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ANALYSIS OF CONDOMINIUM BUILDING MANAGEMENT PERFORMANCE IN CENTRAL TAIWAN

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Abstract

Management performance of condominium building projects is mainly assessed based on subjective judgment with limited objective evidence, thus calling into question the objec-

tive value of such assessments. The study utilizes data envelopment analysis (DEA) to assess management performance of 26 condominium building projects (decision making units; DMUs) in central Taiwan, from four dimensions (operational finance, management system, service quality, personnel quality) with eight input and five output items. Variable differential analysis is applied to improve efficiency by reducing the ratio of inputs for each project. Key influence of each dimension was identified using sensitivity analysis. Five benchmarked and five least efficient DMUs were identified. The approach provides a positive mechanism for facilitating the objective assessment of property management. The empirical outcomes provide managerial insights for assessing project performance efficiency.

Keywords: Condominium building management, performance assessment, data envelopment analysis, input and output, efficiency

Introduction

The trends of residents demanding the gradual improvement of living environment quality and standards have increased the importance of condominium building management (CBM). A condominium is the form of housing tenure and other real property where a specified part of a piece of real estate is individually owned, while use of and access to common facilities in the piece such as hallways, heating system, and exterior areas are executed under legal rights associated with the individual ownership and controlled by the association of owners that jointly represent ownership of the whole piece (Condominium, 2016). CMB is concerned with the comprehensive maintenance and management of a building's hardware and services, along with the software of the community and living environment. CBM requires integrating a variety of business operations and services, and is a key service industry with considerable output value and employment effects. The management and execution of these business items requires the attention of a professional team which represents the building management company in implementing management and service work, and is responsible for maintaining operational efficiency and service quality.

The property management industry (PMI) is a highly profitable service industry in many advanced countries such as UK and Japan. However, in Taiwan, PMI is actually a low margin industry in which firms compete on price rather than quality of service. In fact, these low margins prevent firms from investing in improvements, thus quality service is generally declining. In Taiwan, CBM companies are typically selected by tender for one-year renewable contracts of building management. The determination of whether to extend the contract is made through irregular on-site performance assessments by the management committee accompanied by management firm executives.

Therefore, raising building site service quality and ensuring the overall efficiency of operational management are critical to winning contract rewards.

The current type of assessment method is easily influenced by the subjective opinions of the resident management committee members or the management firm executives, and does not easily reflect actual objective conditions. Thus, there is a need for an objective and reasonable comparison mechanism based on objective field data analysis as the basis for performance assessment. Such a mechanism would establish performance benchmarks, identify areas of poor performance and assist the project manager in improving overall operating performance.

The study assesses the management performance of condominium building projects. "Performance" in this study is defined as "the ratio of outputs and inputs as determined by the proper use of resources and skills." Assessment is performed using data envelopment analysis (DEA) based on empirical data collected from 26 condominium building projects in central Taiwan. The targeted 26 condominium building projects as seen as 26 Decision Making Units (DMU) for the application of DEA. The following sections cover application of DEA, research methodology, data collection and results discussion, and conclusions.

Use DEA to Performance Assessment

Both for-profit and non-profit organizations hope to maximize their output (or services) and minimize their inputs. Organization performance is evaluated on the basis of the balance of inputs and outputs. Evaluating staff performance provides managers with information required to achieve the organization's goals and improve management deficiencies. Many viewpoints have been expressed on the implications of performance assessment. Several methods, such as Balanced Scorecard, Ratio Analysis, Multi-criteria Analysis, Regression Analysis and Production Frontier Approach, are used to measure performance in practice. While many of the measurement methods are practical, they are subject to many restrictions.

DEA is a method of measuring the comparative efficiency of homogeneous operating units. It obtains efficiency values via mathematical planning methods without using production behavior to produce assumptions (or without any alphanumeric settings). Using units with neutral characteristics (i.e., the input and output units are not consistent), it is used to measure technical efficiency, allocation efficiency, technological change and changes in total factor productivity. When using DEA for assessment, only inputs and outputs need to be decided, and it is not necessary to pre-determine mutual weighting, nor is a large data sample required.

Via mathematical modeling of inputs and outputs, DEA calculates production boundaries as the base measurement of efficiency, citing the concept of the production function in executing efficiency

Table 1. DEA-related studies

Authors	Research topics	Research results
Žižka et al. (2016)	Used a two-stage DEA method with BCC model orientated at inputs to evaluate the selected Czech innovative companies, and the impact of a branch on their performance in terms of effectiveness and efficiency.	There are significant differences in both the overall level of performance, and in its pillars – effectiveness and efficiency among branches.
Chiu et al. (2017)	Adopted the context-dependent DEA model to analyze the operating efficiency of 49 international tourism hotels (ITHs) in Taiwan.	Of the 49 ITHs, 17 have been operating at the same levels for over three years; 25 have similar rankings in all levels of attractiveness values; 11 have the same progress values in all levels.
Park & Kim (2016)	Assessed Korea's energy efficiency using a modified hybrid model of index decomposition analysis, artificial neural network, and DEA. The research predicts the optimal energy consumption and estimate the difference between the optimal and real values.	Energy consumption was the most efficient between 1993 and 1994, 1994 and 1995, 1997 and 1998, and 1999 and 2000. If the over-fitting and negative value problems are properly controlled, the proposed hybrid model can be used to predict energy efficiency.
Titko et al. (2014)	Used non-parametric frontier technique DEA via 14 alternative models with different inputs-outputs combinations to measure efficiency of Latvian banks.	Provides general recommendations about the variables selection for DEA applied to the Latvian banking sector. The research contributes to the existing analytical data on bank performance in Latvia.
Hadad et al. (2013)	Proposed a 7-step decision making support system (DMSS) module for selecting project managers based on the past performance of potential managers. The proposed DMSS was demonstrated using an Israeli information technology firm selecting a project manager.	A ranking method within the DEA context (the Cross-Efficient method) was implemented with three inputs and four outputs selected for the project ranking. The DMSS aims to maintain the matching process where subjective considerations can be replaced by objective ones.
Luo et al. (2012)	Proposed a new method for choosing DEA variables based on statistic results. The method was applied to 14 Chinese commercial banks, and both regression and statistic test results were satisfactory.	The proposed method has several advantages including: (1) improves objectivity; (2) provides managers and researchers with measurement variables and exact classifications of the factors; (3) variables come from easily available financial statements.
El-Mashaleh et al. (2010)	Evaluated and benchmarked the safety performance of 45 Jordanian construction contractors.	Input items include annual costs of safety programs and salaries of safety personnel, and contractor safety expenses revenues. The amount of different types of accidents suffered by the contractor are used as the outputs.
Zhang et al. (2013)	Proposed a non-radial DEA model with the slacks-based measure to analyze the environmental efficiency of China's transportation sector.	China's transportation industry is inefficient in terms of environmental impacts. China can significantly reduce carbon emissions, ranging from at least 1.6 million TOEs in Qinghai and at most 33 million TOEs in Guangdong and Shanghai.
Chen et al.	Uses Network DEA to develop a 3-phase	The model is equipped with three dimensions

(2017)	based residential building operation assessment model and use it to assess the operational efficiency of 26 DMUs to obtain the performance index of dimensions.	(with its weight) named staff quality, customer satisfaction and operation performance. Most of the total DMU efficiency values fell between 0.75 and 0.90, with one DMU equipped with 1.
Kheirollahi et al. (2015)	The research proposed a model of congestion, based on relaxed combination of inputs, in stochastic data envelopment analysis with chance constrained programming approaches to solve non-linear problems.	Replacing stochastic models with ‘‘deterministic equivalents”, the study used chance constrained programming approaches to identify congestion input in six Iranian hospitals with one input and two outputs in the period of 2009 to 2012.

Table 2. Inputs and outputs for four different dimensions

Inputs	Definition	OF	MS	SQ	PQ
Direct personnel costs	Labor costs for on-site personnel	**I**		**I**	**I**
Overhead costs	Main office labor costs and on-site office supply costs	**I**		**I**	**I**
Number of personnel deployed	Number of personnel deployed on-site (including general work, security and custodial), based on a unit of 1 person/time = 8 hours.	**I**	**I**	**I**	**I**
Total floor area	Total floor area including each floor of the building, basement levels, roof areas, balconies, mezzanines, and attics.	**I**		**I**	**I**
Number of disaster drills	Number of annual disaster drills	**I**	**I**		
Hours of personnel training	Average total number of annual training hours for personnel	**I**	**I**	**I**	**I**
Number of professional licenses	Total number of licenses and certifications held by on-site personnel		**I**		**I**
Number of community activities	Number of internal activities conducted annually.	**I**	**I**	**I**	
Contract amount	Annual contractual income for the case	**O**			
Satisfaction with management service center	Satisfaction score awarded by the residents’ committee (full score = 50)			**O**	
Disaster score	Annual number of police and fire alerts (full score = 10)		**O**		
Staff retention rate	Annual retention of staff				**O**
Rate of management fee collection	Percentage of management fee collection		**O**		

Note: I indicates the selected inputs while O indicates the selected outputs; OF = Operational finance; \MS = Management system; SQ= Service quality; PQ= Personnel quality

assessment. DEA has been widely used as an effective tool to assess the relative performance efficiency of the completed projects by incorporating multiple input and output variables. Table 1 shows that DEA has been recognized as a robust tool for assessing the performance of business organizations and projects, with analysis methods divided into vertical and horizontal for comparison. The main difference is that vertical analysis uses different annual data to discover changes in efficiency between organizations or projects, while horizontal analysis compares performance between organizations and projects in the same year. This paper focuses on performance assessment in CBM, particularly in terms of the ad hoc nature of projects, and thus uses horizontal analysis.

Although DEA has been extensively utilized for efficiency measurement in various industries, it has not been widely used in the property management industry, let alone in measuring the efficiency of CBM. We suggest DEA could be useful in producing a systematic analysis and assessment of such performance. DEA model and data analysis

The DEA model can be differentiated by "returns to scale" and "orientation" into six types (Golany & Roll, 1989). This study uses the input orientation of the CCR and BCC models. The CCR model demonstrates that the efficiency of a DMU can be expressed as the maximum of the ratio of weighted outputs to weighted inputs (Charnes et al., 1978). The objective in the CCR model is constant return to scale, meaning that a proportional increase in inputs leads to a proportionate increase in outputs. The BCC model was developed to estimate the pure technical efficiency of DMUs with reference to the efficient frontier (Banker et al., 1984). The BCC model also identifies if a DMU is operating in increasing, decreasing or constant returns to scale. Thus, in this context CCR models are considered a specific type of BCC model.

DEA can be differentiated into six steps to implement performance assessment including: (1) define DMU, (2) select inputs and outputs, (3) collect and organize data, (4) process data analysis, (5) build a solution model, and (6) present and interpret results. In this study, the collected data were analyzed using several methods as follows.

Pearson correlation: The correlation between two variables can be measured by multiple statistical methods. One of the most commonly used methods is the linear correlation coefficient (r, Pearson correlation coefficient). This study uses Pearson product differential relation analysis to determine the degree of correlation for the inputs and outputs of each dimension.

Efficiency analysis: Whenever the efficiency value of DMU=1, it indicates that the DMU is efficient. When the corresponding efficiency value < 1, it indicates that the DMU is inefficient. Norman and Stocker (1991) classified

DMUs into four types based on their overall efficiency values.

Sensitivity Analysis: Sensitivity analysis is defined as "the degree of influence of a change in the number of DMUs or of inputs and outputs on the DMU's corresponding efficiency value" (Charnes et al., 1985). Different inputs and outputs result in different efficiency frontiers. One can identify the key contributions of inputs and outputs to the efficiency and advantages of each DMU by adjusting the inputs and outputs.

Scale efficiency analysis: The BCC model can be used to determine the indicators of returns to scale. Constant returns to scales indicate the DMU is producing under optimal scale conditions, where the BCC and CCR models have similar efficiency values. Increasing returns to scales indicate that the DMU is producing at lower than optimal conditions, and that the rate of increase for outputs exceeds that of inputs. Decreasing returns to scales indicate the DMU is producing under beyond optimal scale conditions, and the rate of increase for outputs is less than that for inputs.

Collection and Results Discussion

DMU, Inputs And Outputs Determination

In this study, management services purchased by CBM committees are regarded as a DMU. These services include integrated community management, building management planning, consulting and advisory services (i.e., counseling management operation and the acting). To utilize DEA to perform relative efficiency assessment, one must first determine the DMU in consideration of the following:

1. Similar internal characters: The residential DMUs involve similar management and service items, and the input and output items for management performance are also roughly similar.

2. Different external environment: The environment for each DMU is different in terms of location, area, number of units and scale. Each DMU thus entails different personnel inputs.

3. Number of DMUs: This study collected 26 DMUs and assessed their corresponding efficiency values based on input and output data. According to Norman and Stocker (1991), the number of DMUs (= 26) should not be less than the double of the total number of inputs and outputs (= 13).

