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The Determinants of Passengers' Consumption Motivation at High-Speed Rail Stations

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Abstract: Exploring passengers' consumption motivation can provide the basis for arranging commercial activities in high-speed rail (HSR) stations to generate more revenue for operations. This study uses a mixed multiple-attribute decision-making model for exploring the consumption motivation at HSR stations and complex influential relationships from the passengers' perspective. The passenger traffic at five major HSR stations in Taiwan were evaluated. Based on the results of decision-making trial and evaluation laboratory (DEMATEL) and DEMATEL-based on the analytical network process methods, it is shown that station attributes and consumption environment attributes are key factors that impact product attributes. Moreover, store location, commercial activities offered, product diversity, time pressure, and service convenience have a "cause" characteristic and, therefore, should be focused on when deploying commercial services at HSR stations. The findings from the modified VlseKriterjumska Optimizacija I Kom-promisno Resenje method reveal that time pressure has the largest gap to aspiration level at almost all the stations. Finally, corresponding management implications to HSR stations are proposed.

Keywords: high-speed rail stations; consumption motivation; DEMATEL; DANP; modified VIKOR

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1. Introduction

High-speed rail (HSR) are a popular transportation facility in many countries around the world, including Japan, France, Germany, Spain, Belgium, the United Kingdom, Switzerland, the United States, South Korea, Italy, Taiwan, China, Saudi Arabia, and the Netherlands. It is characterized by safety, comfort and efficiency. Emerging countries, such as Iran, Morocco, and Mexico, are also actively building high-speed rail networks [1,2]. The construction of a HSR network increases accessibility between different cities, causing a change in population distribution and industrial structure [3]. From the perspective of urban design, transportation facilities are seen as transcending the functional elements that ensure efficient traffic flow. Streets, railway stations, and bus stops can all be regarded as important components of an area [4]. However, the development of HSR network is more expensive than building a traditional railway network due to the higher-quality infrastructure required [1]. Failure to properly manage this infrastructure will result in HSR stations remaining idle and could lead to bankruptcy. Policymakers are trying to devise ways to generate revenue from sources other than fares to promote sustainable operation of HSRs. Among them, providing business activities or services is an important strategy [5].

A railway station is an attractive location for commercial purposes, providing shopping, business, and leisure opportunities to both passengers and residents. Therefore, rail companies can generate additional revenue by operating commercial and retail areas.

Currently, HSR operations are mainly funded by fare income, followed by income from ancillary commercial facilities. For example, the JR West line in Japan had a total operating income of about 158.2 billion Japanese Yen in 2020, to which affiliated commercial facilities contributed 574.8 billion yen (about 38% of the total operating income) [6]. To achieve sustainable operations, the positioning and installation of commercial facilities in the train stations are important [7]. Exploring rail passengers' consumption behavior at HSR stations is an important means to provide services based on user perceptions and expectations [8]. There is an abundance of studies on commercial facilities and consumer behavior at airports [9–15], but there are few that explore passengers' consumption behavior at HSR stations, despite it being an important research issue. This study aims to fill this gap on the consumption motivations of passengers at HSR stations.

Previous studies on passengers' consumption behavior in transportation facilities have mostly used statistical regression analysis [12,13,15,16], Pearson correlation test [9], or modified grey correlation analysis [10]. However, as consumption motivations are affected by various qualitative or quantitative factors, multiple-attribute decision making (MADM) models are increasingly being used [17]. Among the many MADM models, analytic hierarchy process (AHP), developed by Saaty [18], is a popular method for analyzing issues in transport infrastructure projects [19]; it has been utilized to explore passenger satisfaction in urban multi-mode public transportation in Ningbo, China [20], and factors of customer happiness in authorized workshops [21]. However, traditional AHP cannot solve the problem of complex influential relationships among the different motivations [22]. Although the analytical network process (ANP), improved by Saaty [23], relaxes the assumption on the construction of a relationship network, the influential matrix still lacks a reliable foundation [24]. Of late, more and more studies have utilized the advanced decision-making trial and evaluation laboratory (DEMATEL) to explore the complex influence relationships in issues related to determinants of consumption, including online consumption [25], airline passenger satisfaction [26], green marketing [27], and second-hand clothing purchase motivation [28]. A hybrid MADM that includes DEMATEL has explored the issues relevant to transport projects, such as connectivity services between metro systems and urban airports [11] or transportation synthetic sustainability indices [29]. However, no study has explored the issues of consumption motivation at HSR stations using real cases.

In this study, we mix three MADM methods to construct a hybrid MADM model to explore passengers' consumption motivation at five HSR stations in Taiwan. First, the DEMATEL method is used to explore the influential relationships between the dimensions/criteria for determining the consumption motivations. Second, a proposed influential relationship based on DEMATEL is introduced into ANP to construct a DEMATEL-based ANP (DANP) for obtaining the weights [30]. Finally, the DANP weight is combined with modified VIšekriterijumsko K Ompromisno Rangiranje (VIKOR) to evaluate passenger's consumption motivation. Taiwan's HSR is a good case for discussion. As one of the shortest HSRs in the world, many locals use it for their daily commute. As the largest BOT project in the world, Taiwan HSR experienced financial difficulties in its early operation stages due to incorrect financial estimation [2,31]. The expansion of commercial service facilities in HSR stations is an important means of easing financial pressures. Hence, exploring passengers' consumption motivation and their "aspiration level" for formulating improvement strategies can help make operations sustainable for Taiwan HSR.

The remainder of this paper is arranged as follows. Section 2 provides a short literature review and constructs the evaluation framework. Section 3 presents the methodology used. Section 4 presents the empirical results and related discussion. Section 5 presents the conclusions, limitations, and policy implications.

2. Constructing a Framework for Exploring Passengers' Consumption Motivations at HSR Stations: A Short Literature Review

Public transportation nodes, especially railway stations, have become the focus in urban land planning. A rail station is a special facility for passengers to embark and disembark, wait, or transfer using several means, such as platforms, floors, escalators, automatic ticketing systems, and transportation equipment [32]. A rail station can be said to have five functions: connect catchment areas and transportation networks, support the transfer of passengers or cargo between transportation modes, promote commercial use of real estate, provide a public space, and contribute to the identity of the surrounding area [33]. Through public transport operators, it can increase the utilization rate of its services by improving the quality of services provided [34]. Ghosh et al. [35] pointed out that platforms are also an important part of a rail station. Individuals use a variety of platform-based convenience facilities, such as refreshment stalls, ATMs, toilets, cloakrooms, and waiting rooms. Retail activities also play a vital role at the station and can help utilize the space effectively by providing shopping facilities to passengers [36,37].

As a representative example of a HSR, the West Japan Railway Company (JR west) integrates commercial facilities into its rail stations for optimizing the station layout, thereby increasing passenger convenience and providing additional value [38]. Kim et al. [39] proposed that a HSR station is not only a transportation hub, but also integrates shopping, dining, business, and leisure activity centers for attracting more passengers. From the passengers' perspective, Ojha [40] indicated that the most important amenities on India's railway stations are the food and beverage facilities. Be it a traditional railway station or a HSR station, its functions have expanded from simply giving a ride to diversified functions such as shopping or dining for more convenience [33].

Selecting a suitable location within the HSR station to configure commercial services is an issue in the design of a rail station. Three dimensions—station attributes (D_1), product attributes (D_2), and environment attributes (D_3)—are used for evaluating the framework to explore passengers' consumption motivations at a HSR station (Table 1).

