

Article

Can Airport and Social Waste Reduction Measures Have a Synergistic Impact on Passenger Behavior?

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Abstract: As an integral part of urban functions, waste reduction behaviors inside the airport and outside in society form a linkage mechanism that influences each other, but the coupling mechanism between the two is not clear. In this study, we constructed a model of the interaction between airport and social waste reduction behaviors and explored the effects of internal airport factors and external social factors on airport waste reduction behaviors. The results show that both internal and external factors have a significant positive effect on passengers' behavior, with publicity and education, social norms, and laws and regulations having a greater effect. Airport internal factors (such as internal facilities, publicity and education and environmental stimulus) and social external factors (such as social norms and laws and regulations) can form a better positive feedback mechanism for waste reduction, and path coefficients for both interactions exceed 0.7. Airport publicity and education can directly improve passengers' waste reduction behaviors, and better promote the continuation of these behaviors in society. It is recommended connecting the publicity and education activities between airports and society. The social external factors are more likely to affect the behavior of airport management, and it is recommended that the design of airport management should be made more effective in developing countries that have weaker awareness of and worse social attitudes towards for waste reduction.

Keywords: waste reduction behaviors; waste management; influencing factors; interactive correlation; coupling analysis



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1. Introduction

With the rapid development of the global social economy, the aviation industry with its characteristics of safety, speed and comfort, has become an important choice for public travel and freight logistics. In the past few decades, the number of air passengers has been growing steadily, although the COVID-19 pandemic slowed that growth, albeit temporarily. However, in the next 20 years, the annual growth rate will remain 4.4% to 4.6% [1]. The international airport is an important hub of shipping and has developed into an integrated zone of operations, integrating transportation, shopping, catering, accommodation, office and other functions. The resulting amount of waste is close to the scale of waste disposal in small cities [2]. For example, in 2017, global airport waste production exceeded 5.7 million tons, and it is expected to double by 2027 [3]. In order to solve the problem of airport waste, the International Civil Aviation Organization (ICAO) has set up a waste management chapter in the ecological airport construction manual, as the core standard to guide the global ecological airport construction [4].

Product ecological design (such as packaging reduction, etc.) and garbage classification and recycling are important measures to promote waste reduction and have become the focus of global attention. The European Union, the United States, Japan and other countries

have established relevant laws and regulations on waste reduction. For example, the European Union launched the *European Green Deal* and put forward a new *Circular Economy Action Plan*, which makes sustainable products, services and business models standardized to establish the value chain of key products [5]. The joint committee of the US National Academy of Science Engineering Medicine (NASEM) proposes the redesign of products and their production processes to promote resource efficiency, longevity, reuse, repair and recycling, while minimizing waste generation [6]. Japan has promulgated the *4th Fundamental Plan for Establishing a Sound Material-Cycle Society*, focusing on a circular society, a low-carbon society and a symbiotic society, emphasizing thorough resource circulation based on the premise of nature protection in the whole life cycle and promoting the correct treatment and regeneration of waste [7].

Under the influence of waste reduction policies and source control measures in various countries, airports are also gradually exploring waste reduction measures suitable for their own development characteristics. For example, Narita Airport of Japan, based on the differences in functional areas, has clarified the transfer process and transfer subjects in the process of garbage disposal, and formulated garbage recycling plans for reduction and recycling, respectively [8]. Vancouver Airport applies intelligent sorting and recycling facilities to help passengers with garbage sorting and recycling (Vancouver Airport Authority, 2022). Seattle Airport and ABU Dhabi Airport have set up guidance boards for garbage sorting facilities in the airport to facilitate passengers to conduct garbage sorting work [9,10]. Incheon Airport considers the impact of the internal environment of the airport on the classification and recycling of passenger garbage, promoting a green layout design of natural plants and flowers in the airport [11].

As public facilities, airports are an integral part of urban functions and are closely related to people's daily lives. The design of waste reduction policies on the social level will have an impact on waste classification behaviors in airports, and conversely, the cultivation of waste classification and reduction behaviors in airports will also affect the subsequent daily behaviors of passengers. In this way, waste reduction behaviors inside the airport and outside in society form a linkage mechanism influencing each other. However, there is still little research in this area, and the coupling mechanism between the two is not clear, making it difficult to realize a synergistic waste reduction policy design in which society and the airport promote each other. We will construct an interactive influence model of waste reduction behavior between the airport and society, explore the effects of internal airport factors and external social factors on waste reduction behaviors at the airport and reveal the interactive relationship between internal airport and external social waste reduction behaviors.

As the largest developing country, China has formed a relatively complete waste reduction system at the social level. For example, in 2017, the *Notice on Accelerating the Classification of Domestic Waste in Some Key Cities* was issued, requiring the establishment of a garbage classification and treatment system to reduce the amount of garbage entering the incineration and landfill treatment facilities [12]. In 2020, the *Law of China on Prevention and Control of Environmental Pollution by Solid Wastes* was revised, defining the reduction in the source of waste as the obligation to collectives and individuals, and emphasizing the reduction in resource consumption and waste production in the process of production, circulation and consumption [13]. At the same time, China's airports have also taken relevant measures to promote waste reduction. For example, in 2018, the Civil Aviation Administration of China (CAAC) issued the *Opinions on Implementing Opinions on Further Promoting Green Development of Civil Aviation*, which emphasized the strengthening of centralized waste separation and resource reuse, and promoted the process of harmless reductions in and resource recovery of pollutants in airports [14]. In 2020, the CAAC promulgated the industry standard—*Four Characteristics Airport Development Guidelines*—proposing that the airport should set up facilities for the classification and harmless treatment of waste [15]. In 2021, the CAAC issued the *Special Plan for Green Development of Civil Aviation during the 14th Five Year Plan period*, which clearly stated that solid waste system management should

be carried out to reduce environmental impact [16]. Therefore, at the level of Chinese society and airports an interactive correlation of garbage reduction behavior has been formed, which jointly has an impact on passenger behavior. As an international first-class large-scale airport, Beijing Daxing International Airport (BDIA), since its commissioning in 2019, has a cumulative passenger throughput of more than 54 million passengers as of 2022, and is planned to have an annual passenger throughput of more than 72 million passengers after 2025 [17]. Relying on BDIA, we conducted a questionnaire survey of 1083 passengers enquiring about their willingness to reduce waste, revealing the interactive relationship between the internal airport and the external social waste reduction behaviors, and putting forward the direction of the corresponding policy design and related recommendations.

The structure of the rest of the study is as follows: Section 2 identifies the airport's internal and society's external waste reduction factors. Section 3 presents the materials and methods used in our study. Section 4 presents an analysis of airport's internal and society's external factors for waste reduction. Section 5 provides an interaction analysis of internal airport and external social factors. Section 6 develops policy recommendations and methodologies. Section 7 presents the main conclusions.