Six top management professionals, each with more than 15 years of property management experience, were invited to extract performance indicators from the *Handbook of Property Management Service Quality Management and Performance Indicators* published by Taiwan's Ministry of Economic Affairs. The same professionals also recommend that the efficiency of targeted CBM be

measured from the viewpoints of operational finance (OF), management system (MS), service quality (SQ) and personnel quality (PQ). A 3-stage interview was conducted to determine the proposed model's performance indicators in terms of inputs and outputs (Table 2). Pearson correlation coefficient analysis was performed to determine whether inputs and outputs are significantly correlated. Shown in Table 2, the proposed inputs and outputs are positively correlated, indicating that the eight inputs and five outputs determined by this study are reasonable.

Efficiency Analysis Of The Operational Finance Dimension

This study assesses DMU efficiency through four dimensions including operational finance, management system, service quality and personnel quality. Operational finance is taken as an example to show the process and results of efficiency analysis, with the analysis of the other dimensions following a similar process.

Overall Efficiency Analysis

The overall efficiency of each DMU is sorted by technical efficiency and referred counts. If a DMU has a value equals to 1, it is an efficient DMU, while a value below 1 indicates relatively inefficient. This study utilizes the CCR input-oriented method to calculate the technical efficiency of each DMU, separately sorting DMUs by technical efficiency (technical efficiency and referred counts), as in Table 3. The table shows 10 efficient DMUs (technical efficiency value = 1), and 16 inefficient DMUs. Overall efficiency is optimal in the top five DMUs (DMU_{09}, DMU_{11}, DMU_{10}, DMU_{17} and DMU_{08}) and least optimal in the bottom five DMUs (DMU_{25}, DMU_{21}, DMU_{03}, DMU_{05} and DMU_{23}). DMU_{09} is the most optimal DMU, and was referred 17 times by inefficient DMUs, followed by DMU_{11} (referred 11 times). DMU_{25} was the least optimal DMU, with a technical efficiency of 0.6175, with 38.25% of resources being wasted.

Analysis Of Pure Technical Efficiency, Technical Efficiency And Return Of Scale

The CCR model can be used to obtain the technical efficiency for each DMU. The pure technical efficiency can then be obtained through the BCC model, and dividing the technical efficiency by pure technical efficiency obtains the scale efficiency, thus indicating whether the inefficiency is due to scale inefficiency or technical inefficiency. If it is due to scale inefficiency, return of scale analysis can determine whether to expand or reduce the scale of operations, depending on whether the return of scale is increasing or decreasing. If technical inefficiency is prompted by pure technical inefficiency, it is subject to management control and could be improved in the short term. If it comes from scale inefficiency, it would be difficult to improve in the short term, and may require the integration of technical efficiency

Table 3. Overall efficiency ranking, efficiency and RS type for all DMUs

DMU	Overall TE	Referred counts	Rank	DMU	TE	PTE	SE	RS type
DMU_{09}	1.00000	17	1	DMU_{01}	1.00000	1.00000	1.00000	CRS
DMU_{10}		10		DMU_{05}	1.00000	1.00000	1.00000	
DMU_{11}		11		DMU_{08}	1.00000	1.00000	1.00000	
DMU_{17}		5		DMU_{09}	1.00000	1.00000	1.00000	
DMU_{08}		4		DMU_{10}	1.00000	1.00000	1.00000	
DMU_{20}		4		DMU_{11}	1.00000	1.00000	1.00000	
DMU_{19}		3		DMU_{15}	1.00000	1.00000	1.00000	
DMU_{01}		2		DMU_{17}	1.00000	1.00000	1.00000	
DMU_{15}		2		DMU_{19}	1.00000	1.00000	1.00000	
DMU_{05}		1		DMU_{20}	1.00000	1.00000	1.00000	
DMU_{04}	0.99756	0	11	DMU_{04}	0.99756	0.99917	0.99840	
DMU_{16}	0.96367		12	DMU_{16}	0.96367	1.00000	0.96367	IRS
DMU_{06}	0.93632		13	DMU_{06}	0.93632	1.00000	0.93632	
DMU_{07}	0.93395		14	DMU_{07}	0.93395	1.00000	0.93395	
DMU_{26}	0.92360		15	DMU_{26}	0.92360	1.00000	0.92360	
DMU_{18}	0.91574		16	DMU_{18}	0.91574	1.00000	0.91574	
DMU_{24}	0.87618		17	DMU_{24}	0.87618	1.00000	0.87618	
DMU_{13}	0.84750		18	DMU_{13}	0.84750	1.00000	0.84750	
DMU_{22}	0.80750		19	DMU_{22}	0.80750	1.00000	0.80150	
DMU_{02}	0.79774		20	DMU_{02}	0.79774	0.91644	0.87048	
DMU_{14}	0.75228		21	DMU_{14}	0.75228	0.85660	0.87822	
DMU_{23}	0.72467		22	DMU_{23}	0.72467	0.85583	0.84675	
DMU_{12}	0.70809		23	DMU_{12}	0.70809	0.88011	0.80454	
DMU_{03}	0.69735		24	DMU_{03}	0.69735	0.89179	0.78196	
DMU_{21}	0.63376		25	DMU_{21}	0.63367	0.78019	0.81232	
DMU_{25}	0.61750		26	DMU_{25}	0.61750	0.73736	0.83745	

Note: TE= Technical efficiency; PTE= Pure technical efficiency; SE= Scale efficiency

and return of scale to be adjusted to optimal scale. According to Norman and Stocker (1991), DMUs can be classified into four types. Explaining details, based on Table 3, are as follows:

1. Robustly efficient units: Technical efficiency, pure technical efficiency and scale efficiency are all equal to 1 for robustly efficient unit which is the benchmark of other units. The return of scale of robustly efficient unit should be fixed or it may maintain an inefficient state. Thus, there is no need to increase outputs or decrease inputs to maintain the current production scale. For example: DMU_{09} (17 times), DMU_{11} (11), DMU_{10} (10), DMU_{17} (5) and DMU_{08} (4).

2. Marginal efficient units: Technical efficiency, pure technical efficiency and scale efficiency are all 1, and efficiency reference sets appear only once

or twice. If there is a slight change in inputs or outputs, the efficiency value may be below 1. For example: DMU_{01} (2 times), DMU_{15} (2) and DMU_{05} (1).

3. Marginal inefficient units: Technical efficiency value is below 1 but greater than 0.9. If the pure technical efficiency is 1 and scale efficiency is less than 1, the technical efficiency and inefficiency stems from scale inefficiency. For example: DMU_{06}, DMU_{07}, DMU_{16}, DMU_{18} and DMU_{26} are stages of ISR, and the scale of production should be decreased to improve inefficiencies. If scale efficiency values are very close to 1 and the scale efficiency value is greater than the pure technical efficiency value, then total efficiency and inefficiency stems from technical inefficiency. To improve these inefficiencies, the most suitable inputs should be used to maximize outputs. Fortunately, this type of situation did not arise in the performance dimensions.

4. Distinctly inefficient units: Unit efficiency values are apparently below 0.9, e.g., DMU_{02} (0.79774), DMU_{03} (0.69735), DMU_{12} (0.70809), DMU_{13} (0.84750), DMU_{14} (0.75228), DMU_{22} (0.80750), DMU_{23} (0.72467), and DMU_{25} (0.61750). Technical efficiency, pure technical efficiency and scale efficiency may all be below 1, with inefficiency stemming from technical inefficiency or scale inefficiency. Improving this type of inefficient situation requires the simultaneous improvement of the ratio of inputs and outputs to adjust the scale of production.

Analysis For Each Performance Dimension

Table 4 shows DMUs which appear at least twice among the top five for each efficiency dimension. Ranked in descending order, they are DMU_{05}, DMU_{15}, DMU_{18}, DMU_{08}, DMU_{24}, DMU_{08}, and DMU_{24}. DMUs which appear at least twice among the bottom five for each efficiency dimension include DMU_{25}, DMU_{21}, DMU_{03}, DMU_{23}, DMU_{20} and DMU_{02}. Some key findings of Table 5 are summarized as follows:

1. The overall efficiency of the four dimensions generally exceeds 0.85. The overall efficiency of the personnel quality dimension was the lowest. Only limited DMUs reach the efficiency frontier in terms of personnel quality performance.

2. The technical efficiency of the operational finance dimension was 0.8897, indicating that 11.03% of project resources were wasted. Pure technical efficiency and scale efficiency were 0.9584 and 0.9244, respectively, indicating that 4.16% of the resource wastage was due to technical inefficiency, while 7.56% was due to scale inefficiency.

3. The technical efficiency of the management system dimension was 0.9443, indicating that 5.57% of DMU resources were wasted in this dimension.

Pure technical efficiency and scale efficiency were 0.9644 and 0.9788, respectively, indicating that 3.56% of the resource wastage was due to technical inefficiency, while 2.12% was due to scale inefficiency.

4. The technical efficiency of the service quality dimension was 0.9197, indicating that 8.03% of project resources were wasted in this dimension. Pure technical efficiency and scale efficiency were 0.9375 and 0.9803, respectively, indicating that 6.25% of the resource wastage was due to technical inefficiency, while 1.97% was due to scale inefficiency.

5. The technical efficiency of the personnel quality dimension was 0.8579, indicating that 14.21% of project resources were wasted in this dimension. Pure technical efficiency and scale efficiency were 0.9584 and 0.8929, respectively, indicating that 4.16% of the resource wastage was due to technical inefficiency, while 10.71% was due to scale inefficiency.

Conclusions

In today's competitive business environment, companies need a method to effectively compare the performance of various projects within a given time period. Such a method is needed to allow managers to effectively allocate resources, motivate project managers and their teams and to create an environment conducive to continuous improvement. The DEA approach provides an input–output framework and can be used to assess overall efficiency and the relative efficiency of each DMU, rather than absolute efficiency. In this study, DEA measures the management efficiency of VBM via eight inputs and five outputs confirmed by the Pearson correlation coefficient, producing management efficiency ratings on a scale of 0–1. The key findings are as follows:

1. For the four dimensions used to assess DMU efficiency, technical efficiency typically averaged more than 0.85. The personnel quality dimension is ranked the lowest in efficiency while the management system dimension is the most efficient. The most efficient DMU in each dimension was DMU_{06} (operational finance), DMU_{26} (management system), DMU_{05} (service quality) and DMU_{18} (personnel quality), respectively.

2. The key influence of each dimension was identified using sensitivity analysis. The management system dimension is found to have a significant degree of influence, while service quality does not. The personnel quality dimension only has a significant degree of influence on overhead costs, but less influence elsewhere.

3. Resource wastage by each dimension can be identified via pure technical efficiency and scale efficiency. Resource wastage for technical efficiency and scale inefficiency are measured for the operational finance dimension (4.16% and 7.56%, respectively), the management system dimension

Table 4. Top five efficiency performers in each dimension

	Better ← Efficiency → Worse					Better ← Efficiency → Worse				
	1st	2nd	3rd	4th	5th	5th to last	4th to last	3rd to last	2nd to last	Last
OF	DMU_{06}	DMU_{11}	DMU_{10}	DMU_{17}	DMU_{08}, DMU_{20}	DMU_{23}	DMU_{12}	DMU_{03}	DMU_{21}	DMU_{25}
MS	DMU_{26}	DMU_{05}, DMU_{15}	DMU_{02}, DMU_{18}	DMU_{08}, DMU_{24}	DMU_{19}	DMU_{23}	DMU_{25}	DMU_{16}	DMU_{20}	DMU_{03}
SQ	DMU_{05}	DMU_{22}	DMU_{15}	DMU_{04}, DMU_{06}	DMU_{03}, DMU_{18}	DMU_{25}	DMU_{23}	DMU_{02}	DMU_{21}	DMU_{20}
PQ	DMU_{18}	DMU_{10}	DMU_{05}, DMU_{26}	DMU_{02}, DMU_{15}	DMU_{13}, DMU_{24}	DMU_{21}	DMU_{11}	DMU_{02}	DMU_{03}	DMU_{22}

Note: OF = Operational finance; MS = Management system; SQ= Service quality; PQ= Personnel quality

Table 5. Average efficiency and resources wasted for each dimension

Indicator / Dimension	TE		PTE		SE	
	Average TE	Resource wastage	Average PTE	Resource wastage	Average SE	Resource wastage
OF	0.8897	11.03%	0.9584	4.16%	0.9244	7.56%
MS	0.9443	5.57%	0.9644	3.56%	0.9788	2.12%
SQ	0.9197	8.03%	0.9375	6.25%	0.9803	1.97%
PQ	0.8579	14.21%	0.9584	4.16%	0.8929	10.71%

Note: OF = Operational finance; MS = Management system; SQ= Service quality; PQ= Personnel quality; TE= Technical efficiency; PTE= Pure technical efficiency; SE= Scale efficiency

(3.56% and 2.12%), the service quality dimension (6.25% and 1.97%), and the personnel quality dimension (4.16% and 10.71%).

4. Among the five most efficient DMUs, DMU_{08}, DMU_{05}, DMU_{15} and DMU_{18} are considered the benchmark DMUs, while DMU_{25}, DMU_{21}, DMU_{03}, DMU_{12} and DMU_{23} are in the five least efficient and most in need of urgent improvement. The main causes of inefficiency and the corresponding adjustment methods to improve particular DMUs are provided, allowing for the improvement of inefficient situations.

This research makes three primary contributions. First, it provides building site managers and researchers with relevant variables for consideration in measuring performance of CBM. Second, the proposed approach is more objective in that DEA relates resources expended on a certain performance to its associated level of success. Third, the data required for analysis can be easily obtained since all relevant variables should be easily collected in the project.

