plan with the weight of 0.197, and the fourth one is d6) engagement and application of the social capital with the weight of 0.167. Then follows the d4) marketing with the weight of 0.111, and d3) condition of reuse business feedback with the weight of 0.047 (Table 5).

Compared the statistic results above with the focus group interviews, the qualitative analysis showed as follows: the management group that has high autonomy and specific responsibility, under the well-organized human resources, can allocate the job responsibility according and has it specialization (R6). Further, they can cooperate with the field experts and business based on the features of the industrial heritages (R3). They will keep developing the innovative services, which will in response to the time and the need of the society (R3). Moreover, the independent budget and healthy financial plan should be renewed accordingly every year, which is the crucial factor of implementing the sustainable development (R6).

### **5. The assessment test of the adaptive indicators for the industrial heritage reuse**

The results of the indicator testing phases are explained as follows: The research has distributed 20 and 23 experts' questionnaires respectively, and 43 responses collected. After the assessment of 22 sub-criteria were analyzed, the weight value from the AHP was included to assess the effectiveness of the adaptive reuse, as shown in Table 6. The indicator system developed by this research would provide as an

**Table 6. The result of the adaptive reuse indicator assessment of the 2 cases**

Main criteria	Sub-criteria	Overall weight	Case study TD (n=20)		Case study TY (n=23)	
			Avg. Performance	Weighted performance	Avg. Performance	Weighted performance
a. The value of reuse (Weight: 0.453)	a1 Sustainable value	0.099	8.700	0.861	7.261	0.719
	a2 Historical value	0.126	9.050	1.140	7.522	0.948
	a3 Educational value	0.096	8.700	0.835	7.348	0.705
	a4 Societal value	0.059	8.850	0.522	6.913	0.408
	a5 Economical value	0.067	8.650	0.580	5.609	0.376
Criterion a : Average performance and weighted performance			43.950	3.939	34.652	3.156
b. The stakeholders of reuse (Weight: 0.120)	b1 Central government	0.016	4.250	0.068	<b>6.696</b>	<b>0.107</b>
	b2 Local government	0.023	5.400	0.124	<b>7.391</b>	<b>0.170</b>
	b3 Professional coordinators	0.034	7.600	0.258	6.652	0.226
	b4 Assets managers	0.016	4.000	0.064	5.783	0.093
	b5 Assets operators	0.031	7.350	0.228	6.565	0.204
	b6 Local residents	0.022	6.000	0.132	<b>6.304</b>	<b>0.139</b>
Criterion b : Average performance and weighted performance			<b>34.600</b>	<b>0.874</b>	<b>39.391</b>	<b>0.938</b>
c. The planning of reuse (Weight: 0.214)	c1 Research study	0.049	7.950	0.390	6.652	0.326
	c2 The positioning of the reuse function	0.060	7.800	0.468	6.783	0.407
	c3 The evaluation prior to the repair of the reuse	0.032	8.000	0.256	7.217	0.231
	c4 The innovative principles of the reuse	0.032	8.700	0.278	6.913	0.221
	c5 The implementation planning of the reuse	0.023	8.350	0.192	6.696	0.154
Criterion c : Average performance and weighted performance			40.800	1.584	34.261	1.339
d. The management of reuse (Weight: 0.212)	d1 Integration of organization and human resources	0.059	7.400	0.437	6.565	0.387
	d2 Research and development of services	0.044	7.700	0.339	6.565	0.289
	d3 The condition of reuse business feedback	0.009	7.350	0.066	5.957	0.054
	d4 Marketing	0.024	7.500	0.180	5.783	0.139
	d5 Financial plan	0.043	7.400	0.318	5.957	0.256
	d6 Engagement and application of social capital	0.036	7.650	0.275	6.304	0.227
Criterion d : Average performance and weighted performance			45.000	1.615	37.130	1.352
overall : average performance and weighted performance			<b>164.350</b>	<b>8.012</b>	<b>145.435</b>	<b>6.784</b>

Note: the weighted performance is the overall performance X average performance

assessment tool when considering a single or multiple industrial heritages reuse. From the overall, 4 main criteria and the 22 sub-criteria performance, one can evaluate the overall adaptive effectiveness and the differences.

### 5.1 case TD is better than case TY on the overall assessment

As shown in Table 6, the average performance and the weighted performance of the case TD (164.350/8.012) are better than the case TY (145.435/6.784). It shows that experts consider the adaptive reuse of case TD is better than the case TY. From the actual operation performance perspective, case TD sets the standard for the industrial heritage reuse that runs by the private sector, no matter on the domestic or international level. This corresponds with the overall assessment, aligns with the public opinion, and has the rationality.

### 5.2 Among the 4 main criteria, case TD has 3 that have higher score than case TY

The performances of the 2 cases on the 4 main criteria showed in Table 6. In case TY, the average performance and the weighted performance on the b) stakeholders of reuse (39.391/0.938) are higher than the one in case TD (34.600/0.874). However, the rest main criteria, case TD has better performance than the case TY. The result might be related to the management group. The case TY is run by the public sector. In addition to providing industrial heritage tour, it has the mission of providing the public with the learning and the promotion of the industrial heritage reuse. Therefore, in case TY, it needs to find the balance among the stakeholders' opinions. In case TD, it is run by the private business sector. The private business rents the sugar factory from the Taiwan



Sugar Cooperation, puts a lot of effort in repurposing the space, and develops innovative ways of the reuse to attract the public to come and visit the industrial heritage. On the actual management perspective, the private sector emphasizes more on the overall plan and the flexible management of the industrial heritage reuse.