2. Influencing Factors of the Airport Waste Reduction

In this section, based on the literature collection and factual basis, we identify the influencing factors of airport waste reduction and put forward the corresponding hypothesis, which lays the foundation for the subsequent model construction.

2.1. Airport Internal Factors

The airport internal factors are the most intuitive drivers influencing airport waste classification and reduction behavior. Currently, numerous airport waste reduction measures have been developed at international airports around the world, focusing on three internal influences: internal facilities; publicity and education and environmental stimulus and Figure 1 illustrates the airport internal factors that have been identified.



Figure 1. Identification of internal influences on airport waste reduction. Notes: (a) Intelligent waste separation and recycling facilities at Vancouver Airport, Canada; (b) special design of waste bin drop-off opening at Philadelphia Airport, USA; (c) guidance map of recycling points at Seattle Airport terminal, USA; (d) color differentiation of waste bins at Austin Borgstrom International Airport, USA; (e) on-site explanation of waste separation and recycling at Shanghai Hongqiao Airport; (f) poster on

waste separation and recycling at Beijing Capital Airport; (g) poster on waste separation and recycling at Shanghai Pudong Airport Waste Separation and Recycling Video; (h) Guangdong Zhuhai Airport waste separation and recycling theme; (i) San Diego International Airport interior clean environment; (j) Beijing Daxing International Airport Terminal natural space design; (k) Singapore Changi Airport interior greenery arrangement.

2.1.1. Internal Facilities

As an important component of the airport, internal facilities include intelligent facilities, input port design, classification and guidance devices, and color distinction of trash cans, which will all affect the airport waste classification. For example, Vancouver Airport has set up intelligent classification and recycling facilities inside the airport, through which passengers can automatically identify the types of waste to be placed in them. The intelligent facilities greatly improve the convenience and accuracy of the classification and recycling of passengers' waste [18]. In Sydney and Philadelphia airports, the shape of waste bins has been carefully designed, with different shapes for different types of waste, e.g., the waste bin input port for paper collection is a flat shape so that only paper can be put into it, while the waste bin input port for plastic bottles is designed in a round shape so that only the bottles pass through, which improves the accuracy of sorting into the key types of waste [19,20]. Seattle, Abu Dhabi and other airports have installed guide signs of the distribution of waste bins, which provide convenient services for passengers to find the corresponding waste bins [10,21]. Austin Borgstrom and Detroit airports have sprayed the waste bins with different eye-catching colors to differentiate between the types of waste, and prompt passengers to carry out the recycling of the corresponding waste [22,23].

Many scholars find the layout of airport facilities affects the results of waste reduction. For example, Baxter et al. found the great importance placed on the infrastructure setup in the waste management of Kansai Airport has a positive impact on airport waste reduction, arguing that the infrastructure layout is a key focus on the success of the Kansai Airport's waste management model [24]. Ferrulli evaluated various waste management programs at airports and argued that facilities related to recyclable waste storage and collection contribute to airport waste management [25]. Pitt and Smith demonstrated that the lack of recycling facilities is the main reason for the failure of recycling programs at airports under the British Aviation Authority, and that adequate recycling facilities can significantly increase the rate of collection of waste [22].

2.1.2. Publicity and Education

Various forms of publicity and education on airport waste recycling, including live lectures on waste classification knowledge, distribution of brochures and posters, broadcasting of promotional videos and holding of themed activities, etc., can change passengers' willingness to classify in a subtle way. For example, Shanghai Hongqiao Airport has set up a waste classification explanation specialist in the terminal building to explain waste classification knowledge to passengers in real time [26]. BDIA has set up waste classification publicity posters in the terminal building, while Air France Group has provided e-brochures and publicity pamphlets on flights, all of which popularize the knowledge of waste classification and guide passengers to participate in garbage reduction independently by means of paper materials [27]. Shanghai Pudong Airport has conducted video publicity on garbage classification, so that passengers understand the airport waste classification and recycling and improve their knowledge of classification and recycling [28]. Zhuhai Airport actively carries out public welfare activities, organized by a team of volunteers in the airport, with activities demonstrating waste classification, to attract passengers to participate in the airport's waste classification actions [29].

Numerous scholars have also conducted systematic analyses of the impact that publicity and education have on waste reduction. Rachel found that publicity and education can increase passengers' recycling awareness and help to achieve the goal of zero-waste emissions in airports when exploring the effect of waste management at Gatwick Airport

in the United Kingdom [30]. Cross argued that Indian airports have achieved plastic waste reduction in airports through awareness and education, enabling travelers to reduce the carrying and use of plastic products [31]. Winter found similar results when analyzing the effects of waste plastic reduction at Sydney Airport in Australia [32].

2.1.3. Environmental Stimulus

A tidy environment, natural space and greenery arrangements in airports can stimulate passengers' psychology and have an impact on the formation of passengers' waste reduction behavior. San Diego Airport has implemented landscaping actions to improve the airport environment, create a clean and tidy atmosphere, and use fertilizers obtained from airport waste composting to landscaping, achieving a closed-loop cycle of waste in the airport [33]. The BDIA terminal building uses 12,800 pieces of glass in its design, which enables most areas in the terminal building to achieve natural lighting, and provides the best possible comfort for tourists through the integration of nature [34]. Singapore Changi Airport has adopted the design of natural spaces in the terminal building, which helps promote passengers' environmental protection behaviors [35].

Many scholars have analyzed the impact of environmental stimuli on waste reduction. Taheri et al. argued that travelers' behavioral intentions are closely related to the environment in airports, and that green environmental settings in airports can provide travelers with the correct behavioral orientation and enable them to gain experiential satisfaction [36]. Han et al. found that a green physical environment has a great influence on passengers' behavioral intentions, and a good green physical environment can make travelers implement waste classification and recycling in airports [37]. Trang et al. found that the green environment will have an impact on travelers' behaviors, and that the physical conditions of the building will change passengers' environmental attitudes [38].

In conclusion, the following hypotheses are proposed:

Hypothesis 1 (H1): *Internal facilities have a positive impact on waste reduction.*

Hypothesis 2 (H2): *Publicity and education will have a positive impact on waste reduction.*

Hypothesis 3 (H3): *Environmental stimulus will have a positive impact on waste reduction.*

Hypothesis 4 (H4): *Airport internal factors have a positive impact on waste reduction.*

2.2. Social External Factors

Passengers' waste classification behaviors can also be affected by the social factors outside the airport. In many studies, the exploration of the factors influencing the social-level mainly focuses on laws and regulations and social norms.