Taiwan's property management industry currently lacks any readily available efficiency measure to objectively assess the efficiency of CBM. Similar situations can be found in Great Chinese Area, and there is a pressing need for a systematic approach to gap filling. The proposed DEA approach is suited to fill this gap, and can be used to measure the management performance of a particular condominium building over time. The authors believe that the proposed approach is applicable to the Great Chinese Area, particularly China, Taiwan, and Macao due to their similar building management environment and philosophy.

Collection of a complete data set should assist in more extensive performance assessment for CBM, and allow for the discovery and remediation of more on-site problems. This study was limited to data collection, and only a single year's data was used for analysis. A longitudinal study may provide effective comparison if DMU data for multiple years are collected. Taking each year as a single DMU, the quality of CBM could be assessed quantitatively over time. In addition, the proposed methodology can be employed at the company level, with each company taken as a single DMU. As a result, management companies will be able to identify their best performing projects and internal factors that contributed to better performance.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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LINKS BETWEEN SWITCHING COSTS, BRAND TRUST, AND CUSTOMER LOYALTY IN MOBILE PHONE SERVICES

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Abstract

The purpose of this study is to integrate and examine empirically for the relationships between switching costs, brand trust, and customer loyalty. All data collected from the target population are analyzed through two-step structural equation modeling (SEM) to examine the hypotheses. 1,050 questionnaires are randomly distributed at 21 telecommunication service stores in Taiwan. As a result, findings indicate that the only moral hazard cost and hold-up cost have indirect impact on behavioral loyalty via brand trust or attitudinal loyalty. Moreover, findings identify not only switching costs as the multidimensional concept but also brand trust and attitudinal loyalty as mediating roles in strengthening customer real purchase action. Besides the need for empirical confirmation of the hypotheses given, finally, there are several practical implications for service marketers and future research directions for scholars.

Keywords: Information Search Cost, Moral Hazard Cost, Hold-Up Cost, Customer Loyalty

Introduction

Customer loyalty has received great attention to be one of the key central elements that generate benefits and gain sustainable competitive advantages to corporations (Matzler et al., 2008; Moisescu & Allen, 2010; Ngo & Pavelkova, 2017). In the marketing literature, therefore, customer loyalty has been recognized as marketing advantages to corporations for decades (Aaker, 1991; Chaudhuri & Holbrook, 2001; Chinomona et al., 2013; Moisescu & Allen, 2010; Ngo & Pavelkova, 2017; Zhang & Mattila, 2015).

To maintain or enhance consumer customer loyalty, not only do companies do their best to provide consumers with better products and services, but also try to prevent consumer switching behavior. What companies do is to hope that consumers can continue purchasing their products or services. Numerous studies have focused on factors as determinants of customer loyalty in different areas and examined the relationships between those factors, such as service quality, brand trust, and risk aversion. Most of studies have demonstrated those factors have positive correlation with customer loyalty (Chaudhuri & Holbrook, 2001; Chinomona et al., 2013; El-Manstrly et al., 2011; Lui et al., 2017; Matzler et al., 2008; Ngo & Pavelkova, 2017; Zhang & Mattila, 2015). However, relatively few studies have examined relationships between switching costs and customer loyalty even though evidence indicates switching costs will increase switching difficulty or prevent consumer switching behavior (Jones et al., 2002). This is because the measurement of switching costs lacks a consistent instrument (Hu et al., 2016). Moreover, the role of switching costs in a service industry has been rarely acknowledged (Jones et al., 2002). To fill this gap, therefore, the purpose of this study is to integrate and examine empirically for the relationships between switching costs, brand trust, and customer loyalty in order to obtain a deeper understanding of customer subsequent brand choice when facing switching barriers.

Empirical illustration of this study is also focused on the mobile phone service market in Taiwan. As of June 2017, the number of mobile phone users has reached 29.68 million with about 130% of penetration rate and indicates that mobile phones in Taiwan are very prevalent (National Communications Commission in Taiwan, 2017). Therefore, it is of great interest to marketing researchers not only for its rapid growth, but also for its implications to customer loyalty management in the competitive mobile phone service market. To accomplish these objectives, the present paper is organized as follows: through literature review and integration in several relevant fields, first of all, the paper derives research hypotheses and develops a conceptual model. Through structural equation modeling (SEM) and Bootstrapping test, next, all data collected from the target population in Taiwan are analyzed. Finally, the findings are presented, followed by conclusions and discussions of the findings including several managerial implications and future research directions.

Related Literature and Development of Hypotheses

Brand Trust and Customer Loyalty

In the marketing literature, customer loyalty is not only defined as a deeply held commitment to rebuy or repatronize a preferred product or service consistently in the future, despite situational influences and marketing efforts having potential to cause switching behavior (Oliver, 1997), but is also viewed as a measure of the attachment that "a customer has to a brand" (Aaker, 2005, p.50). Authors point out customer loyalty is formed in a gradual, sequential manner from cognitive loyalty to affective loyalty to conative loyalty and, finally, to behavioral loyalty. These different aspects of loyalty do not emerge simultaneously,

but rather consecutively over time (Adia et al., 2015; Oliver, 1999). In accordance with Oliver (1999), who suggests that customer loyalty should be categorized into attitudinal loyalty (including cognitive, affective, and conative loyalty) and behavioral loyalty. In the marketing literature, moreover, if the companies make it possible to put more emphasis on the cognitive dimension by offering customized products or services to their customers, then the results will lead to strengthen the affective dimension and followed by conative dimension, finally, increase behavioral loyalty of their customers. This is because once customer attitude towards a brand is positive, highly loyal buyers tend to stay loyal (Adia et al., 2015; Blut et al., 2007; El-Manstrly et al., 2011; Matzler et al., 2006, 2008). Therefore, it is recommended that customer attitude has a significant impact on behavioral loyalty. In the mobile phone service field, therefore, the following hypothesis is proposed:

H_1 Attitudinal loyalty is positively related to behavioral loyalty.

In the commitment-trust literature, brand trust is defined as "the willingness of on the average consumer to rely on the ability of the brand to perform its stated function" (Chaudhuri & Holbrook, 2001, p.82). Riegelsberger et al. (2005) classify trust as cognitive and affective/emotional trust. Cognitive trust based on evaluating the competence, reliability, and predictability of the trusted object reflects the economic understanding of trust as rational choice, while affective trust is the emotion-driven form of trust because of originating from immediate affective reactions, on attractiveness, aesthetics, and signals of benevolence. Orzan et al. (2016) point out a mix of cognitive and affective trust leads to frequently trust-based behavior. In order to build brand trust, therefore, products or services have to meet or even exceed expectations of the customers.

Prior studies also consider brand trust as a key factor building long-term relationships between a company and her consumers. This is because if a consumer trusts a company providing highly values of products/services, then he/she will more likely develop some form of positive behavioral intention towards this company (Lau & Lee, 1999; Liu et al., 2017; Morgan & Hunt, 1994; Rousseau et al., 1998). As a result, customer loyalty as an important outcome of brand trust has been conceptualized either as behavioral intention towards the brand or as actual pattern of purchase behavior, or both (Matzler et al., 2006, 2008). Under uncertain or ambiguous circumstances, especially, not only do higher trust ratings reduce psychological anxiety and may positively affect consumer decision-making process, but also correlate positively with attitudinal and behavioral loyalty (Reast, 2005). In the mobile phone service context, therefore, the two hypotheses are proposed as follows:

H_{2a} Brand trust positively influences attitudinal loyalty.

H_{2b} Brand trust positively influences behavioral loyalty.

Switching Costs, Brand Trust, and Customer Loyalty

In marketing literature, not only is switching cost considered as one of switching barriers that will increase switching difficulty or prevent consumer switching behavior (Jones et al, 2000), but is also defined as the costs that customers need to incur when they move from one service or product provider to others (Heide & Weiss, 1995). That is, when considering changing service providers, customers will evaluate the benefits after are switching and the cost (price) they will pay (Hu et al., 2016). In accordance with Jones et al. (2002, 2003), when consumers perceive that they must pay higher switching costs, the switching motivation will decline. As a result, the related switching costs will diminish the exchange relationship between a service provider and her customers (El-Manstrly et al., 2011). Based on the study by Ngo and Pavelkova (2017), moreover, switching costs are divided into two different types, including the positive switching costs (the benefits from interpersonal relationships and the emotional connection with the service providers) and negative switching costs (monetary costs and procedural expenses like times and efforts). The two switching costs in banking industries significantly impact on customer loyalty.

In this study, switching costs can be clustered into three main groups: information search cost, moral hazard cost, and hold-up cost. Information search costs refer to when changing from one provider to another, specifically, consumers entail search and learning costs (Chiu, 2006; Jones et al., 2002). The higher level of information search costs, the stronger customer loyalty is (Chiu, 2006; Ngo & Pavelkova, 2017). However, empirical results by El-Manstrly et al. (2011) indicate no impact of information search costs on customer loyalty. In order to build the gap, therefore, the two hypotheses are proposed as followed:

H_{3a} Information search costs positively influences attitudinal loyalty.

H_{4a} Information search costs positively influences behavioral loyalty.

In the telecommunication services context, in order to build a good customer relationship with service providers, mobile phone service providers often give consumers promises that consumers can obtain specific services or benefits from their companies before the transaction. All specific services or benefits will be terminated once customers change from the current provider into another (Chiu, 2006). This is the so-called moral hazard cost and belongs to one of relational costs. The higher level of moral hazard costs, the stronger customer loyalty is. Therefore, we propose two hypotheses as follows:

H_{3b} Moral hazard costs positively influences attitudinal loyalty.

H_{4b} Moral hazard costs positively influences behavioral loyalty.

As to hold-up cost, authors point out it is one of sunk costs or financial switching costs (Blut et al., 2007; Chiu, 2006; Ngo & Pavelkova, 2017). This is because preferential programs or a special discount always provide a stronger customer incentive to continue purchasing from the same provider, even when others are offering functionally identical products or services (El-Manstrly et al., 2011). How-

ever, once customers switch from the current provider into others, they may need to pay more money back. In the telecommunication service context, therefore, we propose two hypotheses as follows:

H_{3c} Hold-up costs positively influences attitudinal loyalty.

H_{4c} Hold-up costs positively influences behavioral loyalty.

In the commitment-trust literature, switching costs explicitly foster brand trust and then transferring intentions into action (Burnham et al., 2003). Through setting up higher level of moral hazard costs, for example, mobile phone service providers can build better relationship with their customers and further increase customer brand trust. Moreover, service providers offer specific services or preferential programs to their customers so as to enhance customer satisfaction. The higher customer satisfaction will lead to increase customer brand trust (Aldisert, 1999; Lee et al, 2001). In the mobile phone service context, therefore, the hypothesis is proposed as follows:

H_5 Switching costs positively influences brand trust.

Research Model

Based on the earlier literature, not only does the proposed model in this study examine the mediating role of brand trust in the relationships between switching costs and customer loyalty, but also explores the effects of switching costs on customer loyalty (see Figure 1).

Methodology

The Questionnaire Design and Sample

A personally administered questionnaire was used to collect the date. A total 23 items questionnaire which contains seven parts: Personal characters, switching costs, brand trust, and customer loyalty. Personal characters (6items) contain gender, age, education, occupation, year income, and marriage situation. Brand trust (4 items) and customer loyalty were (4 items) were measured using the scales developed by Chaudhuri and Holbrook (2001). Switching costs (9 items) was measured with a modified version of Chiu (2006), which divided switching costs into three parts: information search cost (3 items), moral hazard cost (3 items) and hold-up cost (3 items).

Based on the study by Licit and Green (1975), Likert-type scales are easily completed by respondents and provide reliable. Therefore, in this study all statements were measured on a five-point Likert-type (1 = strongly agree, 5 = strongly disagree). Moreover, based on recommendation of Hair et al. (2006), to have reliable sample size the minimum sample will be five respondents per survey item. The measurement instrument used in this study had 23 items, which means the minimum number of respondents for factor analysis for this study should be 260. The total of 292 respondents completed the questionnaires on-site.

Data Collection and Analysis of Reliability and Validity

All data collected from the target population are analyzed through a

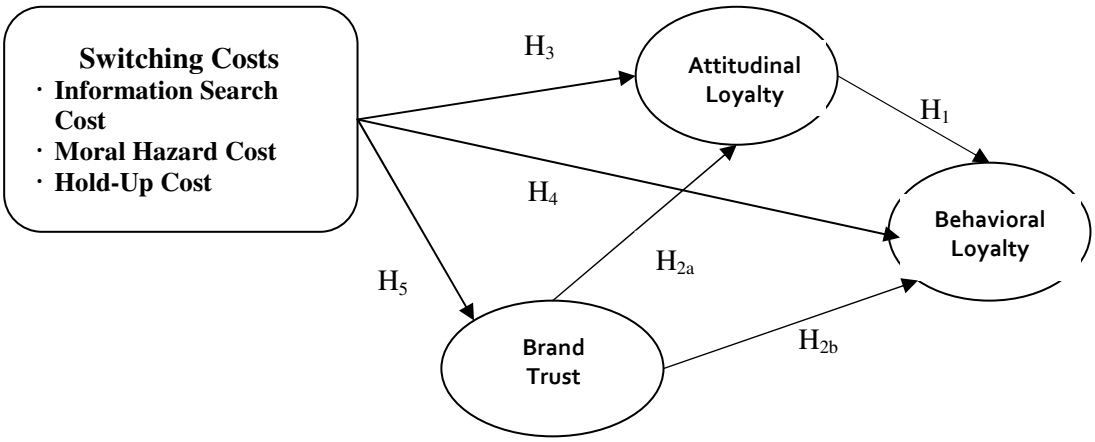

Figure 1. Research model.

