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An Empirical Study on Higher Education C-ESG Sustainable Development Strategy in Lower-Birth-Rate Era

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Abstract: Taking a succession of severe carbon emission issues and surprisingly lower birth rates into account, this empirical research employed the social exchange theory (SET) and environmental, social and governance (ESG) sustainable development doctrine in the decisive processes of the decision theory (DT) in order to comprehensively and deeply discuss and evaluate the interplays and dependences among the contemporary environmental carbon emission issue (social facts—SET), the carbon emission reduction public identity (social behavior—SET) and the higher education sustainable governance (social definition—SET). Beyond a succession of complex assessments, the most contributive and empirical benefits were (1) the registering decision-making of a higher education student was directly influenced by the carbon emission reduction governance concurrence (CERGC) of the carbon emission reduction energy recycling facilities (CERERFs) in higher education institutions; (2) the carbon emission reduction governance concurrence (CERGC) of the carbon emission reduction energy recycling facilities (CERERFs) was also indirectly advanced by offering a series of carbon emission reduction professional trainings (CERPTs), relative courses (CERRCs) and international certifications (CERICs) as well as precipitating an important part of the carbon emission reduction region–university collaboration (CERRUC) and alignment with non-profit organizations (CERANO). Hence, the higher education C-ESG sustainable development strategies are going to comprehensively establish a series of systematic carbon emission reduction professional trainings, relative courses, international certification mechanisms, region–university collaborations (CERRUCs) and alignments with non-profit organizations to concretely develop emission reduction energy recycling facilities (CERERFs) in order to increase student registrations to survive in this lower-birth-rate era.

Keywords: higher education carbon emission; carbon environment social governance (C-ESG); social learning theory (SLT); factor analysis (FA); regression analysis (RA); analytical network process (ANP)

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1. Introduction

In order to limit the negative impacts of climate change, most of the nations which attended the United Nations Conference on Environment and Development (UNCED) in 1992 reached a consensus to institute the United Nations Framework Convention on Climate Change (UNFCCC) due to the diversified contaminations that resulted from the rapid and global industrial and economic developments of the last thirty years. The most critical principle of the UNFCC consisted in requiring each nation to establish executable goals and practicable programs in order to effectively and efficiently reduce the carbon dioxide emissions. Significantly, a series of objectives of the carbon dioxide emissions reduction goals have not only been discussed in papers but also considered for executive action [1]. Notably, due to the Kyoto Protocol from the third session of the Conference of the Parties (COP 3), which took place from 1 to 10 December 1997 in Kyoto, Japan, each signatory government agreed to decrease 5.2% of the total 1990 carbon dioxide emissions from 2008 to 2012. However, owing to the macroeconomic development of each signatory government, they have not achieved the carbon dioxide emission goals agreed on. Until

the Intended Nationally Determined Contributions (INDCs) in the Paris Agreement, the 195 signatory countries first consented to agree to effectively decrease the global carbon dioxide emissions due to the severity of the climate change and global warming issues for humanity. The Paris Agreement on 4 November 2021 express the goal to diminish the negative effects of climate change and global warming based on the efficient declination of global carbon dioxide emissions in order to reduce global warming by 2 degrees Celsius (2 °C) by 2100. The Paris Agreement was considered a historic turning point in the carbon dioxide emission issue because most signatory governments and international companies have not only reduced their global carbon dioxide emissions but are also willing to achieve the net zero emissions goal. In terms of the developed strategies of carbon dioxide emission, the carbon neutrality, carbon net zero and carbon negative have been categorized as the three hierarchical developed strategies [2]. Firstly, the British Standards Institution (BSI) has instituted and announced the PAS 2060 for the specification for the demonstration of carbon neutrality and specifically, the PAS 2060 details the first international standards for the goal of carbon neutrality. Secondly, the concept of carbon neutrality is to practically measure and systematically organize carbon dioxide information and standpoint to achieve the broad carbon balance through internal self-reduction and external offset of carbon dioxide emissions. Critically, carbon neutrality means the total number of carbon dioxide emission is equal to the total number of carbon removal in the entire organizational activities; however, the carbon neutrality is not carbon free because carbon neutrality focuses on carbon clearance and offset. Carbon free means there is no carbon dioxide production in the entire organizational activities. Successively, the carbon net zero means the total number of greenhouse gas emissions is equal to the total number of greenhouse gas clearance in the entire organizational activities. The greenhouse gases cover H_2O, CO_2, O_3, CH_4, N_2O, HFCs, SF_6, etc. Ultimately, carbon negative means the total number of the carbon emissions is lower than the total number of carbon clearance in the entire organizational activities [3]. In association with the Taiwanese policies for the reduction in carbon emission, the Taiwanese government has instituted the greenhouse gas reduction and management laws to establish the long-term goal for the diminishment of greenhouse gas emissions; however, the total number of greenhouse gas emission has, on the contrary, increased. The main reason is that over 50 percent of the total Taiwanese carbon emissions result from the industrial carbon emissions, and the Taiwanese government has opted for the "willing-reduction" attitude for confronting the industrial carbon emissions. To get to the bottom of it, over 98 percent of Taiwanese energy depends on the import of natural resources, but the prices of various Taiwanese energies are the lowest compared to other countries in the world due to the higher stress of each business group. This has resulted most of the Taiwanese enterprises losing carbon reduction motivation due to the lower energy costs. Currently, the majority of enterprises have started to confront the impact and crunch issue of carbon emissions increment.

As a crucial part of society anywhere in the world, the higher education institutions must devote themselves to reduce carbon emissions. The most important reason for this is that higher education is the crux for driving sustainable development, because higher education is not only an institution for sustainability knowledge to evolve, but also a talent cultivation base for it to ripen [4]. Higher education has to channel the diversified groups and organizations to explore sustainable development strategies and actions through its professional knowledge and limited resources in order to achievement sustainable development practices and goals [5]. Furthermore, the mainstream issue of carbon neutrality and sustainability in higher education is now taken into consideration by the government and the management authorities as the operations and procedures of higher education universities have impacts on the environment. Globally, most of the higher education institutions have started not only to take actions to evaluate the influences of carbon emission on the environment but also to become more sustainable in their operations in order to take more social responsibility and establish obligations towards sustainability. Therefore, in sight of Taiwanese higher education, only 18 higher education institutions