2.2.1. Laws and Regulations

Laws and regulations are the strong binding force at the social level for the influence of citizens or airport behaviors, and passengers' waste reduction behaviors at airports are still subject to the comprehensive influence of laws and regulations, which can be divided into two types: Responsibility regulation at the time of translation, and a reward and punishment system. In terms of government responsibility regulation, for example, the U.S. Federal Aviation Administration (FAA) issued *FAA Synthesis Document: Recycling, Reuse, and Waste Reduction Plans at Airports* to set waste management goals for airports and regulate the waste management efforts of airports [39]. The *German Waste Management Act* requires that all products purchased by airports comply with specific environmental and economic standards [40]. The *Indian Cleaning Task Force* is responsible for waste reduction at the nearly 34 airports under the Airports Authority of India to gradually eliminate single-use plastics, etc. [41]. The CAAC requires that all kinds of solid waste such as aviation waste, domestic waste, and food waste at airports should be collected in a segregated manner [14].

In terms of economic incentives and penalties, the San Diego Airport Authority as well as the Chicago Airport Authority have used green preference programs and other incentive-driven programs to encourage airports to adopt recyclable food packaging, tableware, etc., as a means of eliminating single-use plastics [42,43]. The FAA emphasizes that master plans developed by airports must address issues related to airport waste recycling in to qualify for government subsidies [44].

In terms of research, Ma et al. demonstrate that the application of various policy tools for waste reduction efforts can accelerate the construction of a waste management system [45]. Samsudin and Mat Don analyzed the local laws and regulations that public places can comply with regarding waste management and argued that local legislation is important for waste reduction in public places [46]. Giroux explored waste management in Canada and demonstrated that local legislation can be effective against promoting waste recycling management [47]. In a study of waste management efficiency at UK airports, Pitt and Smith found that the introduction of a *Green Airline Award* and financial subsidies at Vienna Airport promoted sustainable waste management by airlines [48].

2.2.2. Social Norms

Social norms are different from the hard constraints of laws and regulations, being a type of flexible constraint for travelers [49], which can be divided into two types: personal consciousness and social atmosphere. On the one hand, personal awareness is the knowledge of travelers accumulated through long-term life in society [50], and travelers who have a long-term habit of waste classification will continue this behavior in public places such as airports. On the other hand, the public has a herd mentality and social attributes, which determine that the general behavior of the society and the evaluation of others will have a direct impact on the public [51], mean that if the airport has formed a better waste classification regimen, it will guide the passengers' behavior in order to obtain their own sense of satisfaction and the good opinions of others.

Van der Werff et al. state that the stronger an individual's environmental awareness is, the more he or she feels morally obligated to carry out appropriate environmental actions, and that the personal awareness that travelers possess largely determines the success or failure of waste reduction efforts [52]. Ru et al. concluded that when an atmosphere of waste classification and recycling is formed, it significantly improves the individual's awareness of classification and recycling and leads the public to develop a high degree of moral obligation and personal subjective willingness [53]. Blok et al. also found that the formation of a social climate can stimulate further environmental sustainability performance [54]. Kochan et al. pointed out that if the individual's willingness to recycle increases, the public will be aware of the negative consequences of not separating waste for recycling, which will increase residents' waste classification and recycling behavior [55]. Shi et al. emphasized the importance of the formation of social norms cannot be ignored in waste reduction, and that individual perceptions and the social atmosphere not only effectively promote waste management in the present, but also contribute to the formation of a virtuous cycle that will continue to reduce the amount of waste in the future [56].

In conclusion, the following hypotheses are proposed:

Hypothesis 5 (H5): *Laws and regulations have a positive impact on waste reduction.*

Hypothesis 6 (H6): *Social norms have a positive impact on waste reduction.*

Hypothesis 7 (H7): *Social external factors have a positive impact on waste reduction.*

3. Methodology

3.1. Model Construction

In order to explore the overall influence of airport internal factors and social external factors on passenger waste reduction behavior, as well as the interaction correlation

between internal and external factors, we constructed an interaction-influenced model of airport and social waste reduction behavior based on structural equation modeling, as shown in Figure 2. Based on social research and a summation of the literature, the basic sub-model of the influence of internal and external factors of the airport on passengers' waste reduction behaviors are constructed (yellow arrows in Figure 2), with the amount of airport waste reduction as the dependent variable of the model, and internal facilities, publicity and education, environmental stimulation, social norms, and laws and regulations selected above as the independent variables of the sub-model, which further correspond to the observation items. The internal facilities include four types of observations: intelligent sorting and recycling facilities, waste sorting and recycling guide signs, special design of waste delivery input ports, and color differentiation of garbage cans. The publicity and education variable includes four types of observations: on-site explanations, brochures and posters, publicity videos, and thematic activities. The environmental stimulus includes three types of observations: a clean environment, natural space, and green planting arrangements. The social norms include two types of observations: personal will and social atmosphere. Laws and regulations include governmental responsibility regulations and economic reward and punishment systems.

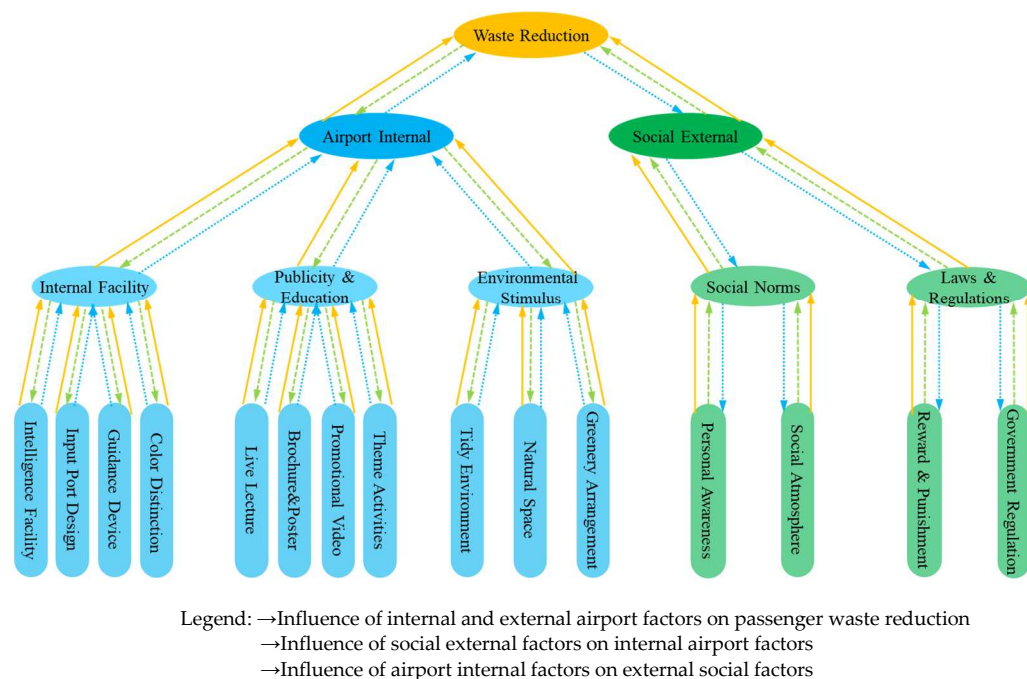


Figure 2. A modeling framework for interactive influence model of airport and social waste reduction behaviors.