Table 1. Standardized loadings and reliabilities

Construct	Indicators	Standardized loadings	AVE	Cronbach's α
ISC	SC1	0.76***	0.60	0.81
	SC2	0.90***		
	SC3	0.65***		
MHC	MC1	0.77***	0.65	0.79
	MC2	0.85***		
	MC3	0.80***		
HUC	HC1	0.69***	0.52	0.75
	HC2	0.72***		
	HC3	0.76***		
Brand Trust	Trust1	0.77***	0.62	0.86
	Trust2	0.58***		
	Trust3	0.90***		
	Trust4	0.87***		
Behavioral loyalty	BL1	0.87***	0.78	0.88
	BL2	0.90***		
Attitudinal loyalty	AL1	0.92***	0.64	0.75
	AL2	0.66***		

Goodness-of-fit indices (N = 291); $\chi^2(51) = 278.667$ ($p < 0.001$); RMSEA = 0.047; RMR = 0.046; GFI = 0.940; AGFI = 0.919; CFI = 0.967; NFI = 0.921.
ISC = information search cost; MHC = moral hazard cost; HUC = hold-up cost.

two-step structural equation modeling (SEM) to analyze a measurement model and a structural model in order to examine the hypotheses. For achieving this statistical analysis, Amos 22.0 is adopted to examine validity and reliability of the instrument as well as all hypotheses. In accordance with Hair et al. (2006), not only is SEM capable of dealing with theoretical constructs which are measured by latent factors, but is also more powerful to fulfill multiple regression and path analysis for examining the complex interrelationships between constructs. 1050 questionnaires were randomly selected from 21 telecommunications service stores of 7 sections of Taichung in Taiwan. Each telecommunications service stores were selected 10 customers to participate in this study for 5 weeks and the questionnaires based interview were conducted face-to-face. Each week go for different day from Monday to Friday. At the end of date collection process, from the total of 303 completed interviews, and only 291 were validated.

Through confirmatory factor analysis (CFA), measurement validity is first evaluated. It is because the measurement model shows an acceptable model fit to the data: $\chi^2 = 278.667$ ($p < .0001$); $df = 51$; RMSEA = .047 (< .05); RMR = .046 (< .05); GFI = .947 (> .90); AGFI = .919 (> .90); CFI = .967 (> .90); NFI = .921 (> .90) (Bagozzi & Yi, 1988). Convergent validity assesses the extent to which items designed to measure the same construct are related, while discriminate validity assesses the degree to which items designed to measure different constructs are related (Hair et al., 2006). It is found that standardized factor loadings of all items measuring the same constructs are over .60 and significantly related ($p < .001$), as well as the average variance extracted (AVE) for all reach constructs of this study exceeds .50 (see Table 1). Reliability of the instrument, moreover, is assessed with Cronbach alpha. Results illustrate alpha coefficients of all constructs exceed .70 and the fact that the internal consistency and stability of the instrument is acceptable (Nunnally, 1978). Therefore, convergent validity is established. Discriminant validity, finally, is tested by comparing the shared variance among indicators of a construct with the variance shared between constructs. The test for discriminant validity is met when the square root of AVE for the construct is greater than its correlations with other constructs. As a result, correlation values of all items measuring different constructs are significantly low and range from .00 to .62. Therefore, discriminant validity is established (Fornell & Larcker, 1981).

Results

The conceptual model was assessed by examining the path coefficients (the β weight values in Table 2). Overall the structural model fit was acceptable: $\chi^2 = 68.794$ ($p = .04$); $df = 50$; RMSEA = .036 (< .05); RMR = .039 (< .05); GFI = .966 (> .90); AGFI = .939 (> .90); CFI = .990 (> .90); NFI = .963 (> .90). All path coefficients and *t*-statistics for hypothesized relationships were calculated through Maximum Likelihood in AMOS. These findings indicate that the indices are all within the acceptable criteria and the structural model has a good fit (Bagozzi & Yi, 1988). Results of hypothesis testing were presented in Table 2. The results (see Table 2)

Table 2. Path coefficients and *t* value

Path	Standardized coefficients	*t* Value
ISC → Attitudinal loyalty	-0.078	-1.305
ISC → Behavioral loyalty	0.026	0.558
ISC → Brand trust	0.023	0.367
MHC → Attitudinal loyalty	0.234***	3.386
MHC → Behavioral loyalty	0.146**	2.568
MHC → Brand trust	0.462**	6.241
HUC → Attitudinal loyalty	0.176**	2.642
HUC → Behavioral loyalty	0.019	0.361
HUC → Brand trust	0.082	1.208
Brand trust → Attitudinal loyalty	0.505***	6.419
Brand trust → Behavioral loyalty	0.152*	2.289
Attitudinal loyalty → Behavioral loyalty	0.677***	8.002

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$. Goodness-of-fit indices ($N = 291$); $\chi^2(50) = 68.794$ ($p = .04$); RMSEA = 0.036; RMR = 0.039; GFI = 0.966; AGFI = 0.939; CFI = 0.990; NFI = 0.963.
ISC = information search cost; MHC = moral hazard cost; HUC = hold-up cost.

indicate that moral cost has positive and significant effects on attitudinal and behavioral loyalty, but hold-up cost only has positive and significant effects on attitudinal loyalty. Search cost, however, has insignificant impacts on brand trust, attitudinal and behavioral loyalty. Moreover, not only do results indicate the positive impact of attitudinal loyalty on behavioral loyalty, but also reveal the significant effects of brand trust on customer loyalty. As a result, H_1, H_{2a}, H_{2b} and H_5 are supported. However, H_4 are partly supported. On further examining indirect effects of switching costs on customer loyalty, of three switching costs, not only do Bootstrapping test results reveal that moral hazard cost has a significantly indirect impact on behavioral loyalty via brand trust and attitudinal loyalty, but also indicate that hold-up cost has an indirect impact on behavioral loyalty via attitudinal loyalty. However, information search costs have no indirect impacts on behavioral loyalty via either brand trust or attitudinal loyalty.

Discussion, Conclusion and Implications

The purpose of this study is to examine switching costs – brand trust – customer loyalty link in mobile phone service market. The findings demonstrate that when customers have perception of higher switching costs, the positive direct effects of moral hazard cost on customer brand trust, attitudinal loyalty, and behavioral loyalty. Moreover, moral hazard costs have indirect impacts on behavioral loyalty via brand trust and attitudinal loyalty. It is recommended that mobile phone service providers need to build exit an excellent relationship with their customers to prevent consumer switching behavior. For example, not only do mobile phone service providers offer incentives to attract their customers, but also have to put more emphasis on training their employees in order to provide better services to their customers. On enhancing brand trust, the study shows mobile phone users

Table 3. Bootstrapping Test Results

Mediation path	Indirect effect
ISC → Brand Trust → Behavioral loyalty	0.003
ISC → Brand Trust → Attitudinal loyalty	0.012
ISC → Attitudinal loyalty → Behavioral loyalty	-0.053
ISC → Brand Trust → Attitudinal loyalty → Behavioral loyalty	0.008
MHC → Brand Trust → Behavioral loyalty	0.07*
MHC → Brand Trust → Attitudinal loyalty	0.233***
MHC → Attitudinal loyalty → Behavioral loyalty	0.158***
MHC → Brand Trust → Attitudinal loyalty → Behavioral loyalty	0.219*
HUC → Brand Trust → Behavioral loyalty	0.012
HUC → Brand Trust → Attitudinal loyalty	0.041
HUC → Attitudinal loyalty → Behavioral loyalty	0.119*
HUC → Brand Trust → Attitudinal loyalty → Behavioral loyalty	0.028

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.
ISC = information search cost; MHC = moral hazard cost; HUC = hold-up cost.

worried about whether the product is really capabilities and commitment, hope to sign the contract as well as many of the supervisory action to protect the contents of the transaction. Therefore, if the company can enhance consumer trust through a contract, is more likely to enhance consumer loyalty to the brand.

Based on empirical results, hold-up costs have impact on attitudinal loyalty, even though hold-up costs have no impact on brand trust and behavioral loyalty. Moreover, hold-up costs indirectly influence behavioral loyalty via attitudinal loyalty. This is because the mobile phone users gaining exclusive rights and assets due to having a contractual relationship with the mobile phone service providers. The higher asset specificity is, the higher the degree of interdependence between the two sides is. In order to improve the renewal rates of consumers, for example, the mobile phone service providers in Taiwan always offer various types of preferential or discount programs, such as mobile phone discounts, more favorable cost of telephone communications and so on. Once the customer defaults on contracts they previously signed, they will be required to pay liquidated damages. When giving up the contract, losing the asset specificity, and then turning to other competitors to purchase goods, on the other hand, customers will pay high switching costs. Therefore, this study shows that the higher hold-up cost leads to prevent consumer switching behavior (Chiu, 2006; Ngo & Pavelkova, 2017).

As expected, brand trust and attitudinal loyalty play important roles in mediating the relationships between switching costs and behavioral loyalty. These findings are in line with prior research about the mediating roles of customer brand trust and attitude (Chinomona et al., 2013; Lee et al, 2001; Matzler et al, 2006; Zhang & Mattila, 2015).

Limitations and Future Research

This study provides some insight into the way in which switching costs affecting consumer perceptions on customer loyalty interact to influence customer loyalty outcomes, but it has several limitations. First of all, the results in this study may not be generalized in all commodities due to only focusing on one type of service - mobile phone service. Therefore, it is recommended that future studies are needed to examine and validate the generalizability of the findings to more service sectors (Zhang & Mattila, 2015). Second, the results are limited due to the respondents only from one national service context. Consequently, not only could future research replicate the current study with a larger sample, but could also consider that customer loyalty is influenced by other factors, including salesperson service behaviors, government relations, and national culture. Moreover, future research can examine the relationship between the mutual influences of these factors and verify the results more accurately.

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AN EXPLORATION OF RELATIONSHIP AMONG LEISURE INVOLVEMENT, LEISURE BENEFITS, QUALITY OF LIFE, AND TRAINING EFFECTS OF COLLEGIATE ATHLETES

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Abstract

This research aims to discuss the predictions and relations among leisure involvement, leisure benefit, quality of life, and training effect of elite collegiate athletes in Taiwan. Multiple Regression and Path Analysis (LISREL) were applied in this research as well. The results of this research are as follow, in collegiate athletes: (1) The life wellness promotion in leisure benefit is the best predictor of training effect; (2) leisure involvement directly effects on both leisure benefits and quality of life; (3) leisure involvement has no impact on training effect; (4) Leisure benefits directly effects on both quality of life and training effect; (5) Quality of life directly effects on training effect. Finally, in accordance with achieved findings, discussions were made and recommendations were offered to future collegiate athletes.

Keywords: Leisure, Quality of Life, Athletes

Introduction

Being outstanding athletes, it is necessary to dedicate a great amount of time on training to carry out their best performance in competitions. Collegiate athletes are in a more complex situation, because they must maintain both of their competition and academic performance. Whether collegiate athletes can make themselves available for leisure activities or not has been an interesting issue for researchers. Since participating leisure activities can help relieving stress and gaining appropriate relaxation for reserving stamina, therefore it is important for athletes. We expect collegiate athletes to participate more leisure activities to avoid detrimental effects of pressure and anxiety, thus achieve a balanced physical and psychological state.

The importance of leisure activities to human being was postulated by Gunter and Gunter (1980) who compared subjects of participation and non-participation of leisure activities to probe individual's degree of participation and context, and further discov-

ered that leisure involvement includes elements of behaviors, cognition, and emotions. Many studies revealed that participation of leisure activities obtain positive effects on quality of life (Leung and Lee, 2005), as well as physical and psychological health and well-being (Su, Lee & Shinger, 2014). Therefore, this study inferred that collegiate athletes participate leisure activities promote their quality of life.

Leisure involvement is a long-term and continuous participation involving multiple aspects and awakening self-awareness and motivations. Leisure involvement reflects the level of focus and the outcome after activities participation, which could attribute to the value that individual has toward leisure activity (Peter & Olson, 1987; Kyle & Chick, 2004). People participate in leisure activities in a long-term period obtained a higher score in attractiveness; the benefit and experience that one received from participating leisure activity may be varied according to time spent and attitude he/she has (Havitz & Howard, 1995; Gahwiler & Havitz,1998). Further, Wiley, Shaw and Havitz (2000) pointed out that leisure involvement concerns with the meaning, importance and relativeness that the participants received from leisure activities, which further influence participants' decision toward the activities. Huang, Tsai, and Lee (2014) conducted a study to compare different levels of participation and discovered that greater participation of leisure activities result in greater leisure benefits. Therefore, this study inferred that collegiate athletes participate leisure activities would receive leisure benefits.