The location of the stores provides unique competitive advantages for the stores and has important implications for business revenue [41]. Unlike large shopping malls or department stores, special consideration has to be given to the relationship among available scale space, accessibility, and types of commercial activities provided at rail stations due to the limited space available [42]. Hence, station attributes (D_1) are selected as one dimension. Moreover, the attributes related to product and consumption environment must also be carefully considered. While designing a mall atmosphere, product and service classification based on customer preferences is very important, especially as satisfying consumers' hedonic and utilitarian values will promote spending [43]. Wagner and Rudolph [44] pointed out that non-food shopping focuses more on retailers' store atmosphere and service convenience, while food shopping focuses more on the product itself. Hence, increasing the consumption efficiency can increase spending whether it is food or non-food shopping. With the rapid developments in technology, customers now interact with technology to create more service results while non-aviation-related activities such as shopping and dining in the airport have increased at the same time [45]. Hence, product attributes (D_2) and environment attributes (D_3) come into the picture. The selected criteria in each dimension are described as follows.

Table 1. Framework for passenger consumption motivation at HSR stations.

Dimension	Criteria	Definitions	Cited Literature
Station attributes (D_1)	Station scale (C_1)	The scale of HSR stations	[14,46,47]
	Store location (C_2)	Location of stores in HSR stations	[12,14,46,47]
	Commercial activities offered (C_3)	Commercial activities provided in HSR stations, such as dining, shopping, and entertainment facilities	[13,48,49]

Table 1. *Cont.*

Dimension	Criteria	Definitions	Cited Literature
Product attributes (D_2)	Product diversity (C_4)	The variety of products offered by the shops in the HSR station	[12,43,50,51]
	Product quality (C_5)	The quality of the products provided by the stores in the HSR station	[43,51,52]
	Product retail price (C_6)	The prices of the products sold by the shops in the HSR stations are reasonable	[16,43,51,53]
	Brand name (C_7)	Whether the brands sold in the HSR stations are well-known to passengers	[10,43,51]
Consumption environment attributes (D_3)	Environment (C_8)	The ambient atmosphere of the shops in the HSR stations, such as cleanliness, lighting, or temperature	[11,45,52,54]
	Time pressure (C_9)	The free time available from the time a passenger enters the HSR station till the time of embarking. If there is too little free time, there will be a time pressure.	[15,16,55,56]
	Service quality (C_{10})	The service quality of the service staff in the stores in HSR stations and whether the quality is high or low	[11,12,51,55,57]
	Service convenience (C_{11})	Convenience of consumption by passengers in HSR stations, such as the convenience of obtaining products, making payments, and deciding the type of business activities to consume	[45,51,58,59]

2.1. Station Attributes (D_1)

An appropriate scale of transportation facilities allows the setting up of a certain number of commercial facilities, which gives passengers the illusion that they are in a shopping center so they increase their spending and improve the retail revenue of the facility [14,46]. Apart from the routine eating and shopping facilities, entertainment activities can also be added [13]. An abundance of commercial facilities, such as hotels, department stores, theaters, and museums can also be provided to increase the consumption of tourists [48]. Stores should be located in the most accessible part for passengers according to the level of turnover. If a store is located in a corner or a passageway that is used less frequently, it will reduce the consumption motivation of passengers [12,14]. In transportation facilities such as airports, the provision of a wider range of retail and catering options has also proven to be an important factor in increasing passenger satisfaction and airport service quality [60]. Based on the above, this study includes three criteria in the dimension of station characteristics (D_1): station scale (C_1), store location (C_2), and commercial activities provided (C_3).

2.2. Product Attributes (D_2)

In consumer behavior, providing multiple brands and high-quality products at competitive prices increases the satisfaction of shoppers and promotes shopping and exploration [43]. Geuens et al. [50] mentioned that diverse types of products sold in transportation facilities that include both internationally-known and locally-known brands can trigger the consumption motivation of passengers. Some studies also indicate that brand name has a significant impact on the consumption satisfaction of passengers [10]. Product discounts also increase passengers' consumption motivation [53]. Lu [51] has shown that product quality, price, and brand reputation are critical in affecting consumption motivation in transportation facilities. Based on the above, this study includes four criteria in the dimension of product attribute (D_2): product diversity (C_4), product quality (C_5), product retail price (C_6), and brand name (C_7).

2.3. Consumption Environment Attributes (D_3)

Time and emotion affect passenger consumption in transportation facilities. Passengers are more concerned about convenience attributes, which involves how to easily and comfortably access the service environment and the availability and quality of convenience facilities and services provided [61]. Quality attributes in the physical environment are more important to operators [45]. Kesari and Atulkar [43] found that the use of bright attractive colors, lighting, cooling, cleanliness, fragrance, and luxurious seating produces a pleasant and exciting environment that allows consumers to relax. Rail stations can be designed in a way that reduces stress for passengers through the use of colors, lighting, temperature control, and decorative objects (real plants or art installations), thereby enhancing passengers' consumption motivation [11,52–54]. Some studies have also shown that time pressure has a significantly negative impact on passengers' consumption motivation [15,16,55,56], as they would be in a rush to catch their trains. Transportation facilities should provide more service personnel who provide high quality services to reduce the time pressure of passengers [51,58,59]. Good service quality by service personnel can also increase passengers' excitement [55], which echoes the viewpoint that good service quality increases passenger satisfaction and motivation [9,11,51,57]. Based on the above, this study includes four criteria in this dimension: environment (C_8), time pressure (C_9), service quality (C_{10}), and service convenience (C_{11}).

3. Methodology

MADM models have received increasing attention in consumer behavior because such models reflect real-world problems better [27]. The determinants of the consumption motivation of passengers in HSR stations can be regarded as complex decision-making processes, so it becomes necessary to use a hybrid MADM model, as consumer motivation is affected by many dimensions/criteria that create mutual influence relationships. Traditional statistical methods such as liner regression cannot handle this complexity [22]. Solving the complexity between the dimensions/criteria for evaluation and finding improvement strategies for decision making are the objectives for using MADM [62]. Some studies have discussed a novel hybrid MADM model based on DEMATEL-DANP-VIKOR/TOPSIS for selecting renewable energy alternatives for green blockchain investments [63] or supplier selection among SMEs based on innovation ability [64]. This hybrid MADM model is being used in discussions on consumer behavior. Perçin [26] utilized the hybrid MADM model to analyze passenger service quality and satisfaction with airlines. The model also evaluated the effect of green sales strategies to enhance brand image in consumers' willingness to spend [27]. Liu and Han [65] discussed the key criteria of consumption behavior for wearable devices. However, there are no studies that explore passengers' consumption motivation in HSR stations using a hybrid MADM model.

This study constructs a new hybrid MADM model for exploring passengers' consumption motivation in HSR stations, spread over four stages. Firstly, two questionnaires were used to survey experts' opinion on influential relationships and passengers' opinions on the 11 criteria identified. Secondly, DEMATEL was used to analyze the influential relationships among the dimensions/criteria to deconstruct its causal properties. Thirdly, the influential relationships yielded by DEMATEL were combined with traditional ANP to obtain the DANP weights for motivation priority. Finally, DANP combined with modified VIKOR was used to evaluate the performance of passengers' motivation in HSR stations to identify the gap in their "aspiration level" for providing suggestions on planning commercial activities. The conceptual framework for MADM modeling is shown in Figure 1, and the process in each stage is described as follows.