In order to further explore the interaction between internal and external factors of airports, this study constructed a sub-model of the impact of airport waste reduction behaviors on society and a sub-model of the impact of social waste reduction behaviors on airports, with the transfer paths of the dependent variables, independent variables and observables shown by the blue arrows and the green arrows in Figure 2, respectively.

3.2. Questionnaire Design and Data Collection

The questionnaire for airport waste reduction contained a detailed explanation of the study, a profile of the respondents, and the questions involved in each observation. In order to portray the measurement items in detail, a five-point Likert scale was used for quantification, citing the corresponding questions from existing studies. The specific questions correspond to those shown in the Appendix A. Before the questionnaire was distributed, a group test was conducted, and based on the feedback, the questionnaire ques-

tions were fine-tuned to further improve the questionnaire. A total of 1083 questionnaires were distributed in China through the Questionnaire Star research platform in March 2022, and 887 valid questionnaires were finally collected, with a recovery rate of 81.9%. The raw data from the survey were filtered through SPSS 22.0 and analyzed and processed using Amos 24.0 software.

The profile of the respondents is shown in detail in the Supplementary Materials. In terms of gender, there were 380 males (42.8%) and 507 females (57.2%). In terms of age, it was mainly concentrated in the range of 18–50 years old, accounting for more than 65% of the respondents. In terms of education, undergraduates were the most numerous, with 540 people, accounting for 60.9%. In terms of occupation, there were 174 people in environmental protection and related fields, accounting for 19.6%, and the rest were not related to environmental protection. In terms of monthly income, it was mainly concentrated on the ranges of CNY 3000–5000 and CNY 5000–8000, accounting for 36.0% and 34.9%, respectively.

3.3. Model Testing and Calibration

3.3.1. Validation Factor Analysis

According to the analysis results of the measurement model, it can be seen that the model fitting indexes meet the statistical requirements ($CMIN/DF = 1.193$, $RMSEA = 0.015$, $GFI = 0.978$, $NFI = 0.983$, $IFI = 0.997$, $TLI = 0.996$, $CFI = 0.997$), in which a smaller $CMIN/DF$ represents a better model fit—the model $CMIN/DF = 1.193 < 2$ so the model has a very good fitting effect; the closer the value of $RMSEA$ is to 0 indicates that the model fits better—the model $RMSEA = 0.015 < 0.05$, indicating that the model fits well; the closer the GFI is to 1 indicates that at this time the model has a better fitting effect—the model $GFI = 0.978 > 0.9$, indicating a good fit; an NFI value closer to 1 indicates that the model fitting effect is better—the model $NFI = 0.983 > 0.9$, therefore, the model fitting effect is good. In response to the measurement relationship, all paths showed as significant ($p < 0.01$), the measurement relationship is good and the measurement model conformational fit is good. As shown in Table 1, the AVE values corresponding to the eight categories of latent variables of internal facilities, publicity and education, environmental stimulus, internal airport factors, waste reduction, external social factors, social norms and laws and regulations were all greater than 0.5, and the CR values were all higher than 0.7, ranging between 0.794 and 0.893. This represents a good convergent validity for the analyzed database [57]. The square roots of the AVEs of the above eight latent variables are all greater than the absolute values of the correlation coefficients between the factors, which proves that there is a good degree of difference between the factors, and the discriminant validity is excellent.

Table 1. Validation Factor Analysis Results.

Latent Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	AVE	CR
(1) Internal facilities	0.823								0.677	0.893
(2) Publicity and education	0.697	0.830							0.689	0.869
(3) Environmental stimulus	0.658	0.729	0.823						0.678	0.863
(4) Airport internal	0.658	0.742	0.710	0.818					0.683	0.812
(5) Waste reduction	0.649	0.723	0.685	0.712	0.832				0.693	0.871
(6) Social external	0.657	0.710	0.690	0.714	0.674	0.812			0.665	0.799
(7) Social regulation	0.723	0.768	0.713	0.728	0.710	0.696	0.815		0.669	0.858
(8) Laws and regulations	0.657	0.718	0.734	0.711	0.692	0.721	0.715	0.826	0.659	0.794

3.3.2. Structural Equation Test

The results of the structural equation test show that the model has good fit indicators and can be accepted ($CMIN/DF = 2 < 3.974 < 5$, $RMSEA = 0.058 < 0.1$, $GFI = 0.914 > 0.9$,

NFI = 0.937 > 0.9, IFI = 0.952 > 0.9, TLI = 0.945 > 0.9, CFI = 0.952 > 0.9). The model explains the relationship between the factors well, and the standard error value is between 0.040 and 0.055, which indicates that the sample statistics are closer to the overall parameter values, and the model has a good measurement effect. Litter reduction was significantly ($\beta = 0.909$, $R^2 = 0.856$, $p < 0.001$) correlated with airport internal ($\beta = 0.915$, $R^2 = 0.852$, $p < 0.001$) and social external factors. Airport internal factors were significantly correlated with their first-order latent factors, with approximately 60% of the internal facilities variable, 73% of the awareness and education variable, and 68% of the environmental stimulus variable explained by the correlation between airport internal factors and their first-order latent factors was also significant, with about 72% of the social norms variables and 71% of the laws and regulations variables being explained by the higher-order variable of social external factors, as shown in Table 2.

Table 2. Structural model evaluation and hypotheses testing results.

Hypothesis	Path	Std. Error	t-Value	p-Value	Standard Path Factor (β)	Hypothesis Test
H1	Airport internal → Waste reduction	0.042	20.869	***	0.909	Established
H2	Social external → Waste reduction	0.043	19.473	***	0.915	Established
H3	Internal facilities → Airport internal	0.042	19.958	***	0.770	Established
H4	Publicity and education → Airport internal	0.043	21.842	***	0.853	Established
H5	Environmental stimulus → Airport internal	0.042	20.664	***	0.818	Established
H6	Social regulation → Social external	0.053	18.230	***	0.845	Established
H7	Laws and regulations → Social external	0.053	19.431	***	0.842	Established

Notes: p is the observable variables' error variance; *** $p < 0.001$.