Celsi and Olson (1988) revealed that the degree of leisure involvement is positively correlated to the awareness of subjects. Mannel (1993) posited that leisure involvement is positively correlated to the experience of psychological tranquility, and further claimed that flow experience is essential to leisure involvement. From the study conducted by Decloe, Karczynski and Havitz (2009), they found that social faction, flow experience and situational involvement are factors of leisure behavior, and further discovered that the degree of involvement in different peers and situations would affect the interest toward leisure activities. Study from Heo and King (2009) showed that experienced athletes tend to invest their time on training, competitions and travelling. According to the study conducted by Liu, Canedy and Tapps (2013) on athletes' lifestyle unveiled that athletes from different regions and areas obtained discrepancy in serious leisure characteristics. Also, athletes' sport skill development, the gaining of social rewards, physical improvements and self-determined enhancement were found positively correlating to the pursuit of leisure activities (Heo, Lee, Lundberg, McCormick & Chun, 2008). Therefore, this study inferred that athletes participate leisure activities would improve the training effect.

Leisure benefit is a subjective concept, and it concerns with personal experiences and feeling. According to subjective evaluation, the benefits that people received from leisure activities may be varied. While participating leisure activities, positive feedback could positively affect the person himself/herself and the society (Kao, 1995). The benefits of participating leisure activities are the relieve of stress and

enhanced development of both physical and psychological abilities. Mannell and Stynes (1991) proposed that people participate sports as leisure activities would be stimulated by many external factors, such as environment, activity types, time and mood. Further, study from Lin, Wong, and Ho (2013) discovered that satisfaction from leisure benefit reveals a positive relation with quality of life. Therefore, managing leisure times and activities become important for collegiate athletes (Chen, Chen & Wu, 2004). According to Kuo (2008), leisure benefits have influences on training effect among elite athletes. Therefore, helping athletes regain confidence and self-assurance, participation of leisure activities is important to training. Thus, this study inferred that athletes receive benefits from participating leisure activities would promote their quality of life. Moreover, this study also inferred that training effects would be affected by leisure benefits.

According to World Health Organization, quality of life is individual's perception of self-goals, self-expectations, standards and care within a cultural value system under six aspects: physical health, mental conditions, independence, social relations, self-beliefs and environments (Yao, 2002). Because athletes have been under a long-term stress, therefore their quality of life is under great influences. It is easy to distinguish athletes from non-athletes in the holistic health. Snyder and colleagues (2010) compared non-athletes with athletes and discovered that athletes are better in physical function, wellness, psychological health and lower body pain; they are also highly active and have a greater sense of happiness. Meanwhile, athletes also perform better than non-athletes in psychological, emotional and physical aspect. Athletes' stressful emotions are often resulted from their strong will and these stressful emotions stir their physical health, psychological conditions, social relations, independence, self-beliefs and surrounding environments. According to Katelaris, Carrozzi and Burke (2003), physical health is often affected by quality of life. For elite athletes, performance is greatly related to quality of life that also being affected by any physical change, for instance, insomnia, lack of focus, or degrading in fitness performance. Therefore, this study inferred that the promotion of quality of life of athletes would also bring forth the promotion of training effects.

Training effect is an interesting issue to be inspected in leisure-related research as well. To inspect the effect of training, data collected from both pre-training and post-training are often compared. Performance excellency and victories in competition, training and periodization are constantly being the focus of the training program, however, recovery (physical, mental and psychological) often remains neglected by coaches and athletes. Such neglect usually leads athletes to insufficient recovery and injuries. Coaches of collegiate athletes often have a clear understanding of how and why athletes succeeded or failed by inspecting the results of evaluation and competition, which lead to adjustment and improvement. This is also the main reason that this study proposes training effects as the canonical variable.

On leisure involvement, the causal relation models of leisure involvement and leisure benefits have been the issue of attention as well as

studies conducted and results contributed. However, there are small research on leisure involvement, benefits to quality of life and training effect. Especially for elite athletes from different categories and sports, what would be the effects on the physical and psychological condition if they are highly focusing on their training and neglecting the rest and recovery? Therefore, according on the aforementioned studies, this study aims to investigate the predictions and effects among leisure involvement, leisure benefits, quality of life and training effects in elite collegiate athletes of Taiwan. The present study also investigates elite collegiate athletes' leisure involvement, leisure benefits, quality of life and training effects, and applies the findings on individual and team sports. This study is expected to help and benefit coaches, athletes and teachers of athletics training and sports in different stages of schools.

The Purpose

From research motivation, the purpose of the present research aims to explore, inspect and predict the relationships and influences among leisure involvement, leisure benefits, quality of life and training effect.

Methodology

Subjects and Data

Subjects of this study were selected from random sampling, 538 collegiate athletes participated 2016 National Collegiate Sports Game in Taiwan. Among these athletes, 298 were males and 240 females; 142 college freshmen, 152 sophomores, 120 juniors, 110 seniors, and 14 from graduate schools. These athletes, 27.52% have been training for 1-3 years, 18.40% for 4-5 years, 24.10% for 6-7 years, and 29.98% for more than 8 years. About training days per week, 7.5% trains 1-2 days/week, 13.52% trains 3 days/week, 24.81% trains 4 days/week, and 54.17% trains more than 5 days/week.

Pilot Testing and Formal Testing

In pilot testing, 250 scales were distributed and 225 retrieved; 15 invalid questionnaires eliminated, which left 210 effective questionnaires, the effective response rate were 84%. Scales retrieved from pilot testing were analyzed and examined through item analysis, reliability analysis and validity analysis to eliminate ineffective items. Formal version of these scales were then produced, scales adopted all obtain high factor loadings.

Tools

Questionnaires.

Scales used in the research were all Likert Scales (1: strongly disagree, 2: slightly agree, 3: agree, 4: mostly agree, 5: strongly agree).

The Leisure Involvement Scale of Collegiate Athletes (LISCA) used in this research was adopted and modified from Leisure Involvement Scale by Kuo and Yen (2012). Two subscales are contained in this scale: life centrality and attractiveness. Life centrality aimed to investigate the feeling occurs after participated leisure activities, not affected by other stimulants and felt the need to share the experience with others; attractiveness subscale investigates the attraction from leisure activities to the ones participate.

The Leisure Benefits Scale of Collegiate Athletes (LBSCA) was adopted and modified from Leisure Benefits Scale by Kuo and Yen (2012). Two subscales are contained: life wellness promotion and balanced life experiences; life wellness promotion aimed to investigate the experience of enhancing life qualities and giving meanings to life, while balanced life experiences investigate how stress-free of the lifestyle that participants have.

The Quality of Life Scale of Collegiate Athletes (QLSCA) was adopted and modified from Quality of Life Scale by Kuo and Yen (2012) as well. Three subscales are in the QLSCA: physical factors, social and environment factors and psychological factors. Physical factors subscale investigates to the improvement of body condition after training; psychological factors subscale investigates the relaxation stage and process of collegiate athletes after training; social and environment factors subscale investigates the satisfaction of surrounding environment and social relations with others after training.

The Training Effect Scale of Collegiate Athletes (TESCA) was adopted and modified from the Training Effect Scale by Kuo (2008). Three subscales are in the TESCA as well: physical fitness, tactical ability and team spirit. Physical fitness investigates the improvement of performance and abilities after training, and tactical ability investigates the ability of enforcing strategies in competition and performance after training; team spirit investigates to the sense of co-operation with teammates after training.

Item Analysis.

Each scale was analyzed by criterion of internal consistency and correlation analysis from SPSS for Windows 18.0. Items with significant CR value and with correlation value greater than .50 was remained. The LISCA contains CR value 13.54-20.85, r value .64-.83 ($p<.05$). The LBSCA contains CR value 10.12-18.30, r value .61-.85, ($p<.05$). The QLSCA with CR value 9.87-23.01, r value .57-.83 ($p<.05$). The TESCA contains the CR value 14.57-24.68, r value .70-.87 ($p<.05$).

Validity Analysis.

Principle factor analysis of exploratory factor analysis was adopted to analyze the validity of scales. The Bartlett sphericity test was applied to all scales as well (LISCA, χ^2 = 4957.92, KMO= .95; LBSCA, χ^2= 7205.90, KMO= .96; QLSCA, χ^2=7158.75, KMO= .96; TESCA, χ^2=4825.92, KMO= .95). Factor loading of each item have achieved higher than .50 and the eigenvalue of each factor is greater than 1, corresponding to the requirement of factor analysis. For total variance explained of each scale, this study discovered that LISCA explained 68.02% of the variance, for LBSCA explained 69.47%, QLSCA explained 70.17% and TESCA explained 81.44% of the variance; the results of validity show the favorable validity of the scales.

Reliability Analysis.

The internal consistency reliability (Cronbach's α) of scales and subscales were examined as well. The Cronbach α of the LISCA (full-scale) was .96, while the subscales ranged within .93-.94. The Cronbach α of LBSCA (full-scale) was .97, and the

subscales ranged within .90-.95. The Cronbach α of QLSCA (full-scale) was .97, the sub-scales ranged within .88-.95. The TESCA (full-scale) obtains Cronbach α of .96, while sub-scales ranged within .93-.95. Above all, the scales and each factor in this research presented favorable reliability.

Data Analysis.

Only valid scales retrieved were analyzed by SPSS for Windows 18.0 and Lisrel 8.80 by means of descriptive statistics, item analysis, exploratory factor analysis, reliability, multiple stepwise regression analysis and path analysis. For confirmatory analysis construct validity and composite reliability were adopted to test validity and reliability. The evaluation indexes of this study including: (1) absolute fit measure index (e.g. χ^2, GFI and RMSEA); (2) relative fit measure index (e.g. NNFI, CFI); and, (3) parsimonious fit measure index such as the chi square to df ratio (χ^2 / *df)* as well as other indexes. The overall model fit test conducted has shown that the model of the study is in an acceptable range. The significance for various tests was set α<.05.

Results

The Predictive Analysis Among Leisure Involvement, Leisure Benefits, Quality of Life to Training Effect

In Table 1, through multiple stepwise regression analysis, dimensions from Leisure Involvement (Life Centrality, Attractiveness), Leisure Benefits (Life Wellness Promotion) and Quality of Life (Social and Environmental Factors) to Training Effect. Dimensions from Leisure Benefits (Life Wellness Promotion) and Quality of Life (Psychological Factors, Social and Environmental Factors, and Physical Factors) achieve significance and form regression equation ($F(4, 537)= 152.19$, $R^2 = .656$, $p < .05$) that indicates the amount of explanation of variance in collegiate athletes ' Leisure Benefits is 65.6%, and Life Wellness Promotion holds the best predictive power (β = .573).

Table 1. Multiple Stepwise Regression Analysis Of Leisure Involvement, Leisure Benefits, Quality Of Life And Training Effects

Variables	R	R^2	ΔR	β	ΔF	F
Life wellness promotion	.76	.57	.57	.45	432.02***	432.02
Social environmental factors	.80	.64	.07	.24	62.11***	288.06
Physical Factors	.81	.65	.01	.12	8.81**	199.65
Psychological Factors	.81	.66	.01	.11	4.07*	152.19

**p < .05 ; **p < .01 ; ***p < .001*

The Relations Among Leisure Involvement, Leisure Benefits, Quality of Life and Training Effects

This study aims to explore the relationship and relevance among leisure involvement, leisure benefits,

quality of life and training effect of collegiate athletes, also construct the relations that verified by Structural Equation Modeling (SEM).

Model Specification.

This research aimed to explore and construct the conceptual model of leisure involvement, leisure benefits, quality of life, and training effect in collegiate athletes. The following hypothesis were proposed.

Hypothesis 6-1: Leisure involvement directly and positively effects leisure benefits.

Hypothesis 6-2: Leisure involvement directly and positively effects quality of life.

Hypothesis 6-3: Leisure involvement directly and positively effects training effect.

Hypothesis 6-4: Leisure benefits directly and positively effects quality of life.

Hypothesis 6-5: Leisure benefits directly and positively effects training effect.

Hypothesis 6-6: Quality of life directly and positively effects training effect.

According to effects of variables in Structural Equation Modeling, variables in this model were further explained as follow.

(1) Exogenous latent variable.

Exogenous latent variable of this study is Leisure Involvement, which consists of the observed variables: Attractiveness and Life Centrality (Table 2).

(2) Endogenous latent variable.

Two endogenous variables are in this study: mediating variables and result variables.

(3) Mediating latent variables.

In this study, the mediating latent variables were Leisure Benefits and Quality of Life. Leisure Benefits were composed of the observed variables: Life Wellness Promotion and Balanced Life Experience; Quality of Life was composed of Psychological Benefits, Physiological Benefits, and Social & Environmental Benefits.

(4) Result latent variables.

Training Effect is the only result latent variable in this study, which composes of Physical Fitness, Tactical Abilities and Team Spirit (Table 2).

Analysis of Skewness and Kurtosis

In order to verify the theoretical model, Structural Equation Modeling with LISREL 8.80 was used in this study. Since the model verification was estimated and effected by sample distribution, therefore the method of estimation needs to be based on the distribution of sample. From table 3 shows that both skewness and kurtosis of the variables are in acceptable range (Huang, 2002; Kline, 1998); for skewness is ranging from -.82 to -.06 and kurtosis ranging from -.66 to .40. The result reveals that ML could be applied to the model estimation (Table 3).