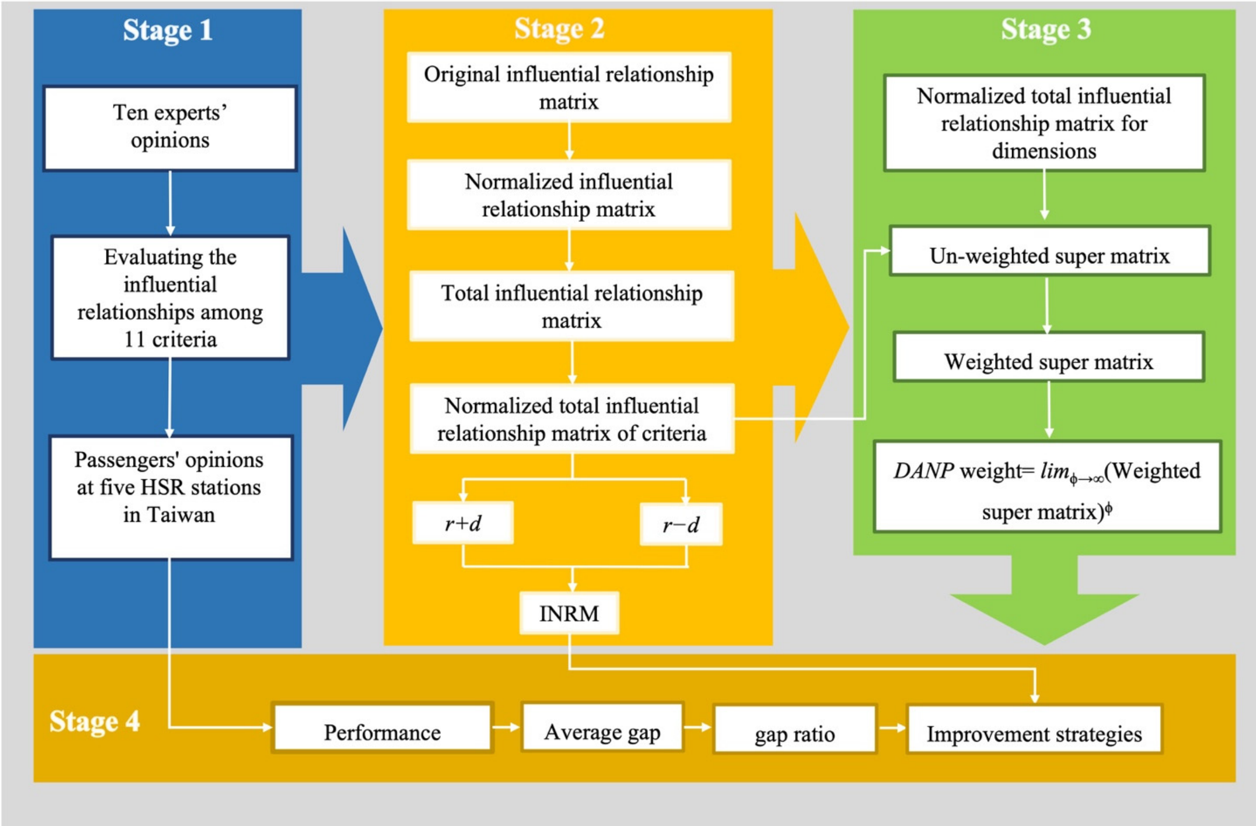

Figure 1. Hybrid MADM modeling process.

3.1. The First Stage: Two Questionnaires for Data Collection

Two questionnaires in Chinese were used for data collection; the first was for collecting experts' opinions for DEMATEL and a detailed design format and references Lin et al. [41]. A total of 18 experts were invited to fill out the questionnaire via email from 1 to 30 September 2020, of which 10 were returned. The experts' profile information is provided in Table 2. These experts have transportation and marketing experience in academic, industrial, and government fields of at least 5 years. Due to this hybrid MADM as expert method, a relatively smaller number of experts would suffice, as suggested by the literature [22,41].

Table 2. The experts' profile details.

Background	Serial Num.	Professional Field	Years of Experience	Job Title	Service Unit
Academia	1	Marketing planning	18	Professor	Department of Shipping Management
	2	Marketing planning	30	Professor	Department of Business Management
	3	Marketing management	22	Professor	Department of Transportation and Logistics
Industry	4	Store management	15	Manager	Logistics Corporation
	5	Store management	20	Manager	Retail Corporation
	6	Store marketing planning	5	Assistant Manager	Retail Corporation
	7	Store management, Store marketing planning	25	District Supervisor	Retail Corporation
	8	Store management, Store marketing planning	17	Director	Retail Corporation
Government	9	Industrial development	10	Engineering Division	Taiwan HSR Corporation
	10	Industrial development	27	Engineering Division	Taiwan HSR Corporation

The second questionnaire surveyed the passengers' opinions; its format also references Lin et al. [41]. A 10-point Likert scale measuring satisfaction/dissatisfaction was used for investigating passengers' motivation. Taiwan has a total of 12 HSR stations. From 2007 to 2020 (see Figure 2), the top HSR stations in terms of passenger volume were Taipei Station, Taichung Station, Zuoying Station, Taoyuan Station, Hsinchu Station, Tainan Station, Banqiao Station, and Chiayi Station. The rest of the stations have been newly built and handle less passenger flow. We selected five stations with the highest passenger flow as our research objects: Banqiao, Taoyuan, Hsinchu, Taichung, and Zuoying HSR stations (see the thick line in Figure 2). Although Taipei HSR Station handles the highest passenger volume, the passenger traffic for Taiwan Railway, Mass Rapid Transit (MRT), and HSR go through the same floor, so it is difficult to distinguish between the passengers. Tainan HSR station was not included because it experienced a significant decrease in passenger volume in 2020.

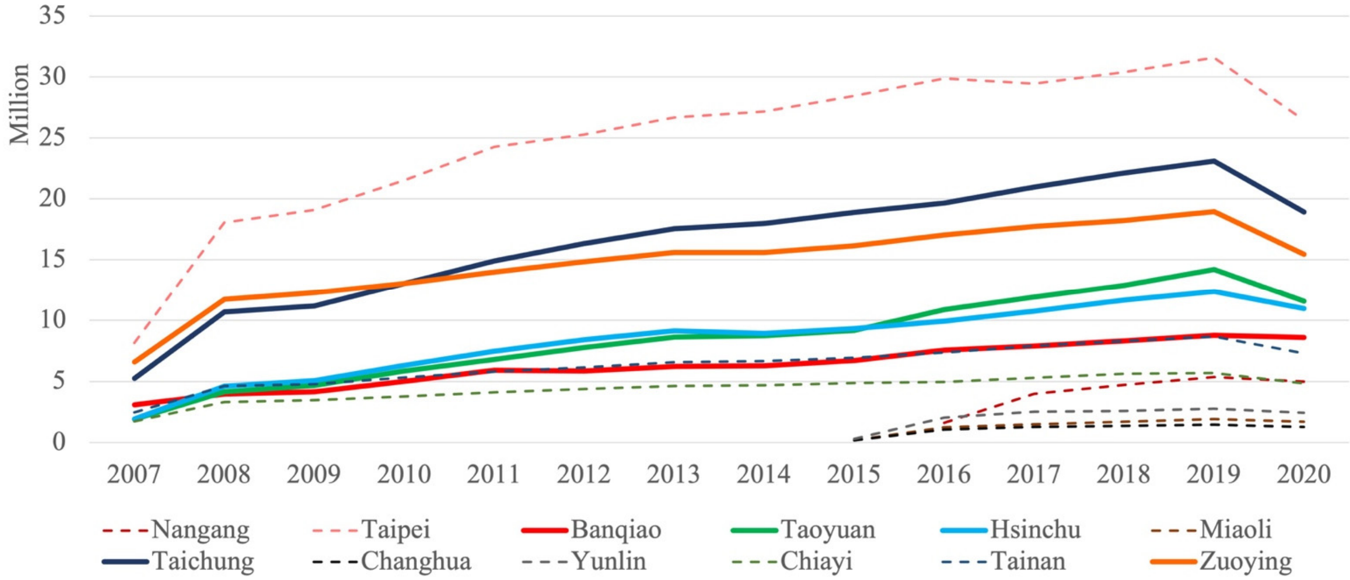

Figure 2. Trend of passenger volume at all Taiwan's HSR stations from 2007 to 2020. Source: Taiwan's Ministry of Transportation Statistics Data Inquiry Network.