3.3.3. Hypothesis Test

The hypothesized effects of internal airport factors and external social factors were tested, and the results are shown in Table 2. The results show that internal facilities ($\beta = 0.770$, $p < 0.001$), publicity and education ($\beta = 0.853$, $p < 0.001$), and environmental stimuli ($\beta = 0.818$, $p < 0.001$) are significantly correlated with internal airport factors, and 86% of the internal airport factors are in turn explained by the waste reduction factors, so that H1, H2, H3 and H4 are valid; social norms ($\beta = 0.845$, $p < 0.001$) and laws and regulations ($\beta = 0.842$, $p < 0.001$) are significantly correlated with the social external factors and 85% of the social external factors are explained by the waste reduction factors, so H5, H6 and H7 are all valid.

4. Comprehensive Influence of Internal and External Factors on Waste Reduction

As shown in Figure 3, both internal airport factors ($\beta = 0.909$) and external social factors ($\beta = 0.915$) have a strong degree of influence on passenger behavior. Airports are part of the public places in society, and passengers are also part of the social group; passengers will be influenced by many factors within the airport to make corresponding behavioral changes. Although the internal factors of airports are directly facing the passengers, the overall contact time of the passengers is relatively short, and if there is no repeated influence and stimulation, it will be more difficult for the passengers to form a sense of waste reduction in the short term, which will affect the effectiveness of the airport internal factors.

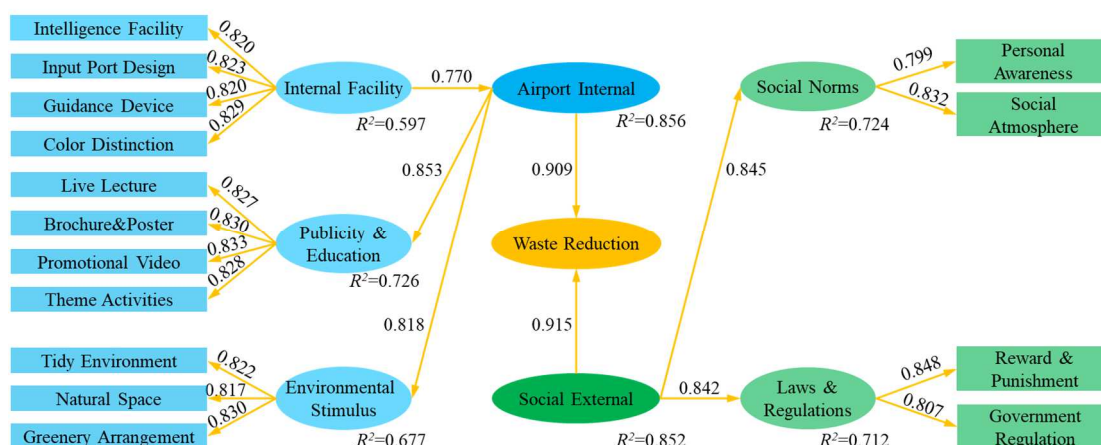


Figure 3. The combined effect of internal and external factors on passenger waste reduction.

On the contrary, the social external factors will influence the environmental behavior of passengers for a long time in their daily life and give them repeated and continuous stimulation to form stable and solidified habits of waste classification behavior, which will still be continued after passengers enter the airport. For the above reasons, the influence of both airport internal factors and social external factors is more significant, and the latter is slightly larger than the form.

4.1. Influence of Airport Internal Factors on Waste Reduction

Publicity and education ($\beta = 0.853$) is the most influential factor within the airport, indicating that passengers are more receptive to familiar means of publicity and education, which in turn leads to better waste reduction behaviors. In its observation items, on-site explanation ($\beta = 0.827$), poster brochures ($\beta = 0.830$), promotional videos ($\beta = 0.833$) and thematic activities ($\beta = 0.828$) have similar effects on passengers' willingness to reduce waste, while on-site explanations and thematic activities have relatively low path coefficients, and some passengers in the interviews believed that it is difficult to participate in corresponding activities for a long period of time when catching flights or transferring at airports, while forms such as videos and posters are more flexible in terms of time and have a better influencing effect on passengers.

The environmental stimulus ($\beta = 0.816$) also presents a superior behavioral influencing effect, which indicates that the beautiful and tidy environmental atmosphere of the airport will promote passengers to form environmental awareness and consciously maintain the internal environment of the airport. Among the observed items, the influencing effect of green planting arrangements ($\beta = 0.830$) and a clean environment ($\beta = 0.822$) is more than that of natural space ($\beta = 0.817$), which is because the former two are in direct contact with travelers and bring travelers a stronger sense of experience.

The effect of internal facilities is smaller than that of publicity and education and environmental stimulation, but internal facilities ($\beta = 0.770$) also have a greater impact on passengers' behavioral intention to reduce waste. Passengers cannot avoid using various public facilities in airports, and any change in these internal facilities will have an impact on passengers' behavioral intention. Changing the internal facilities will change the passengers' sense of experience inside the airport, and the freshness that the new facilities provide for the passengers will bring new stimuli to the passengers to practice waste reduction. Among its observation items, the influencing effect of trash bin color differentiation ($\beta = 0.829$) and trash bin input port design ($\beta = 0.823$) is better than that of guidance signs ($\beta = 0.820$), which indicates that the acceptable time for passengers to separate trash for delivery is shorter, and that the intuitive design scheme of the trash bins has a better influence on passengers. Meanwhile, the intelligence facility is more innovative but has a longer waiting time; the guiding sign only indirectly reduces the passengers' search time for the sorting bin, which will reduce the passengers' experience.

The internal factors of the airport should be focused on while controlling the overall situation, such as playing promotional videos and setting up promotional posters in the airport to provide passengers with visual and auditory stimulation, which can better guide passengers' behavior. In terms of environmental stimulation, more attention should be paid to the green planting arrangements and a tidy environment in the airport, which are in direct contact with passengers. In the internal facilities renovation, the color of the trash bins and the design of the drop-off ports should be the first to be considered as intuitive design solutions.

4.2. Influence of Social External Factors on Waste Reduction

The influences of laws and regulations ($\beta = 0.842$) and social norms ($\beta = 0.845$) on passengers' waste reduction behaviors are basically the same, indicating that both hard and soft constraints drive passengers' behaviors. It is important to pay attention to the influence of social norms and laws and regulations on passengers' waste reduction behavior at the same time. The construction of good social norms cannot be separated from the support of laws and regulations, and the smooth implementation of laws and regulations cannot be separated from the support of social norms, so that the two can be implemented in parallel to achieve better waste reduction results.

