

EXPLORING LOCATION DETERMINANTS OF ASIA'S UNIQUE BEVERAGE SHOPS BASED ON A HYBRID MADM MODEL

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Abstract. Identifying relevant location determinants is a good starting point for shop operators, help to increase profitability and, thus, avoiding business failure. Traditional Analytic Hierarchy Process (AHP) or the Analytic Network Process (ANP) have shortages that require improvement. Herein, Decision-Making Trial and Evaluation Laboratory (DEMATEL), ANP based on DEMATEL (DANP), and modified Vlse Kriterijumska Optimizacija I Kompromisno Resenje (modified VIKOR) are used to construct a hybrid multiple-attribute decision making (MADM) model, encompassing three dimensions and thirteen criteria in exploring the location determinants of Asia's unique Bubble Tea Shops (BTSs) and to evaluate three pre-selected alternatives in Nanjing, China. The empirical findings of the DEMATEL method reveal that traffic traits (D_1) and site traits (D_2) are critical to BTSs, and that once these are enhanced, shop traits (D_3) are also improved. Criteria deemed as important, based on the DEMATEL and DANP methodology, are (in descending order): proximity to a street corner (C_2), proximity to public transportation systems (C_1), road width (C_3), proximity to communities (C_5), proximity to commercial areas (C_6), types of shop (C_9), and proximity to schools (C_7). Different decision-making rankings among alternatives are indicated based upon the modified VIKOR method and corresponding strategies for improvement are presented.

Keywords: Bubble Tea Shop (BTS), location determinants, Decision-Making Trial and Evaluation Laboratory (DEMATEL), Analytic Network Process based on DEMATEL (DANP), modified Vlse Kriterijumska Optimizacija I Kompromisno Resenje (modified VIKOR).

Introduction

As a key factor in the success of long-term strategic decisions, location determinants have received extensive attention in the research on food outlets, such as restaurants (Tzeng et al., 2002; Park & Khan, 2006; Dock et al., 2015; Chen & Tsai, 2016; Yang et al., 2017), convenience stores (Kuo et al., 2002), and the food retail industry (Sevtsuk, 2014; Yıldız & Tüysüz, 2019). As an important feature in people's daily dietary routines, beverage shops—such as coffee shops (Wibisono & Marella, 2020) and tea houses

in Europe (Chen et al., 2018)—have also been examined. A series of retail location theories—including spatial interaction theory (Reilly, 1929, 1931), central location theory (Christaller, 1933, 1966), and bid-rent theory (Alonso, 1964)—have been used to explore the complex relationship between consumers' demands, accessibility, and retail location. Whether it concerns a chain enterprise or a single store, proper decision-making about an establishment's location can help expand the venture's market of concern in order to attract more customers, increase market share

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and subsequent profitability, shorten the period needed to repay fixed capital investments (Chou et al., 2008), and improve customer loyalty via convenience (Yang et al., 2017). Consequently, a convincing evaluation of the store location determinants is a good starting point for operators.

Various multi-attribute decision-making (MADM) models have been applied in the efforts to solve location decision-making problems, which are often shaped by multiple objectives and conflicts of interest (Chou et al., 2008; Chen et al., 2018). This is because the traditional decision-making methods for location selection, such as the checklist method, simulation method, and regression model—are based on the knowledge and experience of managers; these methods can only provide decision-makers with a set of steps to take in solving the problem, without taking into account the relationship between the decision-making factors (Kuo et al., 2002). MADM models that can simultaneously cover qualitative and quantitative indicators are considered suitable for identifying and exploring location determinants (Tzeng et al., 2002; Yıldız & Tüysüz, 2019). Among the many MADM models, the Analytic Hierarchy Process (AHP), as developed by Saaty (1980), and its extended variant have commonly been used to explore the various location selections relevant to the food retail industry (Kuo et al., 1999, 2002; Tzeng et al., 2002; Ho et al., 2013; Yıldız & Tüysüz, 2019). In this regard, Tzeng et al.'s paper (2002) is a representative study in terms of restaurant operators' location selection. In addition, the Analytic Network Process (ANP) (Saaty, 1986) has been utilized to explore location selection decisions in the retail industry (Tolga et al., 2013) and among cafes (Wibisono & Marella, 2020). Moreover, a data mining framework based on rough set theory has been used in relation to the decision-making of restaurant locations (Chen & Tsai, 2016), and evaluations based on the distance from the average solution (EDAS) method and the weighted aggregated sum product assessment with normalization (WASPAS-N) method have been used to explore the factors determining the location of teahouses (Chen et al., 2018). Although these studies have provided a favorable

foundation, these MADM methods carry some unrealistic assumptions that do not take into consideration the relationships between the factors relating to a location's selection (Tzeng & Shen, 2017; Shen & Tzeng, 2018; Liu et al., 2018a; Chen et al., 2019; Peng & Tzeng, 2019; Lin et al., 2021). Hence, reliance on traditional methods to identify and evaluate a location's determining factors is not sufficiently persuasive. Thus, the primary purpose of the present study is to address this issue. The research objects of this study are “hand-shake beverages shops” (a Taiwanese term), also known as “bubble tea shops” (a Mainland China term, hereinafter abbreviated to as BTSs), which sell various types of hand-tea beverages and are common in Asia, especially China, Taiwan, and Hong Kong (see Figure 1).