have announced a definite commitment to carbon neutrality and carbon zero from the total 116 Taiwanese higher education institutions. As the first ranking place of Taiwanese higher education, the NTU has organized the university social responsibility ("USR") office to take charge of the publication of the NTU–USR report. This NTU–USR report consolidated the 17 Sustainable Development Goals ("SDGs") of the United Nations and Foundation and the Sustainability Tracking, Assessment and Rating System ("STARS") of the Advancement of Sustainability in Higher Education ("AASHE") from the United States to be the complete sustainable development goal of the NTU. According to the 2021 NTU–USR report, the total carbon emission has to be lessened up to 50 percent by 2030 and carbon neutrality is going to be approached by the NTU by 2048, due to the 2028 Science Based Targets Initiative (SBTi) of the NTU. The National Taiwan Normal University (NTNU) has obtained the golden prize of the STARS through the settlement of the Global Environmental Education Partnership (GEEP) and Asia Pacific Region Center (APRC) in the environment education center of the Environmental Protection Administration office of the Taiwanese government. The National Central University (Taiwan) has set up the goal to approach the 50 percent of total carbon emission reduction to attain carbon neutrality by 2030 and the 100 percentage of total carbon emission reduction to attain carbon neutrality by 2050. Nanhua University is the most demanding higher education institution in Taiwan. They have devoted themselves to introduce the International Organization for Standardization ("ISO") 50,001 energy management system in 2015 and the ISO 14,064 greenhouse gas evaluated standard in order to achieve 100 percent of carbon neutrality by 2028. Notably, Nanhua University also obtained the Environmental Education Institution and Environmental Education Facility certifications. Recently, the National Yunlin University of Science and Technology (NYUST) has started to construct a carbon neutral policy and a carbon footprint recoding system to approach 50 percent of total carbon emission reduction by 2031, followed by 100 percent of total carbon emission reduction by 2046.

Nevertheless, each higher education institution has devoted themselves to do their best to reduce their carbon emissions, while the critical issue of lower birth rates has become a threat for higher education institutions because the decrement of 6,000 Taiwanese senior high school graduates is going to take place every year starting 2022. Eventually, the total number of senior high school graduates will come down to 200,000 per year starting in 2025, due to the impact of the lower birth rates. According to the 2021 annual report of the Taiwanese Ministry of Education, it was predicted that there would only be 17,700 senior high school graduates in 2028, which implies that up to 40 higher education institutions are going to be closed from 2022 to 2028. Considerably, the majority of Taiwanese higher education institutions have to seriously confront the most critical recurring issue of the recruiting student decrement, even though the majority of the higher education institutions have depended on the government's financial subsidies to operate and survive in Taiwan. Materially, each higher education institution faces struggles in the search for diversified solutions to attract more students in order to confront the severe shock and deep impact of the lower birth rates in Taiwan for higher education suitability. As a result, "how to develop the sustainable development strategy of carbon emission reduction for higher education to attract more students in the lower-birth-rate?" has been the mainstream goal in each higher education institution globally. Making a comprehensive survey on the relative studies [6–11], there is no research that directly and interdisciplinarily discusses and assays the interplays among the current serious environmental carbon emissions, recruiting students and higher education sustainable governance. For this reason, this empirical research employed the social exchange theory ("SET") [12] and environmental, social and governance ("ESG") [13] sustainable development doctrine in the decisive processes of the decision theory ("DT") [14] in order to comprehensively and deeply discuss and evaluate the interplays and dependences among the contemporary environmental carbon emission issue (social facts—SET), the carbon emission reduction public identity (social behavior—SET) and the higher education sustainable governance (social definition—SET) [15] as illustrated in Figure 1.

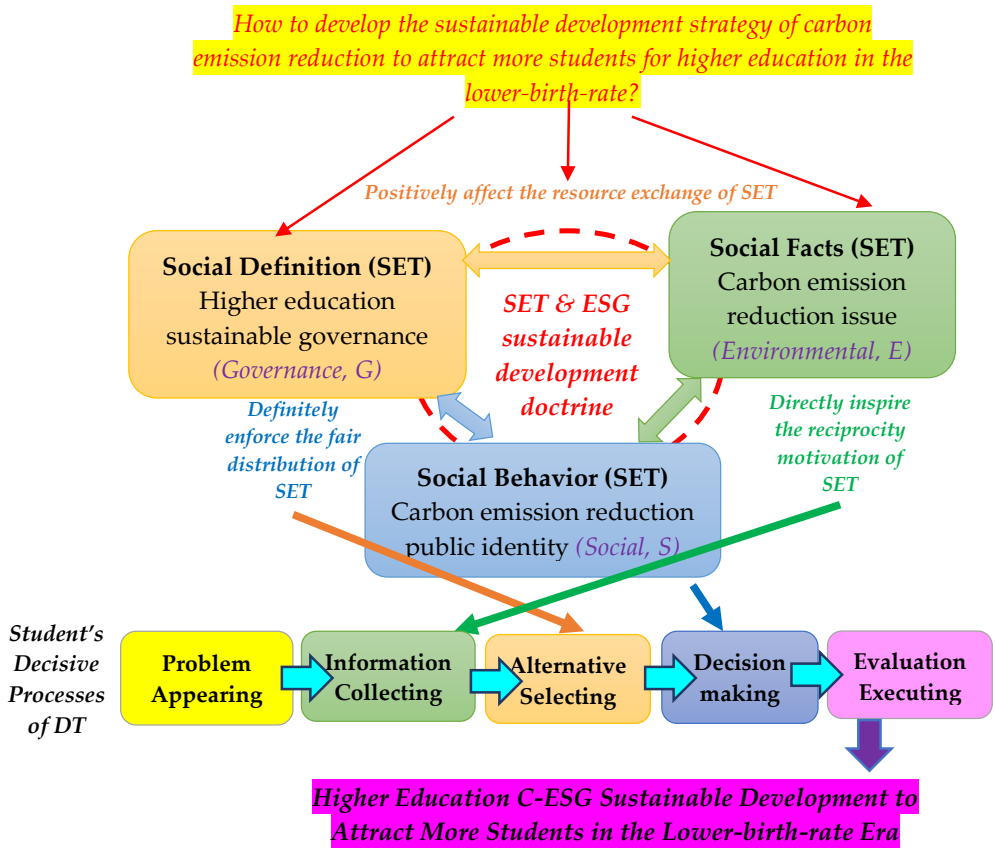

Figure 1. The main research Framework.