Summary of Overall Model Test

Table 4 shows that the Chi-square Test of the model fails to reach significance ($\chi 2$ = 101.83, p > .05),

Table 2. Variable Symbols In The Model

Latent Variables		Observed Variable	M.E.
Exogenous latent variable	Leisure Involvement	(X1) Life Centrality	δ1
		(X2) Attractiveness	δ2
Mediating latent variable	Leisure Benefits	(Y1) Life wellness promotion	ε1
		(Y2) Balanced Life Experience	ε2
	Quality of life	(Y3) Psychological Factors	ε3
		(Y4) Social and Environmental Factors	ε4
		(Y5) Physical Factors	ε5
Result latent variable	Training Effect	(Y6) Physical Fitness	ε6
		(Y7) Tactical Ability	ε7
		(Y8) Team Spirit	ε8

Table 3. Mean, Standard Deviation, Skewness, And Kurtosis Distribution Of Mode Observations

Factor	Mean	S.D.	Skewness	Kurtosis
(X1) Life Centrality	3.59	.87	-.61	-.10
(X2) Attractiveness	3.30	.88	-.06	-.66
(Y1) Life wellness promotion	3.85	.85	-.82	.40
(Y2) Balanced life experience	3.46	.84	-.15	-.49
(Y3) Psychological Factors	3.49	.91	-.15	-.64
(Y4) Social and Environmental Factors	3.60	.85	-.21	-.50
(Y5) Physical Factors	3.72	.91	-.41	-.28
(Y6) Physical Fitness	3.92	.88	-.68	-.02
(Y7) Tactical Ability	3.86	.93	-.66	-.06
(Y8) Team Spirit	4.00	.97	-.80	-.03

which indicates the hypothesis model achieves the ideal value. The absolute fit measures, relative fit measures and parsimonious fit measures ($\chi 2/df$ = 3.51) are all in an acceptable range, revealing the acceptability of the research model.

Measurement Model Analysis

Fornell and Larcker (1981) suggested that CR value above .60 indicates higher reliability which also means a higher consistency of indices. From table 5 (as well as figure 1), the composite reliabilities of all latent variables in this model are greater than .70 and ranging from .78 to .91, which indicates the internal consistency of the research model to be favorable. For the average variance extracted (AVE) of latent variables, according to Fornell

and Larcker (1981), they suggested that the AVE value greater than .50 indicates a higher reliability and convergent validity of the latent variable. From table 5, the AVE values of the variables in this model are ranging from .75 to .77. According to the composite reliability and AVE of the dimensions, the internal consistency of the model have achieved reliability and stability.

Table 4. Overall Model Fit Test

	Model measure	Ideal value	Model value	Model test result
Absolute fit measures	χ^2	$p > .05$	100.79	Accepted
	df		29	
	GFI	≧ .90	.99	Accepted
	RMSEA	≦ .08	.08	Accepted
Relative fit measures	*NFI*	≧ .90	.96	Accepted
	CFI	≧ .90	.97	Accepted
Parsimonious fit measures	χ^2 / df	1 ~ 5	3.51	Accepted

*$p < .05$

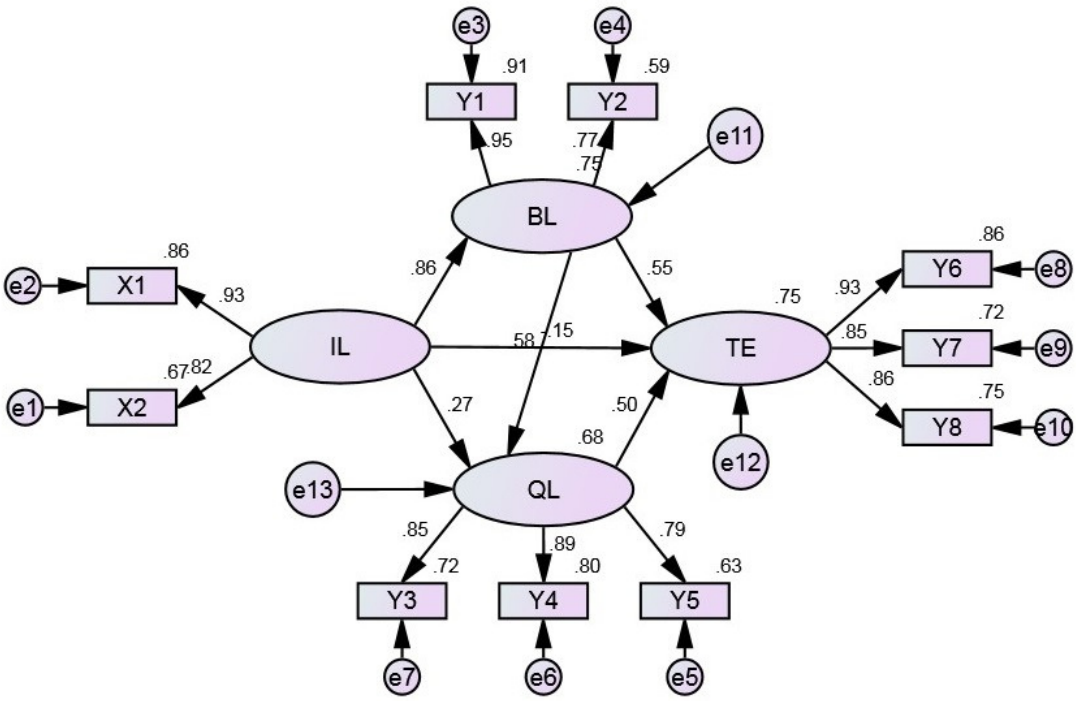

Figure 1. Path Model of the Present Study

Table 5. Parameter Estimate Of Overall Research Model

Latent variables	Observed variable	Factor loading	Composite reliability	AVE
Leisure involvement	X1	.93	.87	.77
	X2	.82		
Leisure benefit	Y1	.95	.85	.75
	Y2	.77		
Quality of life	Y3	.85	.88	.71
	Y4	.89		
	Y5	.79		
Training effect	Y6	.93	.91	.78
	Y7	.85		
	Y8	.86		

*$p < .05$

Test of The Internal Fit of Model

Test of internal fit of model was proceeded after the test of external quality model. An acceptable factor loading of measured variable need to achieve .71 and t-value should reach significance (Hair, Anderson, Tatham, & Black, 1998). The factor loading found in this study was in the interval of .65 - .84; and the factor loading of Y2 is .65.

The t-values of this study all exceeded 1.96 ($p < .05$). The composite reliability of latent variables represents the internal consistency of this aspect, an acceptable composite reliability of latent variables needs to achieve or exceed .60 (Fornell & Larcker, 1981). The composite reliability of the latent variable in this study falls into the interval between .78 - .91, which indicates that this study has an acceptable reliability level, shown in Table 6.

Test of Model Hypothesis

According to the model analysis of this study shown in Table 7, the factor loading of nearly all observed variable achieved significance which indicates these latent variables achieved validity. Table 7 displays the structural parameters for testing hypothesis 1 to 6:

1. The standardized parameter of γ1 is .86 (t=17.39). Reaching the significance that the hypothesis of γ1 is agreed, which indicates that Leisure Involvement has effects on Leisure Benefit.

2. The standardized parameter of γ2 is .27 (t=2.44). Reaching the significance that the hypothesis of γ2 is agreed, which reveals that Leisure Involvement has effects on Quality of Life.

3. The standardized parameter of γ3 is -.15 (t=-1.52). Not reaching the significance, therefore the hypothesis of γ3 is not agreed, this indicates that Leisure Involvement does effect Training Effect

Table 6. Intrinsic Fit Reliability

Latent Variable	Measured Variable	Factor loading	*t*	Composite reliability
Leisure involvement	Life centrality	.93	Reference indicator	.87
	Attractiveness	.82	17.29	
Leisure benefit	Life wellness promotion	.85	Reference indicator	.85
	Balanced life experience	.77	17.92	
Quality of life	Psychological Factor	.85	Reference indicator	.88
	Social and environ-mental factor	.89	20.35	
	Physical Factor	.79	17.04	
Training effect	Physical fitness	.93	Reference indicator	.91
	Tactical ability	.85	22.24	
	Team spirit	.86	23.20	

Table 7. Parameter Estimate Of Theoretical Hypothesis Path

Parameters	Path	Standardized parameter	*T*	Agree
γ1	Leisure Involvement affects Leisure Benefit	.86	17.00***	Yes
γ2	Leisure Involvement affects Quality of Life	.27	2.38*	Yes
γ3	Leisure Involvement affects Training Effect	-.15	-1.50	No
γ4	Leisure Benefit affects Quality of Life	.58	4.92***	Yes
γ5	Leisure Benefit affects Training Effect	.54	4.45***	Yes
γ6	Quality of Life affects Training Effect	.50	5.96***	Yes

NOTE: t value greater than 1.96 indicates significance, *$p < .05$, ***$p < .001$.

4. The standardized parameter of γ4 is .58 (t=4.95). Reaching the significance that the hypothesis of γ4 is agreed, which indicates the effects of Leisure Benefit to Quality of Life.

5. The standardized parameter of γ5 is .54 (t=4.46). Reaching the significance that the hypothesis of γ5 is agreed, this indicates that Leisure Benefit effects Training Effect.

6. The standardized parameter of γ6 is .50 (t=6.15). Reaching the signifi-

cance that the hypothesis of γ6 is agreed, which indicates that Quality of Life effects Training Effect.

Discussion

According to the test of collinearity, it reveals that the tolerance values have all exceeded .400, and the VIF values below 2.578. Therefore, the multiple stepwise regression analysis of this study was found to be freed from collinearity. Dimensions from leisure benefits (life wellness promotion, $\beta = .449$, $p < .001$) and quality of life (social and environmental factors, $\beta = .235$, $p < .001$; physical factors, $\beta = .119$, $p < .01$; psychological factors, $\beta = .111$, $p < .05$) were found capable of predicting training effects, and life wellness promotion serves as the best predictor of training effects. This study discovered that the life wellness promotion of collegiate athletes relates to stress-releasing and relaxing, also the gaining of trust and supports from partners and friend.

Social and environmental factors in quality of life is important to collegiate athletes, as the results showed that collegiate athletes often felt confident about themselves when feeling satisfied about their living environments and relationships with peers; such satisfaction and confidence affect their training effects and eventually lead to improvements on performance in competitions. For psychological factors, it is revealed that when athletes are focused and relaxed, they will have enough stamina and energy to manage the physical fatigue from training, which leads to satisfaction on their quality of life and training effects. The finding of the study also corresponds to the research conducted by Kuo (2008) in which stated life wellness promotion obtains a greater explanatory power to collegiate athletes' training effect.

Originally, this study hypothesized that elite collegiate athletes with greater participation of leisure activities would result better training effects, however the result shows differently. The findings of this study discovered that leisure involvement is not related to better training outcome. This study infer that such result relates to the unpassionate and uninterested attitude toward leisure activities of Taiwanese elite athletes.

The relevance among leisure involvement, leisure benefit, quality of life and training effect of collegiate athletes in this study will be discussed as follow:

1. This study discovered that collegiate athletes' leisure involvement has direct effect on leisure benefit, which supports the first hypothesis, revealing a positive correlation of leisure involvement to leisure benefits. Leisure involvement is able to promote physical, psychological, and social effect to a person's wellness in which leads to the promotion of self-worth and leisure benefit (Chen, Cheng, & Lin, 2013). And this research found that collegiate athletes' leisure involvement achieves a high significance and positive correlation with leisure benefits, which also corresponds with previous research on related issues (Currier, 2004; Fun, 1997; Huang, 2013; Kujala, Kaprio, Sarna, & Koskenvuo, 1998; Kuo, 2013; Lu & Argyle, 1994; Tinsley & Tinsley, 1986).

2. The hypothesis of the direct posi-

tive correlation of leisure involvement to quality of life was supported by the result of this study as well. Leisure involvement is able to promote the feeling of happiness and relieve the pressure from daily life, also helps maintaining psychological and physical health state, further creating the indispensable factor of quality of life. According to Chuang, Li and Lai (2009), leisure involvement effects on people's daily life, especially on improving physical/psychological health, enriching meaning of life and expanding vision, which eventually leads to the promotion of overall quality of life. Agyar (2014) postulated that leisure involvement promotes the satisfaction of life, which is found to be corresponded with the result of this study. The result of this study further found that higher frequency of leisure activities participation would produce more positive effects on health and thus lead to a better quality of life.

3. No correlation found between leisure involvement and training effect, which the third hypothesis of this study would not be supported and approved. Previous studies found that leisure activities involvement was able to relieve negative psychological conditions and bring forth positive effects (Lu, 2002; Siegenthaler & Lam, 1992; Kim, Scott & Crompton, 1997). But, the result of this study shows different results, the reason may be that Taiwanese collegiate athletes excessively focus on training and ignore the importance of leisure activity participation, which leads them unable to have a clear sense of leisure benefits that promote their training effect and performance.