BTSs are quite different from teahouses in Europe (Chen et al., 2018), providing drinks made from different types of tea (the most common being black tea, green tea, clear tea, and oolong tea), sugars (fructose, sucrose, or honey), sweetened ingredients (pearls made from tapioca flour, weak tinctures, and fine grass, for example), milk (creamer or milk), and fruit (fresh fruit and conserves). The degree of sweetness and temperature of the drink can be made according to the customer's needs. Of these variations, and thanks to contemporary globalization, “Bubble/Pearl Milk Tea” (also known as “Oriental Cola” in Taiwan; Lan, 2007) is the best-known beverage normally available at BTSs (Lin & Tzeng, 2010). After decades of rapid expansion, BTSs, which originated in Taiwan in the 1980s (Fortune Business Insights [FBI], 2019), can be found in many countries, including Singapore, Malaysia, Indonesia, Hong Kong, Japan, South Korea, the United States, Australia, and New Zealand (Lin & Tzeng, 2010) and have become a daily feature in the dietary regimens of urban residents in Taiwan and Mainland China. Statistics indicate that the primary consumer groups of BTSs in Beijing, as of July 2018, were the post-1980s and 1990s youth demographics, accounting for 88% of business conducted (Ran, 2018). Currently, 18,142 BTSs operate in Taiwan, reaching cumulative business sales of NT\$52 billion (Ministry of Finance, R.O.C., 2018), which is much higher than the 3,403 cafes and the



Note: Pictures were collected by Tsai (2019) and the research team on August, 2019.

Figure 1. The BTSs on Chinese urban streets such as Taipei of Taiwan (left side) and Nanjing of Mainland China (right side)

12,000 convenience stores in the country (Tsai, 2019). In Mainland China, more than 180,000 BTSs were operating in 2017; furthermore, many cities are still experiencing a growth in the number of BTSs, creating huge competition among the BTS stores. The flourishing of and competition in the BTS market render this study important by virtue of its efforts to conduct a good *ex-ante* evaluation under conditions of limited financial resources and promote BTS businesses' sustainability operation.

Given the shortage of models concerning the location determinants of BTSs, this study attempts to address the questions concerning BTS location determinants via a hybrid MADM model. In summary, this study will first explore the interaction between the determinants related to the choice of a BTS's location, making use of the Decision-Making Trial and Evaluation Laboratory (DEMATEL) method and combining the weights obtained via the DEMATEL-based ANP method (DANP) to identify the critical location determinants of BTSs. In addition, this study evaluates three pre-selected alternatives for BTSs in Nanjing, China, via the DANP and a modified Vlse Kriterijumska Optimizacija I Kompromisno Resenje method (modified VIKOR). The remaining sections are arranged as follows: section 1 proposes the selected location determinants concerning BTSs; section 2 provides detailed descriptions of three pre-selected cases and the modeling procedures of the MADM; section 3 presents the empirical findings; section 4 presents the discussion, and lastly section indicates the conclusion, and research outlook.

1. Constructing an evaluation framework for the location determinants of BTSs

"Location, location, location" is a classic truism often repeated in real estate investment and management; hence, exploring location determination/selection is appropriate for revealing key factors in successful retail operations. The location of retail stores provides retailers with competitive and unique advantages, making the choice of location an important strategic decision that carries great importance to retailers' overall success. Furthermore, such a choice depends on the location's convenience for serving customers and on how many customers the business can attract, which have a significant impact on the store's market share and profitability (Tzeng et al., 2002; Yıldız & Tüysüz, 2019). Since 1929, a series of classic theories exploring the location and spatial distribution of the retail industry have been proposed, including spatial interaction theory (Reilly, 1929, 1931), Hotelling's linear city model (Hotelling, 1929), central place theory (Christaller, 1933, 1966), and even bid-rent theory (Alonso, 1964). These theories aim to identify the factors affecting retail locations by exploring the relationship between consumers' demands and accessibility as a core consideration.