Among the laws and regulations, the economic reward and punishment system ($\beta = 0.846$) has a stronger effect than the government responsibility regulation ($\beta = 0.807$). The reward and punishment system drives passengers and enterprises to consciously carry out waste classification behaviors through market intangibles, whereas responsibility regulations constrain passengers' behaviors through the coercive force of the government. In contrast, passengers are more likely to accept the role of market instruments, such as through price differences to attract them to buy green packaging products, can better achieve the effect of waste reduction. Liability regulation, on the other hand, needs to be guaranteed by government coercion, which requires the participation of many supervisors, but is more difficult to implement in the airport scenario.

In terms of social norms, the social atmosphere ($\beta = 0.832$) has a more significant effect than passengers' personal consciousness ($\beta = 0.799$), indicating that the behavioral guidance effect formed by the social atmosphere is strong in terms of waste reduction and sorting and recycling in the airport scene. However, the formation of social atmosphere still relies on the personal consciousness of passengers accumulated over a long period of time, and personal consciousness coalesces into the social atmosphere, and the social atmosphere changes the personal consciousness, thus forming a virtuous circle.

5. Interactive Influence of Internal and External Factors on Airport

Airports are an integral part of the city's functions, and changes in external factors such as social norms and laws and regulations may lead to changes in internal factors such as waste classification facilities and the layout of green environments at airports. Conversely, changes in airport internal factors may contribute to the formation of social external factors. In this way, a complex system of interactions between internal and external factors is formed, which continues to influence the waste reduction behavior at airports and in society.

5.1. Influence of Social External Factors on Airport Internal Factors

The effect of social external waste reduction behaviors on the airport internal factor settings is shown in Figure 4; social norms ($\beta = 0.615$) and laws and regulations ($\beta = 0.628$) will have a significant impact on the airport management through the change in passenger waste reduction behavior, and the influence of laws and regulations is larger. It shows that although the laws and regulations have less influence on passenger waste reduction behavior, they have a greater influence on airport management, in which the influence of the economic reward and punishment system is especially obvious, which can guide airport behavior through the market mechanism. The influence of social norms in the social

atmosphere is significantly higher than that of individual consciousness, indicating that the binding effect of the social atmosphere on passenger behavior will further potentially affect airport management behavior.

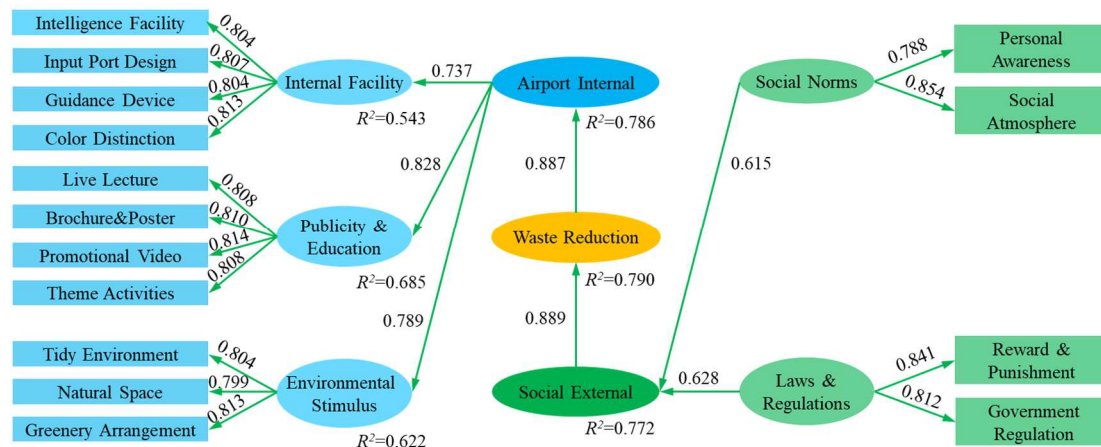


Figure 4. Effect of changes in social external factors on the behavior of airport management.

The path coefficients of the influence of social external factors on waste reduction behaviors, and the path coefficients of waste reduction on internal factors of the airport exceeded 0.8. The high degree of transmission of the influence of social external factors on airport internal factors makes the airport highly influenced by the top-down influence of social external factors, even though it is set up as an independent scenario for waste separation. For the airport management, the most significant influence in the change in social external factors is the publicity and education on waste classification and recycling at the airport ($\beta = 0.828$), followed by environmental stimulus ($\beta = 0.789$) and internal facilities ($\beta = 0.737$). This is because airports are more flexible and convenient for publicity and education and can be more responsive to changes in social external factors, while the purchase of new sorting facilities and airport environmental renovation involves a large amount of investment, and the process of purchasing facilities is more complicated, which directly affect the choices of the airport management.

5.2. Influence of Airport Internal Factors on Social External Factors

Passengers influenced by airport internal factors will not only have an impact on waste classification and recycling behaviors in the airport, but also retain their impression and experience of the airport after leaving the airport, which will not disappear in a short period of time. These personal awareness enhancements will be carried into the daily life of the passengers and will have an impact on the social external factors. We analyzed the effect of changes in airport internal factors on the setting of social external factors using passengers' waste reduction behavior as an intermediate variable as shown in Figure 5, where publicity and education ($\beta = 0.562$) is still the most influential factor, followed by environmental stimulus ($\beta = 0.431$) and internal facilities ($\beta = 0.334$), which has a similarity with the assessment results in Section 4 of this paper, confirming that publicity and education is the key factor in changing passengers' behavioral intentions, while changes in environmental stimulus and internal facilities can directly affect passengers' behavior in the airport, but the continuity of their influence on passengers' subsequent daily behavior is weak.

The path coefficients of the airport internal factors on the social external factors through the passengers' waste reduction behaviors are 0.824 and 0.856, respectively, which are both of high transmittance. If the passengers' waste reduction behaviors are effectively cultivated in airports, it will have a greater impact on the implementation of the laws and regulations related to waste classification as well as the formation of social norms in the social external factors. The identity change and behavioral continuity of passengers in airports and social scenarios are worthy of attention. Along with the rapid development of

the global aviation industry, this will help to form a new cultivation of awareness of waste classification and recycling, which can promote the overall waste reduction in society by strengthening the waste reduction missionary activities in airports and other places with large flow of people.