This study collected passengers' opinion during three periods: the first is from 27 March to 30 March 2020 at Taichung and Hsinchu HSR stations; the second is from 14 August to 17 August 2020 at Taoyuan HSR station; and the third is from 21 August to 24 August 2020 at Zuoying and Banqiao HSR stations. A total of 1320 questionnaires were collected, of which 1201 were valid, that is, their recovery rate was 90.9%. They can be broken down as follows: 204 valid questionnaires at Banqiao HSR station, 239 at Taoyuan HSR station, 202 at Hsinchu HSR station, 348 at Taichung HSR station, and 208 at Zuoying HSR station.

3.2. The Second Stage: DEMATEL

The Battelle Memorial Institute in Geneva developed the DEMATEL method for its Science and Human Affairs Program from 1972 to 1976 for studying complex real-world issues, such as environmental protection and energy production [27]. The DEMATEL method effectively combines experts' and scholars' knowledge to construct an influential matrix that goes into the making of an influence network relationship map (INRM). This INRM explains the causal relationships among the dimensions/criteria and helps identify the critical ones for decision making [22,30,66].

The detailed calculation process of this method is provided in the relevant literature [41,67]. A simplified description of the DEMATEL process is as follows: (1) construct the original influential relationship matrix according to the 10 experts' opinions; (2) obtain the normalized influential relationship matrix; (3) calculate the total influential relationship matrix for the criteria and dimensions; and (4) sum up the rows and columns of the total influential relationship matrix to obtain the vectors r and d. Vector r represents the degree of influence on other criteria/dimensions and vector d represents the degree of influence by other criteria/dimensions. The INRM is created based on $r + d$ (horizontal axis) and $r - d$ (vertical axis). A higher $r + d$ signifies a stronger total received and given influence on other criteria/dimensions and vice versa; a greater $r - d$ implies a stronger given ability to others criteria/dimensions. The criterion with the higher positive value of $r - d$ is considered more important, meaning that the dimension/criteria has a "cause" characteristic, while a negative value of $r - d$ indicates that the dimension/criterion has an "effect" characteristic.

3.3. The Third Stage: DANP

Although the traditional ANP has overcome the unreasonable conditions found in the use of AHP—by relaxing the unrealistic assumption of independent relationships between the criteria [68]—it is still questionable. As traditional ANP assumes that the diagonal matrix is equal to the zero matrix and the super-weighted matrix is obtained by using the same weight [22,41,68], comparing the internal and external dependencies in pairs is challenging [24]. Combining DEMATEL and ANP overcomes this deficiency and provides us a hybrid MADM [24]. In summary, this DANP method introduces the influential relationship matrix based on DEMATEL into the traditional ANP matrix and so, has more advantages than the traditional ANP, as indicated by Liu et al. [68].

The detailed calculation process of this method is shown in the relevant literature [41,69]. Here, we provide only a simplified description of the DANP process. (1) Normalize the total influential relationship matrix of criteria derived from DEMATEL to obtain the normalized total influential relationship matrix of criteria; (2) transpose the normalized total influence relationship matrix of criteria to obtain an un-weighted super matrix and incorporate the normalized total influential relationship matrix of dimensions into this to obtain a weighted super matrix; and (3) the weighted super matrix is self-multiplied one hundred times to make it converge onto a long-term stable super matrix and then the regional weight of each criteria is obtained. The global weight of the dimensions is obtained by summing up the regional weights of all the criteria in the dimension. The global weight of the criteria can be calculated by multiplying the regional weights of the criteria with the global weight of the dimension.

3.4. The Fourth Stage: Modified VIKOR

The revised VIKOR method is used to evaluate passengers' opinions. The traditional VIKOR was developed by Opricovic in his doctoral dissertation in 1979 [70]. The modified VIKOR was proposed by Opricovic and Tzeng [71,72] and has more advantages than the traditional VIKOR that uses distance-like functions (that is, 0 is equal to a negative ideal solution and 1 is equal to a positive ideal solution) to sort and select alternatives. The traditional VIKOR is easy in "choosing the best apples from a bucket of rotten apples." Liu et al. [68] pointed out that this is because the choice of alternatives must include at least two alternatives, and at least one alternative should be zero in performance (meaning no improvement is needed). However, the gap ratio cannot be obtained because the denominator of the fraction is zero at this time, and when the performance scores of the standards are equal (when evaluating multiple alternatives), this must be eliminated. More importantly, there is no way to get an improvement strategy. The modified VIKOR method takes the "aspiration level" as the desired level (that is, equal to 10 points) and the "worst level" as the benchmark (that is, equal to zero points) to avoid traditional problems and proposes an improvement strategy to achieve the aspiration level.

The detailed calculation process of this method has been provided in the relevant literature [41,68]. Here, we provide only an outline of the simplified modified VIKOR process as follows: (1) calculate the average performance value based on passengers' opinions from five HSR stations, and the average gap between performance and aspiration level (10 points) and their gap ratio; (2) combine the DANP weights with the average performance of criteria to obtain the total performance, gap, and gap ratios at the five HSR stations; (3) arrange the five HSR stations based on the total performance and gap ratios of each case and present the improvement strategies by criteria with the highest gap ratio and DEMATEL.

4. Solution

The results for each stage are provided in Appendix A. Tables A1–A3 provide the results for DEMATEL, in which Table A1 indicates the results of the original influential relationship matrix, Table A2 indicates the result of the normalized influential relationship matrix, and Table A3 indicates the result of the total influential relationship matrix for criteria. Tables A4 and A5 indicate the result of the un-weighted super-matrix and weighted super-matrix of criteria in DANP, respectively.

4.1. DEMATEL and DANP

Table 3 provides the empirical results of DEMATEL and DANP, and INRM is given in Figure 3. The empirical results of the dimensions are indicated first. According to $r + d$, which represents the total influence degree, the order is as follows: product attributes (D_2) (55.231), consumption environment attributes (D_3) (52.697), and station attributes (D_1) (43.286). The order of $r - d$, which represents the cause/effect characteristic, is as follows: consumption environment attributes (D_3) (1.345), station attributes (D_1) (1.107), and product attributes (D_2) (−2.453). Consumption environment attributes (D_3) and station attributes (D_1) belong to the "cause" dimensions, meaning that they impact product attributes (D_2). Consumption environment attributes (D_3) also impact station attributes (D_1). Product attributes (D_2) with a negative value is the "effect" dimension.

Table 3. The DEMATEL and DANP of dimensions and criteria.