4. This study discovered that leisure benefits obtain direct and positive effect on quality of life, which supports the fourth hypothesis of this study. Which means that athletes' quality of life is influenced by the leisure benefits they gained. Leisure benefits obtain the function of releasing stress and promoting physical and mental health, which leads to a better performance in competition and quality of life (Kuo, 2013). Further it is worth mentioning that the results of this study correspond with previous research findings that investigated the correlation of leisure benefits to quality of life and found that greater leisure benefits lead to better quality of life (Kao, Wang & Lin, 2009; Kao & Chen, 2012; Kuo & Sun, 2011).

5. This study also discovered that leisure benefit has directly and positively affected training effects, which support the fifth hypothesis as well. This study found that athletes obtain better performance in training and the following effect when they devote more time in leisure activities. This result shares correspondence with other research relate to this issue, which pointed out that leisure benefits influence physical activities on behavior development; leisure benefit from physical activities promotes physical performance development, further enhances physical coordination. (Kao & Chen 2011; Kuo & Kao, 2008). Therefore, it is recommended that collegiate athletes to participate leisure activities to enhance training effect.

6. The last hypothesis of this research concerning the positively effects of quality of life on training effect. The result of this study also supports this hypothesis, which stated that quality of life is positively correlated to training effect. It is worth mention-

ing the correspondence between this study result and other studies related to this issue, which found that physical activities lead to a better quality of life, and further pointed out that there is a positive relation between quality of life and exercise (Anokye, Trueman, Green, Pavey & Taylor, 2012; Mokhtari& Parvane, 2012). By inspecting the quality of life of collegiate athletes, this study has found that athletes with a better quality of life will have a better training effect.

Conclusion and Suggestions

Conclusion

This study discovered that higher life wellness promotion, greater satisfaction on psychological, physical and social and environmental factors will lead to a better training effect, and life wellness promotion is the most influential factor.

This study found that the leisure involvement of elite collegiate athletes directly and positively effects leisure benefits and quality of life, but not training effects; leisure benefits directly and positively effects quality of life and training effect. Also, quality of life directly and positively affects training effect as well.

Suggestions

According to the conclusion, the following suggestions are for collegiate athletes and coaches, athlete administrators, schools, physical education teachers and parents:

1. `This study suggests athletes should focus on their own life wellness promotion, psychological, physical, and social and environmental conditions and status during or after leisure activities, especially the satisfaction. Achieving life wellness promotion, psychologically, physically, socially and environmentally satisfaction will promote quality of life of athletes, as the leisure benefit and quality of life is promoted, athletes tends to perform better in competitions.

2. Further, this study suggests that it is important for athletes to fulfill their leisure time with leisure activities, which lead to better competition performance. This study shows that leisure involvement did no positively affect training effects may result from the amount of time on training that has compressed time spent on leisure activities. But there is still a need for athletes to participate leisure activities, because leisure involvement was found to positively affect leisure benefits and quality of life. Leisure activities were also found to release athletes' stress and pressure from training and competition.

3. Moreover, athletes should carefully plan their post-training and post-competition leisure activities. The purpose aims to relieve stress and anxiety, and make sure that athletes have a balanced psychological and physical conditions. Leisure involvement could ensure athletes to have a good quality of life and a better performance in competition. As for coaches and teachers, they should learn how to plan and manage athletes' leisure activities as well, and pay a close attention on types of activities athletes participate, in regard to safety and benefits.

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FEASIBILITY ANALYSIS OF USING HIGHWAY GUARDRAILS TO PRODUCE CLEANED CARBON DIOXIDE TO NOURISH ECONOMIC PLANTS

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Abstract

Gaseous waste recovery is an important undertaking to be developed, especially the recycling of Carbon Dioxide from automobile emissions. The extent of harm of the pollutant in automobile emissions shall be measured not only by how much the pollutant can be eventually cleaned, but also by how long the duration from the point of time the contaminant generated to the point of time the contaminant cleaned. The dust absorbing chamber and wet-dust cleaning pipes with cyclone power can be mounted on highway guardrails powering by solar energy. Once a contaminant is generated, it is absorbed, and the cleaned Carbon Dioxide is produced. This framework of convert-

ing harmful air polluted Carbon Dioxide into beneficial cleaned Carbon Dioxide is more precious for Taiwan, due to its insufficient natural resources.

Keywords: Greenhouse Effect; Cyclonic Dust Absorption; Wet Dust Cleaning

Background

The recovery of solid waste has been considerably effective in Taiwan, which is reflected by the situation that incinerators have no waste to burn in recent years (Chen & Chen, 2012). However, gaseous waste recovery is an important undertaking to be developed. CO_2 (Carbon Dioxide) is the major factor in greenhouse gas composition, which causes the greenhouse phenomenon. As CO_2 is generated mainly by using fossil fuels (coal, petroleum, natural gas), the Kyoto Protocol specifies that the future CO_2 emissions of various countries must return to the 2005 emissions by 2020, and 2025 emissions must return to the emission standard of 2000. However, according to Taiwan's CO_2 emission data in recent years (Chen & Chen, 2012), in order to return to the 2005 CO_2 emissions (288.8 million MT), the government must make drastic CO_2 reduction policies, otherwise in the current development trend, the annual CO_2 emission of Taiwan will far exceed the aforesaid target value in the future.

CO_2 Emission per Capita of Taiwan and Relevant Countries

According to the reference (Chen & Chen, 2012), the U.S. has the highest annual CO_2 emission per capita, which is one of the reasons the U.S. still refuses to sign the Kyoto Protocol. Taiwan's CO_2 emission per capita was lower than that of Japan before 1997, but higher than that of Japan after 1997. The CO_2 emission per capita grew rapidly in Taiwan, China, and Korea (Chen & Chen, 2012), meaning the economic development in these three regions still highly depend on energy-consuming industries. There is slight difference among the U.S., Japan, and Hong Kong in CO_2 emissions per capita. Singapore's CO_2 emission decreased from 15.41 MT in 1990 to 6.39 MT in 2009, and the effect was outstanding. Taiwan's CO_2 emissions changed inversely to Singapore's, from 5.88 MT in 1990 to 11.58 MT in 2000. It seems that Taiwan only has three policies to improve severely worsening CO_2 emissions, including Policy 1: improving the energy structure; Policy 2: readjusting the industrial structure; and Policy 3: cleaning CO_2 directly for the photosynthesis of economic crops, changing harmful CO_2 into beneficial CO_2.

Regarding Policy 1, as the demand

for a nonnuclear homeland rises, only renewable energy can be developed. Among the renewable energy sources, wind energy is limited by high cost, as wind energy will result in low-frequency noise and landscape problems. Hydraulic energy is limited to water resources. Waste energy is confronted by insufficient sources. In recent years, as the recycling classification is effective in Taiwan, incinerators have no waste to burn. Thus, biomass energy becomes a unique item that may be developed among numerous renewable energy sources. According to the encouraging afforestation efforts (forestation is subsidized with NT$90,000 per hectare) being implemented in Taiwan, importing the barbadosnut as an encouraged tree species, which can produce biodiesel, is one of the energy policies the government shall consider.

Regarding Policy 2, as Taiwan's enterprises are mostly small and medium-sized enterprises, their capital capacity is relatively small, and their products must be made from or integrated with high energy-consuming low-cost primary resources for marketability. Therefore, Taiwan is unlikely to readjust the industrial structure in the near future. Only Policy 3, cleaning CO_2 directly, may be adopted; which is the focus of this study.

Use of Cleaned CO_2

CO_2 is the principal raw material for the photosynthesis of crops, as the organic substances formed by photosynthesis account for 90%~95% of the total solid yield of crops, while only 5%~10% of substances are supplied from soil and fertilizer. Carbon and oxygen contents with the highest solid density ratio are derived from CO_2, which has, at least, the following kinds of use:

Planting Vegetables and Fruits

Taking cucumber planting in Taiwan as an example, there are five effects (Yao & Tian, 2008): (1) promoting the photosynthetic rate of vegetables; (2) increasing vegetable biomass (plant weight, leaf thickness, leaf area); (3) increasing fruit set percentage of fruit and vegetables; (4) increasing vegetable yield (growth and development); (5) upgrading vegetable quality (color and taste).

Cultivating Petroleum Plants with Cleaned CO_2

Petroleum plants include trees with sap that can be made into diesel oil, biodiesel that can be abstracted from tree seeds, and algae that contains petroleum.

A particular tree able to produce "petroleum" was found in the Brazilian tropical rain forest, known as the "Copaiba tree", which is an evergreen tree with wide varieties, is as tall as 20-25 m, and can be exploited once every 1.5 to 2 years. A small hole with a diameter of about 5

cm is drilled into the trunk, and golden yellow oily sap flows out within 1-2 hours. A Copaiba tree with a diameter of 1-1.5 m can produce 15-20 L of sap each time, and the chemical composition of the sap is similar to diesel oil, thus, it can be used as diesel oil without refining (Yao & Tian, 2008).

The barbadosnut (also known as the small tung tree, which scientific name is Jatropha Curcas L.), from which biodiesel can be extracted from the seed, was tested in Miaoli County, Taiwan. The barbadosnut seedling is grown in 3 years, and biodiesel can be extracted from its seeds; during its average 50 year growth, the barbadosnut absorbs a great deal of CO_2 in the growing process, as the seed harvest increases with CO_2. If the encouraging forestation tree species of the 20-year green sea project, as implemented by the government since March 2008, included barbadosnut, the average net income per farmer from planting barbadosnut was NT$304,760/year (Yang & Chen, 2011). During the Japanese occupation, in order to supply aircraft fuel for World War II, Euphorbiaceae wood oil trees were planted in north central Taiwan in a planned manner, and there are 4,000 hectare, which are tens of years old, wood oil trees at present. This is an advantage of Taiwan's ability to produce biodiesel in the short-term, as the yield per hectare is about 10 MT, the bone-dry kernel oil content is 55%, and if it is nourished with cleaned CO_2, the yield will increase. As the fruit ripening time of tungs is inconsistent, collection has high labor costs. The seed collection cost of tall tungs is much higher than that of the short barbadosnut (small tung).

Japanese research and development personnel extracted petroleum from a type of limnetic algae, which has high CO_2 absorbsion, and the extracted petroleum has high heating value and low nitrogen and sulfur contents. In addition, the kelp contains high CH_4 content; if cleaned CO_2 assists large-scale culture in the sea area, as the leaves are mostly on the sea surface, there can be three mechanized harvests annually (Perkins, 2009)

Cleaned CO_2 Help the Greenhouse Culture Vegetables and Fruits

The CO_2 concentration in the atmosphere is about 0.03% (300mg/kg). With daylight substituting sunlight in a greenhouse to cultivate vegetables and fruits, the CO_2 concentration is sometimes insufficient. Thus, the growth and yield rate of vegetables and fruits is reduced, but the ventilation system can help. However, in cold winters, the ventilation of cold air will reduce the temperature, which affects the growth rate of vegetables and fruits. The only solution is to import cleaned CO_2 into the greenhouse.

Theoretically, in the complete com-

bustion of gasoline and diesel oil with free of sulfur, nitrogen and lead pollution sources, the hydrocarbon chain in the fuel is restructured with oxygen to form harmless CO_2 and water. With rising environmental considerations, metal pollutions, such as lead pollution, in Taiwanese produced oil products, have been greatly reduced. Therefore, besides CO_2, the main constituents of gas from vehicles running on the highway are unburnt HC, S, and N in the exhaust gas, as well as the particles resulted from the friction between tires and the ground.

Pollution Gases Generated in Vehicle Running Process

CO_2 is formed by one unit of carbon and two units of oxygen, and is odorless and tasteless. While CO_2 is the first cause of the greenhouse phenomenon, strictly speaking, CO_2 is not a pollutant, but is actually the source of the fiber components for roots, stems, leaves, and fruit after the photosynthesis of all plants. The relationship between CO_2 and human welfare can be described as: the water (HO_2) that bears the boat (human positive welfare) is the same that swallows it up (human negative welfare), which is why cleaned CO_2 is known as CO_2 fertilizer. Therefore, the air pollutants discussed as following do not include CO_2.

Air pollutants generated by the vehicle running process are divided into internal combustion (engine) system air pollutants and waste gas system air pollutants.

Internal Combustion System Air Pollutant

The internal combustion system is resulted from the fuel tank, carburetor, and crankcase. And, the pollution process is almost all the HC spilled by evaporation from the aforesaid three systems. Before antipollution measures were taken (Figure 1), the amount of HC spilled from the three systems account for about 40% of the total amount of air pollutant HC; in addition, 60% of air pollutant HC is discharged from the waste gas system.