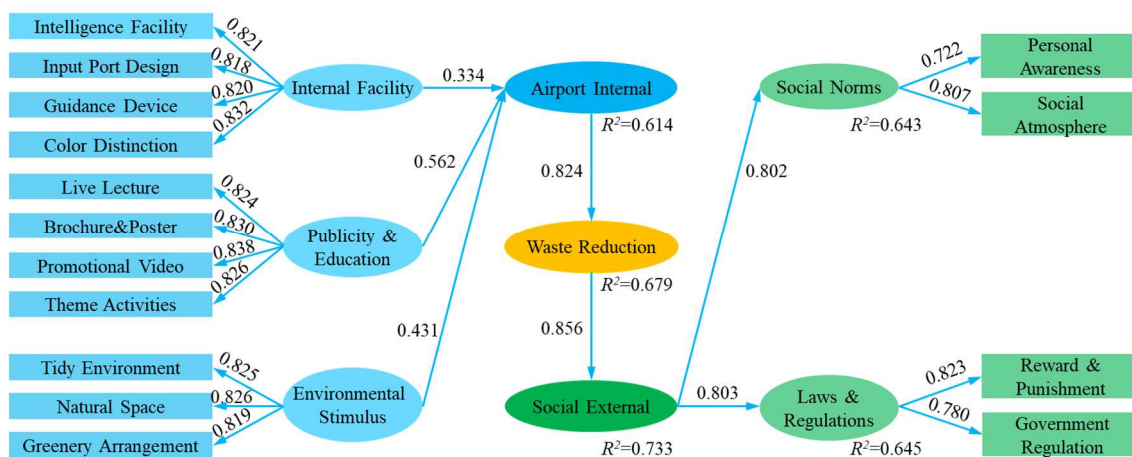


Figure 5. Influence of changes in factors within the airport on social external factors.

6. Suggestions on the Airport waste Reduction Measures

Integrating the influences of airport internal factors and social external factors on passenger waste reduction as well as the interaction of internal and external factors, the overall influences can be obtained as shown in Figure 6. Specifically, analyzing the design direction of airport waste reduction initiatives is suggested as follows:

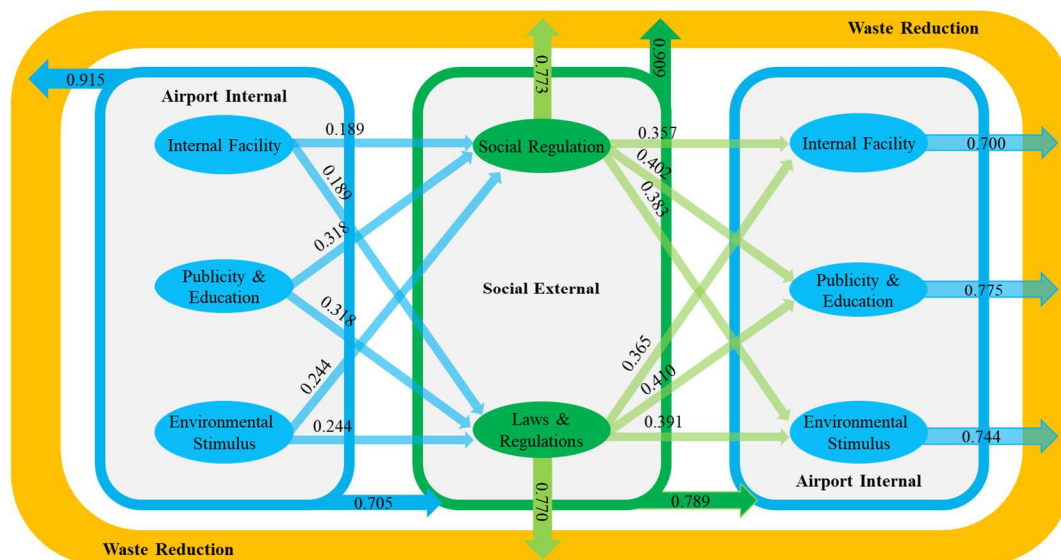


Figure 6. Analysis of the interaction between airport and social waste reduction initiatives.

6.1. Give Full Play to the Direct Role of Internal and External Airport Factors on Passenger Waste Reduction Behavior

As shown in Figure 6, both airport internal factors and social external factors can directly influence the waste reduction behavior of passengers, with path coefficients of 0.909 and 0.915, respectively, which have a very high degree of transmission within the airport scenario, indicating that both have a very important direct influence on the waste reduction in the airport. Meanwhile, the path coefficients of the five independent variables of internal and external factors of the airport, including internal facilities, exceeded 0.70,

which represents an important direct influence on passengers' waste reduction, especially as the path coefficients of publicity and education, social norms, and laws and regulations exceeded 0.77, which has a better effect.

The airport management should pay more attention to the publicity and education about waste reduction in the airport and carry out a variety of highly acceptable publicity and education activities in the airport, such as broadcasting waste classification and recycling publicity videos, distributing manuals and posters, etc., all of which have a significant impact. In addition, the airport management also needs to make efforts to create positive environmental stimulation in the airport, by building a comfortable and beautiful airport environment for passengers and appropriately increasing the arrangement of green plants in the airport to enhance the satisfaction of passengers. With sufficient funding, the construction of internal facilities for waste classification in airports can be considered, to provide passengers with more convenient and easier channels for waste classification and recycling, such as differentiating the color of waste bins and providing some special designs for the waste bin drop-off ports. It should be noted that our research results show that passengers in airports and other transportation hubs are more likely to accept convenient waste classification and recycling equipment, such as intelligent facilities and waste classification guide signs and other investments, although it can directly give passengers a sense of freshness to stimulate passengers' waste reduction behavior, but the overall waiting time for achievement is longer, it may not be able to achieve the expected results, and the follow-up should be focused on strengthening the research and development of rapid waste identification equipment and its application.

6.2. Clarify the Interaction between Internal and External Factors at Airports, and Form a Coupling Mechanism to Jointly Promote Waste Reduction

From the perspective of the influence of paths of internal and external factors on each other, the overall influence path coefficient of the airport internal factors on the social external factors can reach 0.705, which has a better influencing effect. At the same time, the overall influence path coefficient of the social external factors on the airport internal factors can reach 0.789, which indicates that the internal and external factors can form a better positive feedback mechanism. For example, changes in the airport internal factors will promote the behavior of passengers' waste classification and recycling, and bring them out to society, continuously improving passengers' awareness of environmental protection and responsiveness to the policies related to waste classification, while changes in the social external factors will further affect the behavior of the airport management, promoting the passengers' waste classification by enhancing publicity and educational activities, setting up green spaces and improving internal facilities, etc. In this way, internal and external factors jointly promote the passengers' waste reduction and recycling behavior, which is a good effect.

Further refining the interactive correlations between internal and external factors, the coefficients of internal facilities, publicity and education, and environmental stimulus on the influence of social norms and laws and regulations are consistent, with 0.189, 0.318, and 0.244, respectively. Among them, the path coefficients of publicity and education are larger, which suggests that publicity and education, in addition to directly enhancing the behavior of passengers' waste reduction, can better promote the continuation of this kind of behavior in the society. This may be because the means of publicity and education are more consistent between airports and society, and the application of the airport scenario, isolated from the outside, can better enhance the public's awareness of waste classification. It is expected to achieve good results by linking the publicity and education activities of airport and society, such as carrying out a variety of thematic education activities in airport.