	DEMATEL					DANP	
Dimensions/Criteria	***r* (Received)**	***d* (Given)**	$r + d$	$r - d$	**Characteristic**	**Regional Weights**	**Global Weights**
Station attributes (D_1)	22.196	21.089	43.286	1.107	Cause	0.279	-
Station scale (C_1)	6.524	7.512	14.036	−0.988	Effect	0.099	0.356
Store location (C_2)	7.601	7.246	14.848	0.355	Cause	0.096	0.343
Commercial activities offered (C_3)	8.071	6.330	14.402	1.741	Cause	0.084	0.301
Product attributes (D_2)	26.389	28.842	55.231	−2.453	Effect	0.381	-
Product diversity (C_4)	6.972	6.865	13.838	0.107	Cause	0.091	0.238
Product quality (C_5)	6.068	6.912	12.979	−0.844	Effect	0.091	0.240
Product retail price (C_6)	6.645	7.279	13.924	−0.634	Effect	0.096	0.253
Brand name (C_7)	6.705	7.786	14.490	−1.081	Effect	0.103	0.270
Consumption environment attributes (D_3)	27.021	25.676	52.697	1.345	Cause	0.340	-
Environment (C_8)	5.159	7.432	12.591	−2.273	Effect	0.098	0.289
Time pressure (C_9)	8.131	5.514	13.645	2.617	Cause	0.073	0.215
Service quality (C_{10})	6.108	6.671	12.779	−0.563	Effect	0.088	0.260
Service convenience (C_{11})	7.624	6.059	13.683	1.564	Cause	0.080	0.236

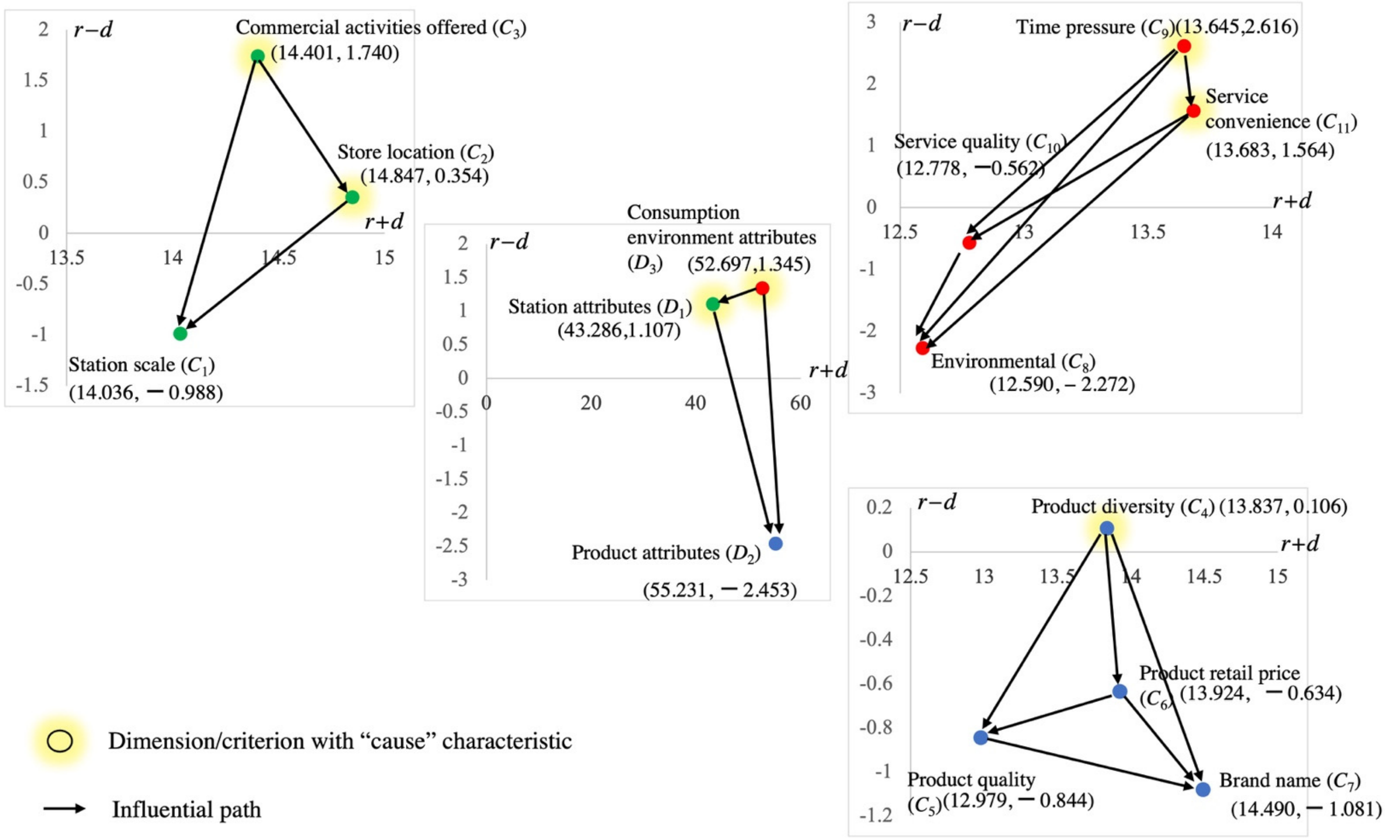

Figure 3. INRM of the criteria in each dimension.

Next, the empirical results of the criteria are indicated. Among the 11 criteria, store location (C_2) (14.848) has the highest value of $r - d$, followed by brand name (C_7) (14.490), commercial activities offered (C_3) (14.402), station scale (C_1) (14.036), product retail price (C_6) (13.924), product diversity (C_4) (13.838), service convenience (C_{11}) (13.683), time pressure (C_9) (13.645), product quality (C_5) (12.979), service quality (C_{10}) (12.779), and environment (C_8) (12.591). Using $r - d$ to identify the cause/effect characteristic, time pressure (C_9) (2.617) with a positive value has the strongest influencing power, which affects other criteria. Likewise, commercial activities offered (C_3) (1.741), service convenience (C_{11}) (1.564), store location (C_2) (0.355), product diversity (C_4) (0.107) are the "cause" criteria as they too have a positive $r - d$. The criteria with a $r - d$ negative value are service quality (C_{10}) (−0.563), product retail price (C_6) (−0.634), product quality (C_5) (−0.844), station scale (C_1) (−0.988), brand name (C_7) (−1.081), and environment (C_8) (−2.273).

The DANP weight shows the regional and global weight. First, the regional weights of the three dimensions from high to low are: product attributes (D_2) (0.381), consumption environment attributes (D_3) (0.340), and station attributes (D_1) (0.279). In terms of criteria, within the station attributes (D_1), station scale (C_1) (0.099) is the highest, followed by store location (C_2) (0.096), and commercial activities offered (C_3) (0.084); within the product attributes (D_2) criteria, brand name (C_7) (0.103) is the highest, followed by product retail price (C_6) (0.096), product diversity (C_4) (0.091) and product quality (C_5) (0.091); within the consumption environment attributes (D_3) criteria, environment (C_8) (0.098) is the highest, followed by service quality (C_{10}) (0.088), service convenience (C_{11}) (0.080), and time pressure (C_9) (0.073). The order of global weights is: station scale (C_1) (0.356), store location (C_2) (0.343), commercial activities offered (C_3) (0.301), environment (C_8) (0.289), brand name (C_7) (0.270), service quality (C_{10}) (0.260), product retail price (C_6) (0.253), product quality (C_5) (0.240), product diversity (C_4) (0.238), service convenience (C_{11}) (0.236), and time pressure (C_9) (0.215).

4.2. Modified VIKOR Results for Five HSR Stations

The performance value, gap ratio, and aspiration level for the five HSR stations are calculated by plugging the DANP weights into the modified VIKOR (see Table 4 and Figure 4). The descriptions are as follows:

Table 4. The performance and gap ratio at the five HSR stations.