As seen in Figure 1, the three analytical perspectives (social definition, social facts and social behavior) of the SET theory and the three evaluated aspects (environmental, social and governance) of the ESG sustainable doctrine were consolidated in order to comprehensively analyze the interplays and dependences among the contemporary environmental carbon emission issue (social facts—SET theory), the carbon emission reduction public identity (social behavior—SET theory) and the higher education sustainable governance (social definition—SET theory). These interplays and dependences are further illustrated as:

1. Firstly, the carbon emission reduction issues (environmental, E) in the social facts of the SET can directly stimulate the reciprocity motivation ("RM") of the higher education organizational sustainable governance (governance, G) in the social definition of the SET and the carbon emission reduction public identity (social, S) in the social behavior of the SET. The reason for this is that the RM of the SET focuses on the balance between individual internal reward (e.g., love, feeling, respect, favorite decision, etc.) and external reward (e.g., money, body labor, decision-making, etc.) in the collection of students' DT processes information.
2. Secondly, the carbon emission reduction public identity (social, S) in the social behavior of the SET can definitely enforce the fair distribution ("FD") of the higher education organizational sustainable governance (governance, G) in the social definition (SET) and the carbon emission reduction issues (environmental, E) in the social facts of the SET. The reason for this is that the FD of the SET concentrates the equity between the costs and rewards in students' decision-making regarding DT processes [16].
3. Lastly, the higher education organizational sustainable governance (governance, G) in social definition (SET) can also positively affect the resource exchange ("RE") of the carbon emission reduction issues (environmental, E) in the social facts of the SET and carbon emission reduction public identity (social, S) in the social behavior of the SET. The reason for this is that the RE of the SET centralizes the exchange of individual

abstract concepts (e.g., love, feeling, respect, reputation, etc.) and concrete materials (e.g., money, body labor, etc.) in students' alternative selecting of DT processes.

Finally, in light of the statistic evaluations and measurements of the interplays and dependences in the SET theory and ESG sustainable doctrine, the factor analysis ("FA") of quantitative analysis [17] was applied to approach the large-scale questionnaires for a higher research validity, exactness and representativeness. The reason for this is that the FA of quantitative analysis has been induced to identify and refine the entire evaluated factors through the calculation of large-scale questionnaires.

Furthermore, in order to obtain a higher research reliability, accuracy and preciseness, the three-latitude entropy ("3-LE") of qualitative analysis [18] was employed to approach the experts' weighted questionnaires. The reason for this is that the 3-LE of qualitative analysis has been created to detect the interplays and dependences among each evaluated factor through the measurements of professional weighted questionnaires. Eventually, the analytical network process ("ANP") of hierarchically decided analysis [19] was applied for the hierarchical analyses among the contemporary environmental carbon emission issues (social facts—SET), the carbon emission reduction public identity (social behavior—SET) and the higher education sustainable governance (social definition—SET) through the measured results of FA of quantitative analysis and 3-LE of qualitative analysis [20].

2. Research Literatures

2.1. Literature on Carbon Emission in Higher Education

Currently, in light of the global carbon neutrality issue, China is the highest carbon emission country in the world and its carbon emission has reached up to 2912 megaton per year from 2020. The United States (US) are the second highest carbon emission country in the world and its carbon emissions have approached 1,626 megaton per year from 2020. Lastly, India is the third highest carbon emission country in the world and its carbon emission has also measured up to 666 megaton per year from 2020. Owing to the Paris Agreement, the Chinese government has committed to the carbon zero goal by 2060; the US government has complied to the carbon zero achievement by 2050 and India's government has announced the accomplishment of carbon zero by 2070. As the next step, Google has announced that the not only has carbon neutrality been achieved since 2007 through the 100 percent recycling and renewal energy policies and actions but also that the carbon emissions and footprints have been removed in 2020. Furthermore, Google has undertaken the necessary reengineering actions for 24/7 carbon-free energy by 2030 [21]. Apple has stated that carbon neutrality will be achieved by 2030 and, furthermore, Microsoft has announced that carbon negativity will be achieved by 2030. The famous supermarket chain company, ALDI Süd, has started to reduce 66 percent of its carbon emissions and footprints from 2012, and carbon neutrality is to be practiced by ALDI Süd by 2017. Currently, due to the concrete threat of climate change and global warming, more and more countries have adopted the Carbon Border Adjustment Mechanism ("CBAM") to execute the gap and trade of carbon rights through the European Union Emission Trading System (EU ETS) in order to achieve carbon zero, in line with the 2050 carbon zero goal of the European Union. As established by the 2050 carbon zero goal of the European Union, each imported production has to provide its carbon embedded emissions, footprint and record to purchase the European Union CBAM certificate in order to really reflect its carbon cost [22,23]. The CBAM certificate includes carbon emission in produced process, carbon emission and footprint evaluation, carbon price payment, withdrawal, write-off, buy-back and remit. Subsequently, more and more governments have started to establish the carbon tax mechanism to collect carbon fees in order to develop carbon emission reduction infrastructures and social benefits. As a critical role of social driving forces, higher education has to take serious social responsibility in the carbon emission reduction endeavor. Hence, in association with the carbon emission policies and the statements of the globally famous higher education institution, the University of Cambridge has instituted three step commitments for carbon emissions reduction: first and second steps: carbon zero is going to

be approached in the entire campus in order to effectively achieve the global increment of 1.5 degree Celsius (1.5 °C), and the total number of 2025 carbon emissions of each student have to be diminished to up to 25 percent of the total number of 2015 carbon emissions of each student. The University of Oxford has announced that the total number of 2030 carbon emissions must be diminished to up to 50 percent of the highest historical number of carbon emissions [24]. Harvard University has instituted the achievements of a carbon neutral goal by 2026; an 80 percent reduction in the total carbon emissions by 2050 and zero fossil fuel usages by 2050 [10]. Columbia University has stated that the total number of carbon emissions has to be reduced not only up to 35 percent of the 2006 carbon emissions by 2020, but also up to 80 percent of the total carbon emissions. Cornell University aims to achieve carbon neutrality in 2035. The University of Tokyo has announced that the total carbon emissions are going to subside by 50 percent [25]. Particularly, the association for the AASHE induced the five analytical aspects (academics, engagement, operations, planning and administration as well as innovation and leadership) to establish STARS. More precisely, STARS is a transparent, self-reporting framework for higher education to measure their sustainability performance through the interactive collaboration of the entire student body, lectures and faculties in higher education institutions [25,26]. In 2022, there are 5 higher education institutions in the Platinum, 88 higher education institutions in the Gold, 116 higher education institutions in the Silver, 31 higher education institutions in the Bronze and 12 higher education institutions in the Reporter levels of STARS ranking. More precisely, the academic analytical perspective covered the courses and research. The engagement analytical perspective comprehended the public involution and campus participation. The operation analytical perspective embodied the hardware infrastructures and software policies. The planning and administration analytical perspective contained the higher education school affairs development plans and programs [27]. Moreover, the innovation and leadership analytical perspective involved the students' and professors' innovations and the university's social responsibility. Furthermore, Universitas Indonesia, in 2010, utilized the 17 SDGs of the United Nations to develop the six appraised items (infrastructure facility, energy and climate change, waste disposal, water resource, transportation and education) in order to establish the GreenMetric World University Ranking ("GMWUR") [28].