The effective measures for reducing internal combustion system air pollutants are described as follows, as dotted portion in Figure 2: Measure 1: enhancing the design of fuel tank A, carburetor B, crankcase C, and the engine to avoid HC spilling or evaporating. Measure 2: intercepting the HC spilled from fuel tank A and carburetor B in a charcoal canister, where compressed air drives it into the engine for secondary combustion (see the upper right of Figure 2). Measure 3: sealing the air outlet connecting the crankcase to the outside, and collecting the evaporated HC gas into the Intake Manifold with a backstop exhaust valve

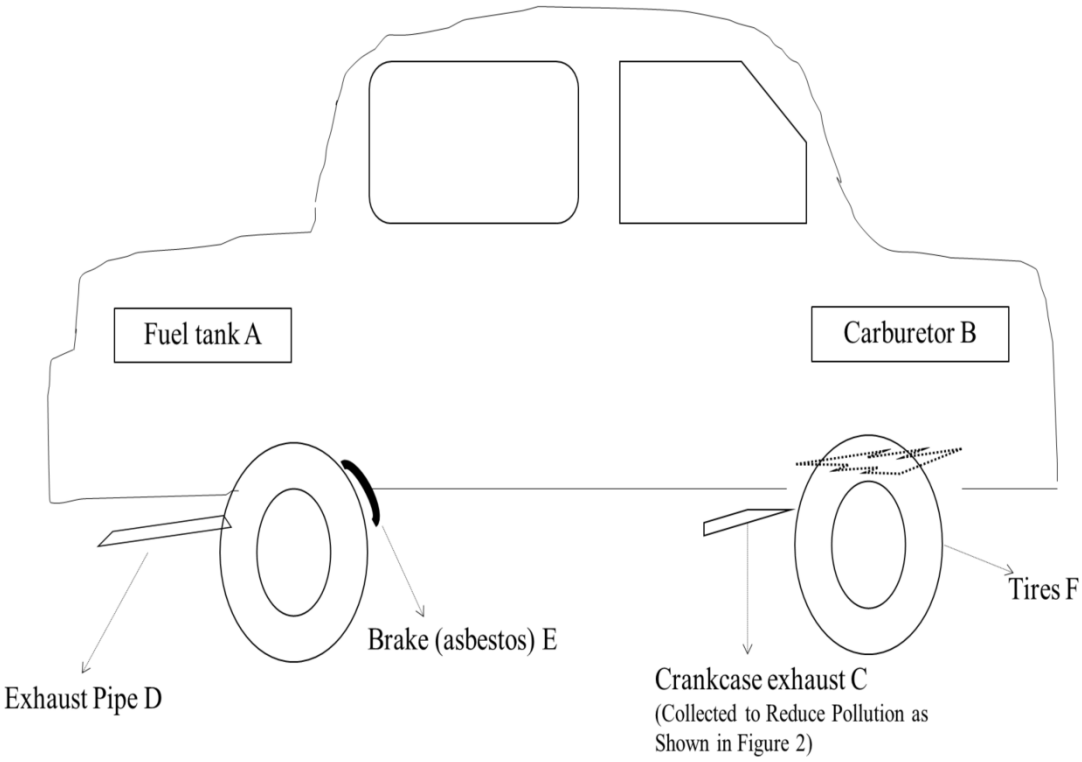

Figure 1. Traffic Pollution Generated by the Vehicle

Notes:

- HC Emissions: A & B 20%; C 20%; D 60%
- CO, NO_x, Lead & D Emissions: 100%

  Particle Pollution during driving: E & F 100%

for secondary combustion (see the left of Figure 2). At present, the aforesaid three measures are the consensus for reducing internal combustion HC system pollutants.

Waste Gas System Air Pollutant

The pollution reduction method is to mount a catalytic reactor in front of the silencer of the exhaust pipe, which has the function of oxidizing CO and HC to CO_2 and water, as well as to reduce NO to N. At present, vehicles to be sold in the U.S. must be equipped with a catalytic reactor. In the internal combustion engine, increasing the air-fuel content ratio reduces CO and HC contents, but increases the NO volume. In the view of pollution reduction, the optimum ratio of air to fuel content of the internal combustion engine depends on the cost of marginal CO and HC pollution reduction being equal to the marginal NO pollution reduction cost value.

Referring to the U.S., Taiwan's government can require that the engine systems and waste gas systems used by auto plants are equipped with the aforesaid pollution reduction facility, in order to minimize the pollution source resulted from operating vehicles. The next issue is to separate the CO_2 outside the vehicles on the highway from the mixed polluted air.

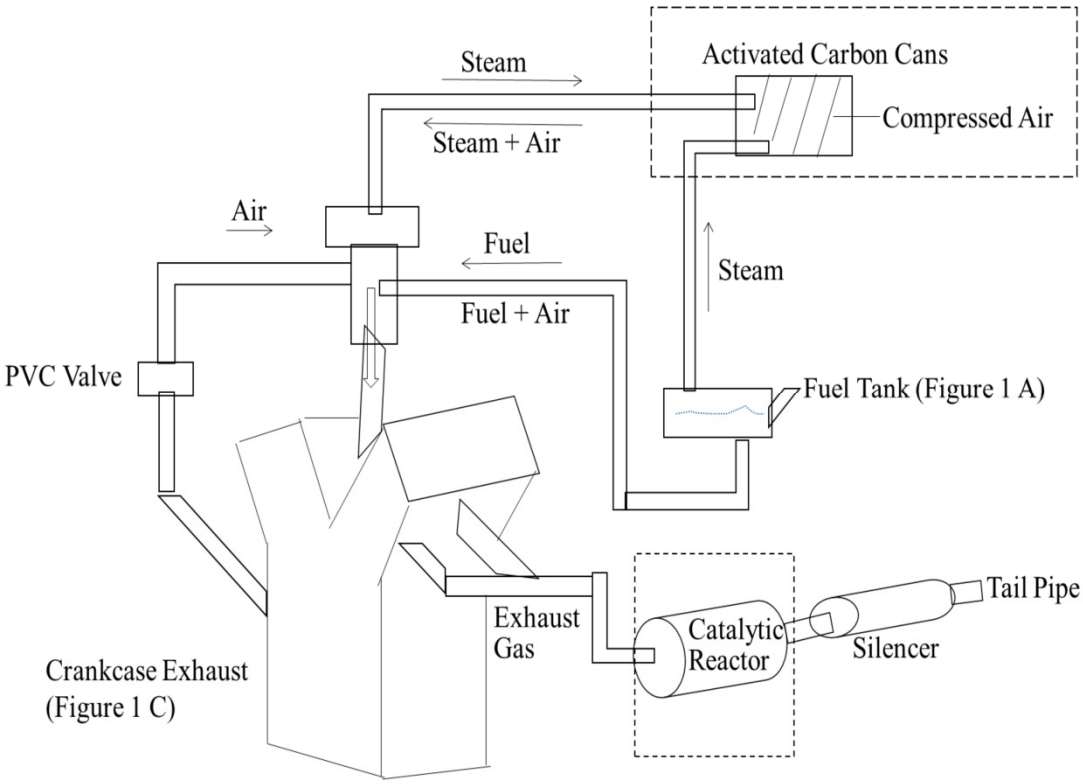

Figure 2. The Way to Reduce HC in the Internal Engine (As Shown in the Dashed Box)

Mounting Pollution Reduction Facilities on Highway Guardrails

The existing cyclone collector and packed column dust scrubber are combined and improved in this paper (Perkins, 2009) to form the (temporarily named) "cyclonic sprinkling pollution reducer", as shown in Figure 3. There can be numerous identical cyclonic sprinkling pollution reducers located on highway (especially freeways) guardrails.

The reasons for this design:
There are trees on both sides of highways (including safety islands), which require regular irrigation. In order to economize irrigation labor, additional water pipes can be mounted, roadside flowers and trees can be watered by an automated time switch, and the water required for the sprinkle scrubbing section in Figure 3 can also be switched.

1. There is an open space above highway guardrails where photovoltaic panels can be installed, which can provide the power source for the pollution absorbing fans and the sprinkling scrubbing section, as shown in Figure 3.
2. There are two types of existing cyclone collectors, the dry cyclone collector and the wet cyclone collector. While the wet cyclone collector has better dust absorption effect, the question of how to dispose of its polluted mud presents another problem. Therefore, Figure 3 is designed for dedusting dry-wet region separation.
3. The pollutants from automobile exhaust pipes are complex, and the particle shapes and weights are different. The polluted air, as shown in Figure 3, is sucked or pushed in (pushed in by the airflow driven by a running vehicle) under the rotation effect, as resulted from the semicone (large in-cone area of polluted air, small out-cone area) shape, where heavier particles impact the inner wall of the semicone, which are then slowed down by friction as they slide down along the wall surface to the dust collecting groove. As the dust collecting groove is a semicircular column opened upward, without the interference of external force, the particles slide along the semicircular column wall surface to the bottom of semicircular column groove. However, the semiconic cyclone has external air blown in at any time, thus, the particles that slid along the wall to the groove bottom may be raised again by the air. In order to avoid the probability of raising the particles again, a half cover is mounted above the semicolumnar dust collecting groove, which enables the contaminated particles to slide along the wall to the groove bottom, which also reduces the particles that have slid to the groove bottom from being raised again by subsequent airflow.
4. When the contaminated particles are cleaned in the cyclone dust collection

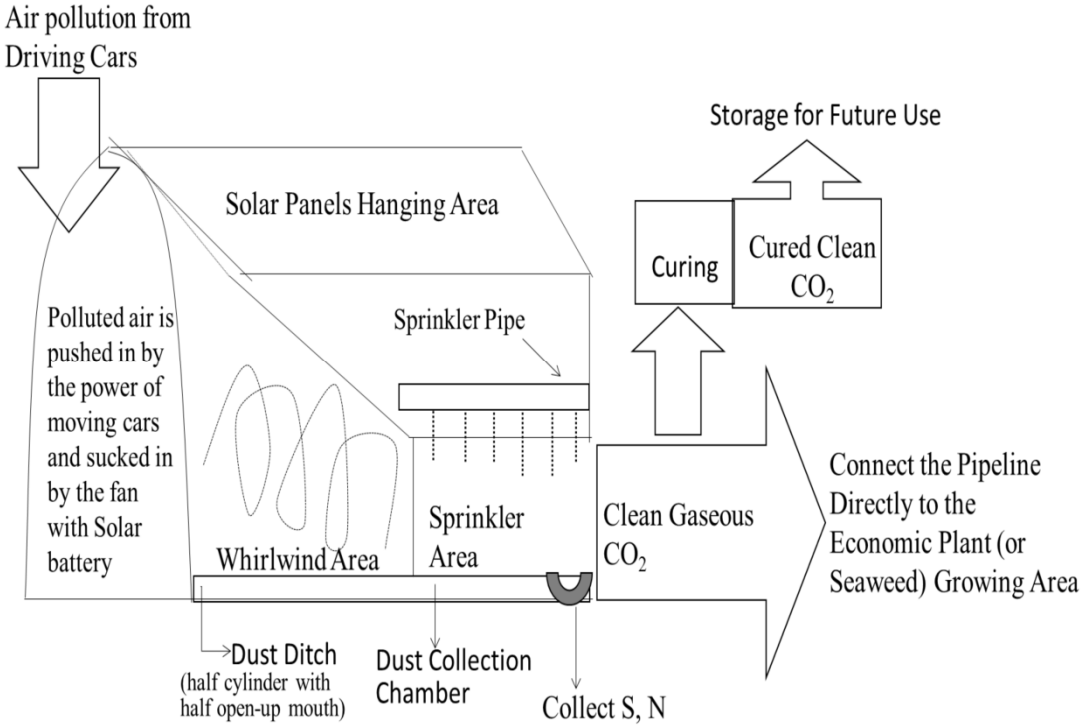

Figure 3. The Solar Power Generation System Installed in Highway Guardrail Zone

5. zone (on the left of Figure 3), the residual air pollutant components are S and N. As the wet scrubbing absorbs SO_2 and NO_2, the sprinkling scrubbing section is designed on the right of Figure 3. The cleaned SO_2 and NO_2 can be used as disinsectization solution, disinfection solution, and cleaning solution; Figure 3 shows the cyclone scrubbing pollution eliminator.
6. If the government gives rewards and punishments; as the exhaust directions of automobile exhaust pipes are optional, the exhaust direction of small vehicles running near the inside lane can be left, while the exhaust direction of large vehicles running the near slow lane can be right, thus, the efficiency of sucking exhaust gas in the cyclone scrubbing pollution eliminator in Figure 3 will be increased.

Producing cleaned CO_2 is the same as producing electricity, meaning they shall be distributed according to demand immediately after production, instead of being stored. While the use of cleaned CO_2 is mentioned in this paper, the short time lag between yield and demand must be considered.

Conclusion

Taiwan's greenhouse gas emission was increased by 134% from 1990 to 2005, which ranked first in the world, meaning Taiwan's economic development

remains highly dependent on energy-consuming industries in the past. As Taiwan cannot improve its industrial structure to reduce carbon emission in the short-term, producing cleaned CO_2 to turn the defect in CO_2 into an advantage seems to be a unique option.

Under the circumstance of being hard to live, this paper proposes a framework that not only saves energy, it also cleans highway CO_2 instantly. This framework of cleaning highway CO_2 extensively mounts the "cyclone sprinkling scrubber", as designed in this paper, on existing highway guardrails, in order to produce cleaned CO_2. This paper demonstrates the component structure of the cyclone sprinkling scrubber, and describes the principle of the design. A partial effect of producing cleaned CO_2 is related to the engine pollution prevention effect, as implemented by vehicle manufacturers, as well as to the exhaust direction of exhaust pipes, which are discussed and described in this paper.

The idea of producing cleaned CO_2 in this paper is still a preliminary concept. Is it feasible? How many supporting measures are required? Feasibility is to be proved through actual experimental data after "cyclone sprinkling scrubbers" are manufactured and mounted on freeway guardrails.

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