Dimensions/Criteria	Banqiao HSR Station		Taoyuan HSR Station		Hsinchu HSR Station		Taichung HSR Station		Zuoying HSR Station	
	Performance	GR	Performance	GR	Performance	GR	Performance	GR	Performance	GR
Station attributes (D_1)	2.191	0.781	1.827	0.817	1.635	0.837	1.986	0.801	2.015	0.798
Station scale (C_1)	8.074	0.193	6.749	0.325	5.837	0.416	7.615	0.239	7.361	0.264
Store location (C_2)	7.167	0.283	6.527	0.347	6.248	0.375	6.888	0.311	7.255	0.275
Commercial activities offered (C_3)	8.392	0.161	6.343	0.366	5.450	0.455	6.807	0.319	7.034	0.297
Product attributes (D_2)	3.030	0.697	2.444	0.756	2.843	0.716	2.642	0.736	2.620	0.738
Product diversity (C_4)	8.275	0.173	5.816	0.418	6.455	0.354	6.557	0.344	6.851	0.315
Product quality (C_5)	8.250	0.175	6.845	0.315	8.074	0.193	7.621	0.238	7.303	0.270
Product retail price (C_6)	6.863	0.314	6.151	0.385	6.856	0.314	6.408	0.359	6.332	0.367
Brand Name (C_7)	8.397	0.160	6.778	0.322	8.347	0.165	7.121	0.288	7.000	0.300
Consumption environment attributes (D_3)	3.049	0.695	2.587	0.741	3.079	0.692	2.803	0.720	2.693	0.731
Environment (C_8)	8.397	0.160	7.297	0.270	8.896	0.110	8.158	0.184	7.548	0.245
Time pressure (C_9)	4.328	0.567	6.377	0.362	3.797	0.620	5.417	0.458	5.740	0.426
Service quality (C_{10})	8.525	0.148	7.724	0.228	8.871	0.113	8.230	0.177	7.697	0.230
Service convenience (C_{11})	8.662	0.134	7.582	0.242	8.653	0.135	8.193	0.181	7.745	0.225
Total	8.271	0.173	6.858	0.314	7.557	0.244	7.431	0.257	7.327	

Note: GR denotes gap ratio.

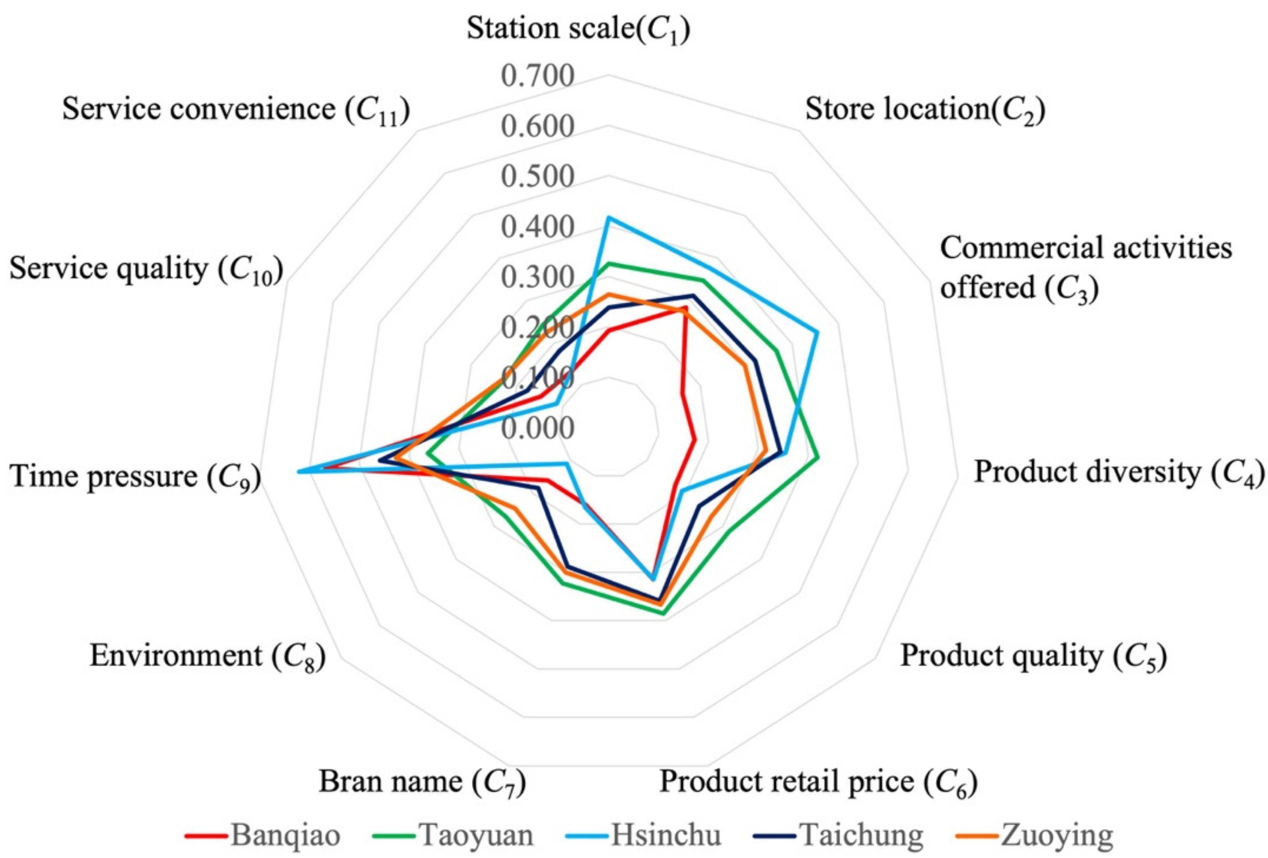

Figure 4. Radar chart of the gap ratio for the five HSR stations.

At Banqiao HSR station, the dimension with the highest gap ratio is station attributes (D_1) (0.781), followed by product attributes (D_2) (0.697), and consumption environment attributes (D_3) (0.695). The criterion with the highest gap between performance value and desire level is time pressure (C_9) (0.567), followed by product retail price (C_6) (0.314), store location (C_2) (0.283), station scale (C_1) (0.193), product quality (C_5) (0.175), product diversity (C_4) (0.173), commercial activities offered (C_3) (0.161), brand name (C_7) (0.160), environment (C_8) (0.160), service quality (C_{10}) (0.148), and service convenience (C_{11}) (0.134).

At Taoyuan HSR station, the dimension with the highest gap ratio is station attributes (D_1) (0.817), followed by product attributes (D_2) (0.756), and consumption environment attributes (D_3) (0.741). The criterion with the highest gap is product diversity (C_4) (0.418), followed by product retail price (C_6) (0.385), commercial activities offered (C_3) (0.366), time pressure (C_9) (0.362), store location (C_2) (0.347), station scale (C_1) (0.325), brand name (C_7) (0.322), product quality (C_5) (0.315), environment (C_8) (0.270), service convenience (C_{11}) (0.242), and service quality (C_{10}) (0.228).

At Hsinchu HSR station, the dimension with the highest gap ratio is station attributes (D_1) (0.837), followed by product attributes (D_2) (0.716), and consumption environment attributes (D_3) (0.692). The criterion with the highest gap ratio is time pressure (C_9) (0.620), followed by commercial activities offered (C_3) (0.455), station scale (C_1) (0.416), store location (C_2) (0.375), product diversity (C_4) (0.354), product retail price (C_6) (0.314), product quality (C_5) (0.193), brand name (C_7) (0.165), service convenience (C_{11}) (0.135), service quality (C_{10}) (0.113), and environment (C_8) (0.110).