2.2. Literature on Analytical Theories

According to Figure 1, the SET theory was created to integrate the social fact ("SF"), social behavior ("SB") and social definition ("SD") [29] to comprehensively analyze the interplays and interactive dependences in the personal responses of individual cognitions and behaviors on the various social conditions and issues in the diversified social construction and institution of the social science fields. The reason for this is that the personal responses of individual cognitions and behaviors directly influence the global social construction and institution because the person is a unit of the entire society. On the contrary, the global social construction and institution indirectly affects the personal responses of individual cognitions and behaviors because each person is going to compare and introspect their cognitions and behaviors with the entire social abstract developing tendency and the concrete public behavioral conditions. The SET was microscopic in order to enable the discussion of each other's personal responses of individual cognitions and behaviors in the various social conditions and issues through the resource exchange ("RE"): the exchange of individual abstract concepts (e.g., love, feeling, respect, reputation, etc.) and concrete materials (e.g., money, body labor, etc.); through the fair distribution ("FD"): the balance between the costs and rewards and reciprocity theory ("RT"), the balance between individual internal reward (e.g., love, feeling, respect, etc.) and external reward (e.g., money, body labor, etc.) [30]. With respect to the higher education student's decisive processes, the DT was the first theory for intensively analyze the various influences in the individual decision-making procedures, the challenge being to seek the most suitable option from all kinds of various alternatives after doing a series of comprehensive considerations and

analyses for confronting the complex issues or solving the complicated problems. From World War II, not only social science scholars but also engineering science researchers have devoted themselves to seeking the most effective and efficient decided theories and models to assist people in making the best decision in diversified complex issues and conditions. Therefore, the decision-making procedures have been defined as (1) problem appearing, (2) information collecting, (3) alterative selecting, (4) decision making and (5) evaluation executing [31]. The most important aspect to note is that this decision-making procedure is a type of feedback loop due to its recyclable execution procedures. By following to the development of DT, the rational decision-making model (RDMM) and the limited rational decision-making model (LRDMM) have been induced for the focused analyses in the personal decision-making cognitions, considerations, behaviors and responses for the more complicated research issues and problems.

2.3. Literature on Evaluated Methods

With reference to the systematic measurements for a higher research reliability, exactness, this research consolidated the FA method of quantitative analysis to manage the large-scale 250 interviewed questionnaires and then, the 3-LE of qualitative analysis to execute the experts' weighted questionnaires for a higher research reliability, accuracy and preciseness. Ultimately, the ANP of the hierarchically decided analysis was utilized for the hierarchical measurements among the contemporary environmental carbon emission issues (social facts—SET), the carbon emission reduction public identity (social behavior—SET) and the higher education sustainable governance (social definition—SET) through the measured results of FA of quantitative analysis and 3-LE of qualitative analysis. Firstly, in the discussion of the FA of quantitative analysis, the FA of quantitative analysis was employed for the assessments of large-scale questionnaires in various social science studies. The reason for this is that the FA of quantitative analysis was designed for integrating, identifying and classifying the key factors from a number of apprised factors through a series of weighted compared computations of regression analysis. In Equation (1) of FA of quantitative analysis, the dependent variables (direct observed influenced factors) were expressed as $Y(y_1, y_2, \ldots, y_k)$ and the independent variables (direct unobserved influenced factors) were illustrated as $X(x_1, x_2, \ldots, x_k)$. The interactive dependence computation of the evaluated relation weights between the dependent and independent variables were measured as [32]

$$X_1 = \lambda_{11} Y_1 + \lambda_{12} Y_2 + \ldots + \lambda_{1k} Y_k$$

s.t. 1: $Y_{-} = P^1 X_{-}, X_{-} = P^1 Y_{-}$

s.t. 2: standardized intersection of variance to be 1 (maximum).

If maximization: $X_k - u_k = \lambda_{k1} f_1 + \lambda_{k2} f_2 + \ldots + \lambda_{km} f_m + e_k$ (s.t. $(X-u)_{-_{k\times 1}} = \wedge_{m_{k\times m}} f_{m\times 1} + e_{-_{k\times 1}}$).

Variance–covariance matrix represented as

$$\sum = \wedge \Phi \wedge^1 + \Psi, \Psi = diag(\Psi_1, \Psi_2, \ldots, \Psi_m) \text{ (s.t. } \Phi = I_{m\times m}) \quad (1)$$

After implementing FA of quantitative analysis, the 3-LE of qualitative analysis was employed for the deep evaluation of the interplays among the contemporary environmental carbon emission issues (social facts—SET), the carbon emission reduction public identity (social behavior—SET) and the higher education sustainable governance (social definition—SET) for a higher research accuracy and reliability. More precisely, the entropy statistic measurement of three latitudes pairwise comparisons matrix was systematically estimated for the "discrete probability connections" in interaction-compared assessments of each evaluated criterion $(P_1, P_2, \ldots, P_k)$ in Equation (2) (Ghosal, Sinha, Majumder and Misrad, 2020) as

$$E(P_1, P_2, \ldots, P_k) = -\varnothing_k \sum_{i=1}^{k} P_i In(P_i) \quad (2)$$

s.t. 1: $\varnothing_k = 1/I(k)$ was the normal quantity and $0 \leq E(P_1, P_2, \ldots, P_k) \leq 1$.