### 5.3 Case TD has 19 sub-criteria that have better performance than the Case TY

The average performance, the weighted performance and the overall assessment of the 2 cases on the 22 sub-criteria are shown in Table 6. The case TD apparently has better performance than the case TY on the most sub-criteria, except that case TY has better performance on b1) central government (6.696/0.107), b2) local government (7.391/0.170), and b6) local residents (6.304/0.139). This might be related to that case TY is run by the public sector.

The local government conducts the project and provides the related services and facilities. Therefore, in the main criteria b) stakeholders of reuse, especially the government part, case TY has a significantly higher performance.

### 5.4 The order of the sub-criteria arranged by the experts is similar to the assessment results of the 2 cases

As shown in Table 7, the order based on the AHP and the order based on the assessment of the 2 cases, the sub-criteria share similar order. The top 10 sub-criteria consist 0.702 of the overall weight. It shows that the top 10 indicators can be used as an assessment tool when considering the adaptive reuse of industrial age by the professions and scholars in the future.

**Table 7. The comparison of AHP and the order 2 cases**

	AHP experts	case TD	case TY
a2 Historical value	1	1	1
a1 Sustainable value	2	2	2
a3 Educational value	3	3	3
a5 Economical value	4	4	6
c2 The positioning of the reuse function	5	6	5
a4 Societal value	6	5	4
d1 Integration of organization and human resources	6	6	6
c1 Research study	8	8	8
d2 Research and development of services	9	9	9
d5 Financial plan	10	10	10

## 6. Conclusion

This research has established the hierarchical framework of the adaptive reuse indicators for the industrial heritage based on the experts' opinions. It is expected to help clarify the adaptive indicators that should be taken into consideration before and after the reuse of the industrial heritage space. The

research also provides the industry, government and university with the adaptive indicators as an assessment tool for the conducting the industrial heritage reuse. The main research conclusions are as follows:

### 6.1 Establish the weight of 4 main criteria of the space reuse adaptability

The research analysis shows that among the 4 main criteria, the weight value of a) value of reuse is the highest, 0.453, which shows that the confirming the value of the industrial heritage is the fundamental base. First, confirming value, and then follows the plan, implementation, and the management. The second highest one is c) planning of reuse with the weight of 0.214. It shows that once value of reuse is confirmed, the following works and plans can start, including the research study, the positioning of the reuse function, the restoration assessment prior to the reuse, the innovative design principles of the reuse, and the implementation plan of the adaptive reuse, and so on. The third one is d) management of reuse, with the weight of 0.212, which means that the management will affect the success of the reuse. With the great amount of capital invested in the restoration and the related facilities that the reuse needs, it needs a well-organized management to sustain the reuse project and brings the potential of the industrial heritage into the full play, promoting the value of the cultural heritage. The last but not the least is b) stakeholders of reuse with the weight of 0.120. Each of the stakeholders of the industrial heritage is welcome to provide their suggestion to the planning of reuse, so that the professional coordinators can organize the adaptive reuse plan that meets the various needs from the stakeholders.

### 6.2 Establishing the weights, rankings, and overall order for each sub-criterion within the 4 main criteria

The research used the AHP to weight the statistic results and confirmed the weight, the order of the main criteria and the overall rank of the 22 sub-criteria under the 4 main criteria (Table 5). The top 3 among a) value of reuse are a2) historical value > a1) sustainable value > a3) educational value. The top 3 among b) stakeholders of reuse are b3) professional coordinators > b5) assets operators > b2) local government. The top 3 among c) planning of reuse are c2) positioning of the reuse function > c1) research study > c3) evaluation prior to the repair of the reuse. The top 3 among d) management of reuse are d1) integration of organization and human resources > d2) Research and development of services > d5) financial plan.

The top 10 of the 22 sub-criteria contain 0.702 of the overall weight. The order is as follows: a2) historical value > a1) sustainable value > a3) educational value > a5) economical

value > c2) positioning of the reuse function > a4) societal value, d1) integration of organization and human resources > c1) research study > d2) research and development of services > d5) financial plan. This research found that the 4 main criteria and the 22 sub-criteria are not equally important; at the same time, it categorized importance and rank of 4 main criteria, sub-criteria, and 22 sub-criteria.

### 6.3 The indicators applied to 2 cases produce 3 results

The research used 2 cases to test the feasibility of the indicator system, and the results correspond with the public's opinion and have its rationality. Result 1, the case TD has better performance than the case TY on the overall assessment. Result 2, the case TD performed better than the case TY on the a) value of the reuse, c) planning of reuse and d) management of the reuse of the main criteria. Result 3, except the sub-criteria b1) central government, b2) local government, and b6) local residents that are better than case TD, the rest performance of the case TY is lower than the case TD. Case TD has 19 sub-criteria performance better than case TY among the 22 sub-criteria.

### 6.4 The rationality of the applied results shows the indicator system is effective

In the first phase, weighting the indicators, the AHP applied to obtain the 4 main criteria and the 22 sub-criteria of the adaptability of the industrial heritage reuse. At the same time, the research checked the consistency of the experts' opinion, and the consistency is acceptable. In the third phase, testing the indicators, the research applied the indicators on the 2 chosen cases to test the feasibility and the results which are similar to the first phase. The results from the 2 phases show the rationality and prove that the indicator system as the assessment tool for the adaptive reuse is effective.

The indicators system established by the research can be used as the assessment tool for the adaptability while considering the industrial heritage reuse. The timeline can divide into the preliminary assessment, the formation assessment and the overall assessment. The preliminary assessment means that in the beginning of conducting the industrial heritage reuse, the indicator system can be used as the checking items to examine objectively and completely the adaptability of industrial heritage. The formation assessment means that while conducting the reuse of the industrial heritage, the indicator system can be used as the self-assessment of adaptive reuse. The overall assessment means that when the industrial heritage reuse is complete, the indicator system can be used to evaluate the effectiveness of adaptability.

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