At Taichung HSR station, the dimension with the highest gap is station attributes (D_1) (0.801), followed by product attributes (D_2) (0.736), and consumption environment attributes (D_3) (0.720). The criterion with the highest gap ratio is time pressure (C_9) (0.458), followed by product retail price (C_6) (0.359), product diversity (C_4) (0.344), commercial activities offered (C_3) (0.319), store location (C_2) (0.311), brand name (C_7) (0.288), station scale (C_1) (0.239), product quality (C_5) (0.238), environment (C_8) (0.184), service convenience (C_{11}) (0.181), and service quality (C_{10}) (0.177).

At Zuoying HSR station, the dimension with the highest gap is station attributes (D_1) (0.798), followed by product attributes (D_2) (0.738), and consumption environment attributes (D_3) (0.731). The criterion with the highest gap ratio is time pressure (C_9) (0.426), followed by product retail price (C_6) (0.367), product diversity (C_4) (0.315), brand name (C_7) (0.300), commercial activities offered (C_3) (0.297), product quality (C_5) (0.270), store location (C_2) (0.275), station scale (C_1) (0.264), environment (C_8) (0.245), service quality (C_{10}) (0.230), and service convenience (C_{11}) (0.225).

4.3. Discussion

According to the DEMATEL and INRM results, the dimensions with positive values of $r - d$ are: station attributes (D_1) and consumption environment attributes (D_3). An improvement in station attributes (D_1) will lead to an improvement in consumption environment attributes (D_3). Product attributes (D_2) are affected by other criteria due to its negative $r - d$ value. Time pressure (C_9), commercial activities offered (C_3), store location (C_2), product diversity (C_4) and service convenience (C_{11}) have positive values of $r - d$, which should be focused on by policymakers. Among them, time pressure (C_9) with the highest value should be a critical criterion. These findings are consistent with previous findings on passengers' consumption motivation at airports [15,16,55,56]. The time pressure at HSR stations is more obvious than at other transportation facilities because the procedures required to board an HSR are not the same as that at the airport where there are a series of steps to go through: parking, check-in at the counter, security check, customs check, and final boarding [55]. Most HSR passengers arrive closer to boarding times and the time spend in the lobby and train station is less. This viewpoint also echoes that of Sadikoglu [55] who found that time pressure negatively affects travelers' consumption motivation and purchase behavior.

However, as passengers tend to spend less time at HSR stations, there should be greater focus on providing fast and simple commercial activities, such as dining and shopping, supplemented by entertainment activities to induce spending. This is also inconsistent with the results from airport. Tseng et al. [13] showed that when airline passengers have ample time to spend in the terminal, they tend to consume in the order of shopping, entertainment, and food. Moreover, the important role of store location should be highlighted. As Sahak et al. [12] and Wu and Chen [47] pointed out that a good store location attracts more airport passengers. Currently, almost all stores tend to be set up on both sides of the aisle that gets the highest passenger flow, with some small stores being set up beyond the gate area. Product diversity should be an important factor for promoting passengers' consumption, which is in line with the findings of Geuens et al. [50] and Lu [51] based on evidence from airline passengers. The variety of products available in airport stores encourages passengers to spend more inside the terminal [12]. Since most passengers at HSR stations are business travelers, domestic or foreign tourists, the stores should provide more catering and souvenir shopping options. Souvenir shops can induce people to buy products with commemorative characteristics.

The modified VIKOR results show that for all five HSR stations in Taiwan, station attributes (D_1) has the largest gap to aspiration level. Among the 11 criteria, product diversity (C_4) at Taoyuan HSR Station has the highest gap because there is a greater proportion of tourist traffic at this station (see Table 5). Tourists have less time pressure and pay more attention to the functions of products and services. The remaining four HSR stations have the highest gap in time pressure (C_9), because these stations handle more business travelers who tend to be short on time. This is consistent with Lin and Chen's [11] findings that business travelers experience more time pressure. Hence, improving on time pressure (C_9) is an important strategy for almost all stations. Hsinchu HSR station is the smallest among the five stations and cannot provide abundant commercial activities. The poor performance of commercial activities offered (C_3) suggests that it should prioritized for enhancing the station's operations.

Table 5. The types of passengers in the five HSR stations in Taiwan.

	Banqiao HSR Station		Taoyuan HSR Station		Hsinchu HSR Station		Taichung HSR Station		Zuoying HSR Station	
	Times	**%**	**Times**	**%**	**Times**	**%**	**Times**	**%**	**Times**	**%**
Work	74	36.3	85	35.6	105	52.0	160	46.0	65	31.3
Travel	72	35.3	71	29.7	39	19.3	71	20.4	77	37.0
Visit	45	22.1	61	25.5	31	15.3	73	21.0	47	22.6
Other	13	6.4	22	9.2	27	13.4	44	12.6	19	9.1
Total	204	100	239	100	202	100	348	100	208	100

5. Conclusions

Compared with the many studies on passengers' consumer behavior at airports [12,13,15,16,47,50,51,55,56], this study is the first on passengers' consumption motivation at HSR stations. This study explores the influential relationships among passengers' consumption motivation using DEMATEL and brings this relationship into the traditional ANP for obtaining more realistic DANP weights. A modified VIKOR is also applied to evaluate passengers in five HSR stations in Taiwan. This proposed hybrid MADM model provides new research ideas for clarifying the consumption motivations of HSR passengers and suggestions for improvement in HSR station operations.

Based on the relevant literature on passengers' consumption motivation at public facilities, a framework covering three dimensions and 11 criteria is constructed for exploring passengers' consumption motivation at HSR stations, and a hybrid MADM model is utilized for decision making. The results of DEMATEL and DANP reveal that station attributes and consumption environment attributes affect product attributes. In terms of criteria, time pressure is critical to passengers' consumption motivation at HSR stations. Moreover, store location, product diversity, and service convenience have "cause" characteristics and should be focused on by policymakers. The station environment is most affected by other criteria. The result of modified VIKOR shows that Banqiao HSR station has the highest gap ratio to aspiration level. There should be more product diversity at Taoyuan HSR station, while Banqiao, Hsinchu, Taichung, and Zuoying HSR stations should improve on time pressure.

These findings provide useful suggestions for the future planning of commercial activities at HSR stations around the world: (1) Reduce time pressure through electronic payment—It is recommended that decision makers should simplify and speed up the process of obtaining products or services to reduce the time pressure of passengers so that they spend more time in HSR stations. Stores in HSR stations can also emphasize zero-risk consumption. For example, by providing products of stable quality to maximize satisfaction of passengers or employing well-trained service personnel who can reduce the search time. Reducing transaction time also saves passengers' time and stores should make full use of electronic payment systems towards that end. (2) Diversify the commercial activities—Currently, the types of commercial activities provided to HSR passengers include souvenir shopping, convenience stores, drug stores, and restaurants and fast food outlets, as well as additional services, such as ATMs, car rentals, and vending machines. According to Tseng et al. [13], HSR stations in Taiwan do not provide entertainment-related activities. Therefore, it is recommended that entertainment-related activities should be provided to increase the diversity of commercial activities. (3) Improve the spatial efficiency of store location—HSR stations can set up stores along the routes where passengers are going to take a ride, set up stores on the way to and from the platform, or count the stores most frequently consumed by passengers or their degree of convenience to arrange it close to the gate.