s.t. 2: the number of $E(p_1, \ldots, p_k)$ was reversely associated with the interactive dependences among each assessed criterion. At last, as an extension of Equation (2), the interaction-compared measurements of the "discrete probability connections" in the interactive dependences were completely computed in the entropy triangular weights ($H(Y/X)$) measurements as described in Equation (3) [33]:

$$\begin{aligned} H(Y/X) &= \sum_{x \in X} p(x) * H(Y/X = x) \\ &= -\sum_{x \in X} p(x) * p(y/x) \log p(y/x) \\ &= -\sum_{x \in X, y \in Y} p(x,y) \log p(y/x) \\ &= -\sum_{x \in X, y \in Y} p(x,y) \log(p(y/x)/p(x)) \\ &= \sum_{x \in X, y \in Y} p(x,y) \log(p(x)/p(x,y)) \end{aligned} \tag{3}$$

Lastly, in order to advance the research accuracy and professionality to identify and refine the entire cause and effect among each assessed criterion, [34] the analytical hierarchy process ("AHP") for analyzing the one-way research subject and problem was employed. By complying with more complex issues and problems, a one-way hierarchical analysis of AHP had to be reviewed because AHP could only analyze one-way relations between each evaluated criterion. Therefore, [35] the ANP was applied to handle the multiple interactive relations between each evaluated criterion through the pairwise compared matrix. The basic pairwise compared matrix was described as the following:

$$\mathrm{A} = \begin{pmatrix} 1 & . & a_{1j} & . & a_{1n} \\ . & . & . & . & . \\ a_{i1} & . & a_{ij} & . & a_{in} \\ . & . & . & . & . \\ a_{n1} & . & a_{nj} & . & 1 \end{pmatrix}_{n \times n} = \begin{pmatrix} W_1/W_1 & . & W_1/W_j & . & W_1/W_n \\ . & . & . & . & . \\ W_i/W_1 & . & W_i/W_j & . & W_i/W_n \\ . & . & . & . & . \\ W_n/W_1 & . & W_n/W_j & . & W_n/W_n \end{pmatrix}_{n \times n}$$

In this basic pairwise compared matrix, the measured weights were defined as W_j and the pairwise ratio was demonstrated as W_i/W_j. Furthermore, there were three kinds of measured relations in this basic pairwise compared matrix as $a_{ij} = W_i/W_j$; (2) $a_{ij} = 1$, for $I = j$, $a_{ij} \times a_{ji} = 1$.

As it can be seen, the relative pairwise weights ($W = [W_1, \ldots, W_j, \ldots, W_n]$) and the local priority vector w (eigenvector) could be estimated by the vector quantities method (AW = nW) issued from the inductive principle (AW = $\lambda_{\max}$) in this basic pairwise compared matrix. Furthermore, the priority vector and maximized eigenvalues were computed by this basic pairwise compared matrix as well.

In terms of the verification of ANP of hierarchically decided analysis, the two-stage algorithm was measured in Equation (4).

$$Rw = \lambda_{\max} w; w_i = \sum_{j=1}^{m} (Rij / \sum_{i=1}^{m} Rij)/m \tag{4}$$

Moreover, the consistency index (*C.I.*) can be assessed in each pairwise compared matrix, and the consistency ratio (*C.R.*) can be further assessed through the numbers of *C.I.* and random index (R.I) computed from the estimated table of random index figures in Equation (5)

$$C.I. = (\lambda_{\max} - n)/(n-1); C.R. = C.I./R.I. \tag{5}$$

As the most critical aspect of each pairwise compared matrix of ANP of hierarchically decided analysis, each number of the *C.R.* in each basic pairwise compared matrix must be lower than 0.1.

3. Research Design

3.1. Analytical Hypotheses

Based on the main research question, the brief research topic and the essential concept shown in Figure 1, three critical analytical hypotheses have been constructed:

First analytical hypothesis: Do the three analytical perspectives (social definition, social facts and social behavior) of the SET theory and the three evaluated aspects (environmental, social and governance) of the ESG sustainable doctrine directly affect students' information collecting (IC) in DT processes?

Second analytical hypothesis: Do the three analytical perspectives (social definition, social facts and social behavior) of the SET theory and the three evaluated aspects (environmental, social and governance) of the ESG sustainable doctrine directly impact students' alternative selecting (AS) in DT processes?

Third analytical hypothesis: Do the three analytical perspectives (social definition, social facts and social behavior) of the SET theory and the three evaluated aspects (environmental, social and governance) of the ESG sustainable doctrine directly influence students' decision-making (DT) in DT processes?

3.2. Evaluated Criteria

This research discussed in depth the question "How to develop the sustainable development strategy of carbon emission reduction for higher education in the lower-birth-rate?" from consolidated analytical perspectives: the contemporary environmental carbon emission issue (social facts—SET), the carbon emission reduction public identity (social behavior—SET) and the higher education sustainable governance (social definition—SET). For this reason, the 5 analytical aspects (academics, engagement, operations, planning and administration as well as innovation and leadership) of STARS, the 6 appraised items (infrastructure facility, energy and climate change, waste disposal, water resource, transportation and education) of the GMWUR and the 17 SDGs [36] of the United Nations were defined as the evaluated factors. Owing to Figure 1, the carbon emission reduction relative courses ("CERRC"), the carbon emission reduction relative research ("CERRR"), the carbon emission reduction international certification ("CERIC"), the carbon emission reduction professional trainings ("CERPT") and the carbon emission reduction school affairs sustainable development plan ("CERSASDP") were defined as the evaluated RM factors for carbon emission reduction public identity (social, S) in the social behavior perspective of the SET [37]. Subsequently, the carbon emission reduction recording system ("CERRS"), the carbon emission reduction environment-protection equipment ("CEREPE"), the carbon emission reduction waste disposal devices ("CERWDD"), the carbon emission reduction energy recycling facilities ("CERERF") and the carbon emission reduction on transportation installations ("CERTRI") were clarified as the evaluated RE factors of the carbon emission reduction issues (environmental, E) in the social facts perspective of the SET [38]. Lastly, the carbon emission reduction intercollegiate alliance ("CERIA"), the carbon emission reduction industry–university cooperation ("CERIUC"), the carbon emission reduction region–university collaboration ("CERRUC"), the carbon emission reduction alignment with non-profit organizations ("CERANO") and the carbon emission reduction governance concurrence ("CERGC") were circumscribed by the evaluated FD factors of the higher education organizational sustainable governance (governance, G) in the social definition perspective of the SET [39]. Additionally, as a practical reflection on these evaluated criteria, the 5-point Likert scale method was utilized in the large-scale questionnaires in the FA of quantitative analysis. The type of questions in the questionnaire are, e.g., "What importance do you attribute to the CERRCs to attract more students of higher education institutions in the context of lower birth rates?" The 5-point Likert scale method was also utilized in the experts' pairwise compared questionnaires of the 3-LE of qualitative analysis and ANP of hieratical analytical analysis.