The results of the influence of social external factors on the airport management side show that social norm formation and legal and regulatory constraints have the greatest influence on airports' publicity and education ($\beta = 0.410$), followed by environmental stimulus ($\beta = 0.391$) and internal facilities ($\beta = 0.365$). The influence path coefficients of

all three exceeded the influence path coefficients of airport internal factors on external factors, and changes in social external factors are more likely to influence airport managers. National or regional promulgation of waste classification and other related environmental protection policies will not only have an impact on waste reduction in domestic scenarios but will also have a good driving effect on public places. This is particularly true for developing countries, where individual awareness and the social atmosphere towards waste reduction is poor, the enactment of strong laws and regulations can be promoted to the whole society through waste reduction demonstration areas such as airports, utilizing the public's herd mentality to promote the formation of public awareness of waste reduction more quickly. At the same time, airports, as international display windows, are both national business cards and display platforms, and the internal and external linkage impacts on airport are not only regional but also potentially international.

7. Conclusions

The amount of waste at international airports is close to that in small cities. As an integral part of urban functions, the waste reduction behaviors inside the airport and outside the society form a linkage mechanism that influences each other, but the coupling mechanism between the two is not clear. In this study, we explored the effects of internal airport factors and external social factors on airport waste reduction behaviors, revealed the interactive relationship between airport internal and external waste reduction behaviors, and put forward the direction of the corresponding policy design and related recommendations. The results show that both internal and external factors have a significant effect on passengers' waste reduction behavior, with publicity and education, social norms and laws and regulations having a greater effect. Airport internal factors and social external factors can form a better positive feedback mechanism for waste reduction, and path coefficients for both interactions exceed 0.7. Airport publicity and education can directly improve passengers' waste reduction behavior, and better promote the continuation of this behavior in the society, so it is recommended connecting the publicity and education activities between airports and society. The social external factors are more likely to affect the behavior of airport management, and it is recommended that the design of airport management should be encouraged to be more effective in developing countries that have weaker awareness and social atmosphere for waste reduction. In developing countries where the social atmosphere is weak, strong laws and regulations can be enacted and promoted to the whole society through waste reduction demonstration areas such as airports, which can promote public awareness of waste reduction more quickly.

In this study, through a combination of qualitative and quantitative methods, a variety of models are constructed to explore the internal factors of airports and the external factors of society that affect passengers' waste reduction behaviors, and the interaction between internal airports and the external factors of society is further studied, to put forward the corresponding policy recommendations to promote the waste reduction work. Along this line of research, the linkage between internal and external factors influencing waste reduction at different scales can be further explored to provide new ideas and methods for waste reduction and to form a positive interaction between internal and external factors. There may be potential variables that have not been evaluated in the study, and the proposed policy recommendations have not been modeled accordingly, which are expected to be supplemented with the subsequent studies.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/su151813859/s1>, Figure S1. Statistical Chart of Respondents' Information.

Author Contributions: Y.G. and Y.W. (Yufeng Wu) led the project and conceived the original idea; X.G. and Y.G. designed the research and developed the model, ran the simulation, drew the figures and wrote the paper; C.K., Y.W. (Yingjia Wang), T.Z. enhanced the discussion. All authors analyzed the results and contributed to writing this paper. All authors have read and agreed to the published version of the manuscript.

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Appendix A

Internal facilities	Intelligence facility	- I think airports should use smart sorting and recycling facilities - I think the intelligent classification and recycling facilities can help me with the waste classification and recycling - I think the use of smart waste bins promotes waste reduction
	Input port design	- I think the delivery port of the airport waste bins should have a shape suitable for different waste input, such as the input port of throwing plastic bottles can be set in a round shape - I think the design of waste delivery ports with different shapes of waste bins can help me sort the waste - I think the special design of the waste bin delivery port promotes waste reduction
	Guidance device	- I think the airport should use some guidance, including signs, etc. - I think the guidance can help me to sort out and recycle waste - I think the use of guidance, to promote waste reduction
	Color distinction	- In my opinion, airports should distinguish the colors of waste bins, and different colors of waste bins should be suitable to the types of waste - I think the color distinction of the waste bin can help me to sort and recycle waste - I think the color distinction of the trash bin can promote waste reduction
Publicity and education	Live lecture	- I think we can arrange the waste classification and recycling explanation personnel in the airport - I think the on-site explanation can help me to sort my waste - I think the on-site explanation helps to reduce the amount of waste
	Brochure and poster	- I think poster brochures can be distributed in the airport to let passengers know about waste classification - I think the poster manual can help me understand waste classification - I think the poster manual is good for waste classification
	Promotional video	- I think the airport can play videos about waste classification and recycling - I think the publicity video of waste classification and recycling helps me to sort my waste - I think the playback of the promotional video promotes waste reduction
	Theme activities	- I think the airport can hold themed activities on waste classification and recycling - I think the theme event helps me to sort the waste - I think the theme activity is conducive to waste reduction

Environmental stimulus	Tidy environment	- I think the airport should be clean up - I think a clean environment will prompt me to sort waste - I think a clean environment is conducive to waste reduction
	Natural space	- I think natural space (such as rest area with good light) should be set in the airport - I think the setting of natural space will prompt me to sort and recycle waste - I think the use of natural space helps to reduce waste
	Greenery arrangement	- I think the green plants should be added in the airport - I think the green plants will make me want to sort the waste - I think the reasonable layout of green plants will promote waste reduction
Social norm	Personal awareness	- I think everyone should do waste classification and recycling - I think the waste should be sorted and recycled in the airport - I think the waste should be sorted and recycled outside the airport
	Social atmosphere	- I think other's waste classification and recycling behavior will affect me - I think waste sorting and recycling will be praised by others - I think others agree with my waste sorting and recycling
Laws and regulations	Reward and punishment	- I think the regulatory documents issued by the government will restrain my behavior - I think I know more about the government responsibility regulation documents related to waste classification and recycling - I think the regulatory documents related to waste classification and recycling will promote my waste reduction
	government regulation	- I think the reward and punishment system of waste classification and recycling restricts my behavior - I know the reward and punishment system for waste classification and recycling - I think the rewards can promote my waste classification and recycling
Waste reduction		- I think the waste reduction is good - I support waste reduction
Airport internal		- I think the setting of internal facilities is beneficial to waste reduction - I think the publicity and education is beneficial to waste reduction - I think the change in environmental stimulus is good for waste reduction
Social external		- I think the formation of social norms is beneficial to waste reduction - I think the promulgation of laws and regulations is beneficial to waste reduction

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