This study has the following limitations. First, it only considers the opinions of Taiwanese experts to deconstruct the influence relationships and one must be cautious when generalizing the results to HSR stations in other countries/regions. The proposed index framework and hybrid MADM model should be used to evaluate other HSR stations to confirm the validity of the results. Second, this study only surveys the passengers at five major HSR stations in Taiwan; future studies should look at analyzing more passengers. This study also does not consider the fuzzy semantics that go into people's decision making; future studies could further expand on that. Finally, since the study aimed to explore the complex relationship between the dimensions/criteria in this study, a cost–benefit analysis of inputs was not conducted using multi-objective attribute decision-making methods.

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Appendix A

Table A1. Initial influential relationship matrix of criteria.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}
C_1		2.000	1.800	2.100	1.400	1.200	1.800	1.600	1.400	1.400	1.400
C_2	2.300		1.900	1.900	1.300	1.900	1.800	1.700	2.100	1.600	2.400
C_3	2.500	2.700		2.200	1.600	1.500	2.500	2.300	1.500	2.100	1.600
C_4	2.600	1.400	2.000		2.000	2.000	1.800	1.800	1.200	1.700	1.100
C_5	1.000	1.000	1.100	1.400		2.600	2.300	1.700	1.300	1.600	1.200
C_6	1.200	1.500	1.300	1.800	2.200		2.600	2.300	1.000	1.700	1.300
C_7	1.700	1.800	1.600	1.500	2.200	2.300		2.100	0.800	1.700	1.300
C_8	2.100	1.700	1.300	1.000	1.200	1.400	1.400		0.700	1.200	0.700
C_9	2.300	2.500	1.800	2.000	1.700	1.900	1.800	1.800		1.900	2.700
C_{10}	1.200	1.000	1.100	1.600	2.000	1.800	2.100	1.700	1.300		1.500
C_{11}	2.100	2.800	1.800	1.700	1.600	1.600	1.500	1.600	2.400	1.800	

Table A2. Normalized influential relationship matrix of criteria.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}
C_1	0.000	0.102	0.092	0.107	0.071	0.061	0.092	0.082	0.071	0.071	0.071
C_2	0.117	0.000	0.097	0.097	0.066	0.097	0.092	0.087	0.107	0.082	0.122
C_3	0.128	0.138	0.000	0.112	0.082	0.077	0.128	0.117	0.077	0.107	0.082
C_4	0.133	0.071	0.102	0.000	0.102	0.102	0.092	0.092	0.061	0.087	0.056
C_5	0.051	0.051	0.056	0.071	0.000	0.133	0.117	0.087	0.066	0.082	0.061
C_6	0.061	0.077	0.066	0.092	0.112	0.000	0.133	0.117	0.051	0.087	0.066
C_7	0.087	0.092	0.082	0.077	0.112	0.117	0.000	0.107	0.041	0.087	0.066
C_8	0.107	0.087	0.066	0.051	0.061	0.071	0.071	0.000	0.036	0.061	0.036
C_9	0.117	0.128	0.092	0.102	0.087	0.097	0.092	0.092	0.000	0.097	0.138
C_{10}	0.061	0.051	0.056	0.082	0.102	0.092	0.107	0.087	0.066	0.000	0.077
C_{11}	0.107	0.143	0.092	0.087	0.082	0.082	0.077	0.082	0.122	0.092	0.000

Table A3. Total influential relationship matrix of criteria.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}
C_1	0.575	0.645	0.568	0.621	0.593	0.613	0.677	0.642	0.487	0.575	0.529
C_2	0.774	0.647	0.652	0.699	0.676	0.733	0.774	0.739	0.589	0.668	0.649
C_3	0.824	0.805	0.598	0.748	0.726	0.757	0.847	0.806	0.590	0.725	0.646
C_4	0.729	0.655	0.608	0.559	0.656	0.685	0.720	0.690	0.505	0.622	0.544
C_5	0.578	0.560	0.500	0.551	0.493	0.636	0.659	0.608	0.449	0.548	0.484
C_6	0.639	0.630	0.552	0.614	0.639	0.567	0.723	0.683	0.473	0.596	0.529
C_7	0.665	0.648	0.569	0.607	0.643	0.676	0.611	0.680	0.470	0.601	0.534
C_8	0.549	0.515	0.444	0.463	0.474	0.504	0.536	0.448	0.367	0.459	0.400
C_9	0.820	0.804	0.687	0.746	0.735	0.779	0.822	0.789	0.527	0.722	0.700
C_{10}	0.591	0.564	0.504	0.563	0.588	0.605	0.653	0.610	0.453	0.475	0.501
C_{11}	0.768	0.774	0.649	0.693	0.690	0.723	0.764	0.737	0.604	0.678	0.544

Table A4. Un-weighted super-matrix of criteria.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}
C_1	0.321	0.374	0.370	0.366	0.353	0.351	0.353	0.364	0.355	0.356	0.350
C_2	0.361	0.312	0.362	0.329	0.342	0.346	0.344	0.342	0.348	0.340	0.353
C_3	0.318	0.315	0.269	0.305	0.305	0.303	0.302	0.294	0.297	0.304	0.296
C_4	0.248	0.243	0.243	0.214	0.236	0.241	0.239	0.234	0.242	0.234	0.241

Table A4. *Cont.*

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}
C_5	0.237	0.234	0.236	0.250	0.211	0.251	0.253	0.240	0.239	0.244	0.240
C_6	0.245	0.254	0.246	0.261	0.272	0.223	0.267	0.255	0.253	0.251	0.252
C_7	0.270	0.269	0.275	0.275	0.282	0.284	0.241	0.271	0.267	0.271	0.266
C_8	0.287	0.279	0.291	0.292	0.291	0.299	0.298	0.268	0.288	0.299	0.287
C_9	0.218	0.222	0.213	0.214	0.215	0.208	0.206	0.219	0.192	0.222	0.236
C_{10}	0.258	0.253	0.262	0.264	0.262	0.261	0.263	0.274	0.264	0.233	0.265
C_{11}	0.237	0.245	0.234	0.231	0.232	0.232	0.234	0.239	0.256	0.245	0.212

Table A5. Weighted super-matrix of criteria.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}
C_1	0.088	0.102	0.101	0.102	0.098	0.098	0.098	0.103	0.101	0.101	0.099
C_2	0.099	0.086	0.099	0.091	0.095	0.096	0.096	0.097	0.099	0.096	0.100
C_3	0.087	0.086	0.074	0.085	0.085	0.084	0.084	0.084	0.084	0.086	0.084
C_4	0.095	0.093	0.093	0.081	0.090	0.092	0.091	0.090	0.093	0.089	0.092
C_5	0.090	0.089	0.090	0.095	0.080	0.096	0.096	0.092	0.091	0.093	0.092
C_6	0.093	0.097	0.094	0.099	0.103	0.085	0.101	0.098	0.097	0.096	0.096
C_7	0.103	0.102	0.105	0.105	0.107	0.108	0.092	0.104	0.102	0.104	0.102
C_8	0.099	0.096	0.100	0.100	0.099	0.102	0.102	0.089	0.096	0.100	0.096
C_9	0.075	0.077	0.073	0.073	0.073	0.071	0.070	0.073	0.064	0.074	0.079
C_{10}	0.089	0.087	0.090	0.090	0.090	0.089	0.090	0.091	0.088	0.078	0.088
C_{11}	0.082	0.085	0.080	0.079	0.079	0.079	0.080	0.080	0.085	0.082	0.071

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