3.3. Collected Questionnaires

With the goal of higher research validity and representativeness, 125 freshmen and 125 seniors of higher education were randomly interviewed in person for the large-scale questionnaire investigated base. The collected way consisted only of the questionnaire without any invasive investigation. The total number of valid questionnaires and participants was 232, including 121 freshmen and 111 seniors of higher education, with a questionnaire validity rate of 92.8%. Significantly, all 232 participants were older than 18 years of age, which means they were all considered adults in Taiwan and they all consented to the questionnaire's content to be used in this research. Hence, all the surveyed data conformed to the right of examination in social science research, in line with the academic regulations of the Taiwanese Institutional Review Board (IRB) and Ministry of Science and Technology and of Education. The validity rate of the retrieved weight questionnaires is of 92.8%, its description is illustrated in Table 1.

Table 1. The descriptive statistic of factor analysis (FA) method.

Gender		Male: 128 (55.17%)		Female: 104 (44.83%)	
Studying Groups		Fresh: 121 (52.15%)		Seniors: 111 (47.85%)	
Geography	Northern Taiwan [1]: 42 (18.1%)	Middle Taiwan [2]: 75 (32.32%)	Southern Taiwan [3]: 55 (23.7%)	Eastern Taiwan [4]: 17 (7.35%)	Foreign countries [5]: 43 (18.53%)
Did you care about the carbon emission policies of higher education?				Yes: 193 (83.19%)	No: 39 (16.81%)
Have you considered the university's carbon emission policies during decision-making for higher education registration?				Yes: 6 (54.2%)	No: 226 (97.41%)
Did you intend to take any courses regarding carbon emissions in higher education?				Yes: 157 (67.67%)	No: 75 (32.33%)
How many courses regarding carbon emissions have you taken in higher education?	0: 14 (6.03%)	1: 139 (59.91%)	2: 68 (29.31%)	3: 10 (4.71%)	4 and more: 1 (0.04%)

[1]: Chilung, Taipei, New Taipei and Taoyuan cities. [2]: Hsinchu, Miaoli, Taichung and Changhua cities. [3]: Yunlin, Chiayi, Tainan and Kaohsiung cities. [4]: Hualien and Taitung counties. [5]: Foreign countries.

With reference to the research results, [40] it was addressed that the experts' and professional collected questionnaires have to up to 10 percent of large-scale surveyed data with the least errors regarding higher research validity and reliability with the Delphi method. Hence, the first group of 20 experts was interviewed in person in the assessments of 3-LE of qualitative analysis. It is worth noting that these 20 experts and professionals included 5 researchers who have over 10 years of research experience in carbon emissions; 10 researchers who have over 10 years of research experience in higher education sustainability and lastly 5 professionals who have over 10 years of working experience in higher education sustainability. Ultimately, the second group of 20 experts was interviewed in person in the ANP of hierarchically decided analysis. These 20 professionals and specialists comprised five professors who have over 10 years of working experience in carbon emissions, five professors who have over 10 years of empirical working experience in higher education recruiting departments and lastly 10 specialists who have over 10 years of working experience in senior high school graduation departments.

4. Research Measurements

FA Systematic Approach of Quantitative Analysis

With reference to the measured Equation (1) of the FA method of quantitative analysis, Table 2 expresses that the calculated numbers of the Kaiser–Meyer–Olkin measure of sampling adequacy was 0.786, which is bigger than 0.7, and the appraised numbers of significance of the Kaiser–Meyer–Olkin measure and Bartlett's test was 0.000 . . . , which is

lower than 0.05. As a result, the FA method of quantitative analysis was decidedly suitable for measuring these 107 valid questionnaires.

Table 2. The KMO and Bartlett's Test of FA approach of quantitative analysis.

Kaiser–Meyer–Olkin Measure of Sampling Adequacy		**0.703**
Bartlett's test of sphericity	Chi-squared test	411.235
	df	105
	Significance	0.000...

In sight of the research results of the FA of quantitative analysis, the entire communalities of each evaluated criterion were computed into the measurements of Equation (2), as shown in Table 3. Table 3 demonstrates the entire commonality of each factor in the FA method of quantitative analysis. The commonality of CERRCs was 0.727, of CERRC was 0.716, of CERRR was 0.767, of CERIC was 0.689, of CERPTs was 0.705, of CERSASDP was 0.664, of CERRS was 0.712, of CEREPE was 0.745, of CERWDDs was 0.735, of CERERFs was 0.739, of CERTRIs was 0.644, of CERIA was 0.31, of CERIUC was 0.674, of CERRUC was 0.721, of CERANO was 0.765 and of CERGC was 0.743. In the essential consumption of the FA of quantitative analysis, the total numbers of communalities of each evaluated factor were closed to 0.7, which means that the interactive communality did exist among each evaluated factor in these large-scale 232 valid questionnaires.

Table 3. The communality KMO and Bartlett's Test of FA approach of quantitative analysis.

Criteria, Sub-Criteria and Candidates	**Initial**	**Extraction**
CERRC (carbon emission reduction public identity (social, S))	1	0.716
CERRR (carbon emission reduction public identity (social, S))	1	0.767
CERIC (carbon emission reduction public identity (social, S))	1	0.689
CERPTs (carbon emission reduction public identity (social, S))	1	0.705
CERSASDP (carbon emission reduction public identity (social, S))	1	0.664
CERRS (carbon emission reduction issues (environmental, E))	1	0.712
CEREPE (carbon emission reduction issues (environmental, E))	1	0.745
CERWDDs (carbon emission reduction issues (environmental, E))	1	0.735
CERERF (carbon emission reduction issues (environmental, E))	1	0.739
CERTRI (carbon emission reduction issues (environmental, E))	1	0.644
CERIA (higher education organizational sustainable governance (governance, G))	1	0.731
CERIUC (higher education organizational sustainable governance (governance, G))	1	0.674
CERRUC (higher education organizational sustainable governance (governance, G))	1	0.721
CERANO (higher education organizational sustainable governance (governance, G))	1	0.765
CERGC (higher education organizational sustainable governance (governance, G))	1	0.743

After administering the FA of quantitative analysis, executed with Equations (2) and (3) of 3-LE of quantitative analysis, the interaction-compared measurements of the "discrete probability connections" in the interactive dependences were directly computed for the entropy measurement of the conditional triangular weights (*H(Y/X)*) by handling the 20 valid experts' weighted questionnaires in order to increase the research validity and representativeness as described in Table 4.

Table 4. The weights of 3-LE of qualitative analysis.

Carbon Emission Reduction Public Identity (Social, S)					Carbon Emission Reduction Issues (Environmental, E)	Higher Education Organizational Sustainable Governance (Governance, G)				
CERRC (0.716)	**CERRR (0.767)**	**CERIC (0.689)**	**CERPT (0.705)**	**CERSASDP (0.664)**		**CERIA (0.731)**	**CERIUC (0.674)**	**CERRUC (0.721)**	**CERANO (0.765)**	**CERGC (0.743)**
0.1206	0.175	0.0848	0.0727	0.1431	CERRS (0.712)	0.0182	0.0028	0.1481	0.1047	0.0185
0.1615	0.173	0.0964	0.101	0.117	CEREPE (0.745)	0.1377	0.0181	0.1131	0.107	0.1475
0.116	0.1598	0.0491	0.1226	0.0991	CERWDD (0.735)	0.1216	0.0049	0.0333	0.0822	0.0958
0.1646	0.0323	0.1631	0.1896	0.0755	CERERF (0.739)	0.0925	0.0076	0.1707	0.143	0.1759
0.0674	0.1866	0.0683	0.0967	0.1549	CERTRI (0.644)	0.0221	0.0008	0.1174	0.1115	0.0301

In light of the measured results of 3-LE of qualitative analysis as displayed in Table 4, the highest weighted scales for the influences on the CERERFs of carbon emission reduction issues (environmental, E) were (1) the CERGC (0.1759), CERRUC (0.1707) and CERANO (0.143) of higher education organizational sustainable governance (governance, G) as well as the CERPTs (0.1896), CERRCs (0.1646) and CERICs (0.1631) of carbon emission reduction public identity (social, S); (2) the higher weighted scales for the impacts on the CERTRIs of carbon emission reduction issues (environmental, E) were CERRR (0.1866) and CERSASDP (0.1549) of carbon emission reduction public identity (social, S) and (3) the higher weighted scales for the impacts on the CEREPE of carbon emission reduction issues (environmental, E) were the CERIA (0.1377) and CERIUC (0.0181) of higher education organizational sustainable governance (governance, G).

Finally, in order to deeply and synthetically evaluate the interplays and interactive dependences among the contemporary environmental carbon emission issue (social facts—SET), the carbon emission reduction public identity (social behavior—SET) and the higher education sustainable governance (social definition—SET) on higher education students' decisive processes of DT, Figure 2 constructed the cross-analytical hierarchies of ANP of hierarchically decided analysis based on the evaluated results of the FA of quantitative analysis and 3-LE of qualitative analysis. The three critical analytical hypotheses have been verified in the ANP analytical hierarchy of Figure 2.

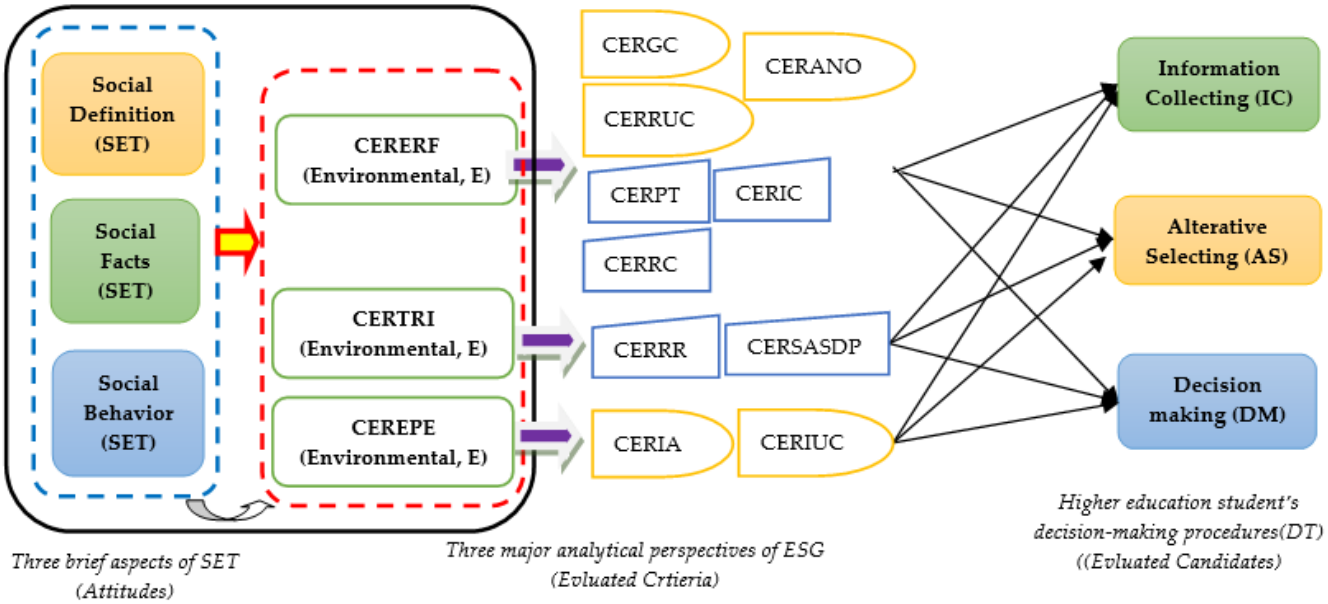

Figure 2. The ANP evaluated hierarchy.

In Figure 2, the numbers of the *C.I.* and *C.R.* in the assessed pairwise compared mix of ANP of hierarchically decided analysis among each appraised criterion are represented,

while the candidates were measured in Table 5. In summary, all the numbers of *C.I.* and *C.R.* were seemingly smaller than 0.1, which signified that the entire pairwise compared matrix consisted of higher interplays and correlations among each evaluated attitude, criterion and candidate.

Table 5. The entire commonalities of each attitude, criterion and candidate.

Pairwise Comparison Matrix	*C.I.*	*C.R.*
Social Definition (SET)	0.0409	0.0705
Social Facts (SET)	0.0527	0.0909
Social Behavior (SET)	0.0498	0.0858
CERERF (environmental, E)	0.0565	0.0974
CERTRI (environmental, E)	0.0567	0.0977
CEREPE (environmental, E)	0.0507	0.0874
CERGC	0.0443	0.0763
CERRUC	0.0471	0.0812
CERANO	0.046	0.0793
CERPT	0.0432	0.0745
CERRC	0.0523	0.0901
CERIC	0.0531	0.0915
CERRR	0.0534	0.0921
CERSASDP	0.0465	0.0927
CERIA	0.0538	0.0927
CERIUC	0.0473	0.0815

Subsequently, Table 6 displays the assessed calculated results of the FA method's quantitative analysis and 3-LE of qualitative analysis of the ANP of hierarchically decided analysis with the highest research reliability, representativeness, validity and truthfulness.

Table 6. The consolidated evaluated measurements of FA systematic approach and ANP hierarchical model.

				IC		AS		DM	
Criteria	**Weights**	**FA and 3-LE Weights**	**Sub-Criteria**	**Weights**	**Evaluated Score**	**Weights**	**Evaluated Score**	**Weights**	**Evaluated Score**
CERERF	0.7166	0.1759	CERGC	0.0609	0.0077	0.2120	0.0267	0.7272	0.0917
		0.1707	CERRUC	0.0636	0.0078	0.2186	0.0267	0.7178	0.0878
		0.143	CERANO	0.0703	0.0072	0.2367	0.0243	0.6930	0.071
		0.1896	CERPT	0.0601	0.0082	0.2228	0.0303	0.7171	0.0974
		0.1646	CERRC	0.0603	0.0071	0.2233	0.0263	0.7164	0.0845
		0.1631	CERIC	0.0587	0.0069	0.2099	0.0245	0.7315	0.0855
CERTRI	0.2195	0.1866	CERRR	0.0592	0.0024	0.2122	0.0087	0.7285	0.0298
		0.1549	CERSASDP	0.0592	0.0020	0.2115	0.0072	0.7292	0.0248
CEREPE	0.0639	0.1377	CERIA	0.0621	0.0019	0.2270	0.0020	0.7109	0.0063
		0.0181	CERIUC	0.0599	0.0005	0.2297	0.0003	0.7104	0.0008
Synthetically comparative index					0.0639		0.219		0.7171

The highest synthetically comparative index ("SCI") of the ANP of hierarchically decided analysis was the decision-making (DM) (0.718) and, more precisely, the CERGC (0.0917) was the highest weight evaluated factor in the CERERFs.

5. Conclusions and Recommendations

Due to a series of severe carbon emission issues and surprisingly lower birth rates, most higher education institutions have devoted themselves to finding higher education sustainable development strategies to attract more student registration and survive a lack of contemporary higher education students. Therefore, this research consolidated the SET and DT to comprehensively discuss and analyze the interplays and dependences among the contemporary environmental carbon emission issue (social facts—SET), the carbon emission reduction public identity (social behavior—SET) and the higher education sustainable governance (social definition—SET). In addition to completing a succession of complex assessments, the three analytical hypotheses were inductively testified and, conclusively, the three most contributive findings and empirical benefits were defined as:

(1) According to the comprehensive evaluated results for the three hypotheses, the registering decision-making (DM) of higher education students was directly influenced by the carbon emission reduction governance concurrence (CERGC) of the carbon emission reduction energy recycling facilities (CERERFs) in higher education institutions. This means that the first and second analytical hypotheses were not accepted and the third analytical hypothesis was fulfilled.

(2) Furthermore, the carbon emission reduction governance concurrence (CERGC) of the carbon emission reduction energy recycling facilities (CERERFs) was also indirectly advanced by offering a series of carbon emission reduction professional trainings (CERPTs), relative courses (CERRCs) and international certifications (CERICs) as well as supporting the carbon emission reduction region–university collaboration (CERRUC) and alignment with non-profit organizations (CERANO).

(3) In terms of research achievement and goal, the higher education C-ESG sustainable development strategies will comprehensively establish a series of systematic carbon emission reduction professional trainings, relative courses, international certification mechanisms, region–university collaborations (CERRUCs) and alignments with non-profit organizations to concretely construct emission reduction energy recycling facilities (CERERFs) in order to attract more student registration to survive this lower-birth-rate era.

Despite the fact that this research cross-employed multiple social science theories, quantitative, qualitative and hierarchically decided evaluated methods as well as large-scale and experts' questionnaires, the limited resources and time were barriers to this research. Therefore, an important number of analytical methodologies (such as the complex analyses of factors affecting the implementation of green human resource management using a hybrid fuzzy ANP and type-2 fuzzy decision-making trial and evaluation laboratory (DEMATEL) approach [41], eco-innovation and cleaner production as sustainable competitive advantage antecedents and the mediating role of green performance [42]) should be considered for the future of the higher education C-ESG sustainable development strategies to develop more advantageous and significant contributions and findings based on the valuable conclusion and contributive findings of this research.

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Abbreviations

SDGs	Sustainable development goals
STARS	Sustainability tracking, assessment and rating system
AASHE	Advancement of sustainability in higher education
ISO	International Organization for Standardization
SET	Social exchange theory
ESG	Environmental, social and governance
DT	Decision theory
RM	Reciprocity motivation
RE	Resource exchange
FD	Fair distribution
FA	Factor analysis
3-LE	Three-latitude entropy
ANP	Analytical network process
CBAM	Carbon border adjustment mechanism
SF	Social facts
SB	Social behavior
SD	Social definition
CERRC	Carbon emission reduction relative course
CERRR	Carbon emission reduction relative research
CERIC	Carbon emission reduction international certification
CERPT	Carbon emission reduction professional training
CERSASDP	Carbon emission reduction school affairs sustainable development plan
CERRS	Carbon emission reduction recording system
CEREPE	Carbon emission reduction environment-protection equipment
CERWDD	Carbon emission reduction waste disposal device
CERERF	Carbon emission reduction energy recycling facility
CERTRI	Carbon emission reduction on transportation installation
CERIA	Carbon emission reduction intercollegiate alliance
CERIUC	Carbon emission reduction industry–university cooperation
CERRUC	Carbon emission reduction region–university collaboration
CERANO	Carbon emission reduction alignment with non-profit organization
CERGC	Carbon emission reduction governance concurrence

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