As the predecessor of the gravity type model, spatial interaction theory assumes that customers may be presented with a trade-off between attractiveness and distance

barrier effects when it comes to the specific products or services provided by a store. As such, site-relevant factors such as store size, price, service level, and attractiveness need to be considered (Chen & Tsai, 2016). The principle of minimum differentiation proposed by Hotelling (1929) places greater emphasis on the influence of clustering effects, indicating that the proximity to competitors in the geographical area is an indicator of the attractiveness and competitiveness of the region (Chou et al., 2008); that is to say, proximity to competitors is more critical than proximity to customers (Prayag et al., 2012). According to central location theory, retail location is determined by the "range" of the maximum distance that consumers are willing to travel in order to obtain goods; thus, the theory carries the implicit assumption that a store should be located in an area with a large population and be within an acceptable traveling distance (Prayag et al., 2012). The bid-rent theory identifies a positive relationship between rent and distance from the city center, meaning that a location's rent increases the closer it is to the city center, greater proximity being accompanied by greater opportunities to serve a larger number of well-known customers. These elements are also regarded as good indicators of performance and competitiveness (Yıldız & Tüysüz, 2019).

Based on the above theoretical elements, the existing literature employing MADM to explore the location determinants relevant to food stores (such as restaurants, food retailers, and beverage shops) has provided a valuable evaluative framework. Fisher (1997) has proposed a comprehensive model for selecting restaurant franchisees, including location demographics, transportation support, accessibility and visibility, physical attributes, traffic flow, clusters of competitive stores, and economic indicators. Tzeng et al. (2002) adopted the AHP in presenting a restaurant's decision-making framework, covering 11 sub-dimensions across five major categories, covering economic, transportation, competition, commercial, and environmental domains. Similarly, Park and Khan (2006) used Delphi technology to examine a total of 56 US franchise restaurant locations using six dimensions, namely, overall location, site location, demographics, traffic information, competition, and cost. Chen and Tsai (2016) proposed a restaurant location model based upon data mining and a range of dimensions such as demographics, market conditions, store fees, store conditions, and accessibility. Using the hesitant analysis hierarchy method (H-AHP) and gray correlation analysis (GRA), Yıldız and Tüysüz (2019) constructed a multi-criteria strategic location decision-making model for the food retail industry with the spatial scale of the city in mind. Some research has also explored the decision framework employed by beverage shops. Chen et al. (2018), for example, utilized the distance from average solution (EDAS) method and the weighted aggregated sum product assessment with normalization (WASPAS-N) method, along with relevant criteria, to develop a decision model for teahouse locations. The criteria relevant to Chen et al.'s model included rent, property area, distance

to landscape, public transportation, pedestrian flow, parking flow, presence of competitors, crime rates, distance to public facilities, outdoor advertising, and distance to refuse removal services. Recently, Wibisono and Marella (2020) have utilized the AHP and ANP methods to discuss the location decision-making for cafes, including relevant criteria such as location characteristics, demography, cost, physical features, and competition.

Given the foundation presented by the existing literature, traffic traits (D_1), site traits (D_2), and shop traits (D_3), cumulatively comprising a total of 13 relevant criteria, are proposed in this study as determinants in decisions about BTS store locations (for more details, see Table 1). Although the business acumen of the operator is an important factor in explaining the success of restaurant operations (Parsa et al., 2005; Chathoth & Olsen, 2007; John et al., 2015), this study excludes this factor in order to focus the research on location-centric determinants of BTS (Tzeng et al., 2002; Chen & Tsai, 2016; Chen et al., 2018). The 13 selected criteria are explained below.

1.1. Traffic traits (D_1)

Accessibility has played a critical role in the choice of location. Retail store owners often find convenient locations and increase their exposure to potential customers (Brown, 1993). Greater convenience in public transportation, such as subways, buses, and trolleybuses, will affect accessibility for consumers (Austin et al., 2005; Widener et al., 2017; Chen et al., 2018; Murphy et al., 2018; Wu et al., 2018). Tzeng et al. (2002) have also pointed out that restaurant operators pay greater attention to transportation than other factors. Compared to the distance from bus stops, the distance from subway stations has a more significant impact on the concentration of retail or food service industries (Sevtsuk, 2014). A study from Taipei, which echoes the bid-rent theory of Alonso (1964), has also found that being located near newly built subway stations will incur a greater probability of commercial gentrification, meaning that an area is more easily transformed into retail and restaurant services (Lin & Yang, 2019). Chen et al. (2018) have also found that high pedestrian flows and a high frequency of public transportation were advantageous in a teahouse's location choice. Thus, it can be predicted that "proximity to public transportation systems" (C_1) is regarded as appropriate as one of the criteria for location determinants of BTSs.

On the other hand, distance to a street corner and road width also affect consumers' access to a shop/location.

Through research on retail locations in Cambridge and Somerville (UK) and Massachusetts (USA), Sevtsuk (2014) found that if a shop can directly access more streets, it will attract more people and subsequently enjoy greater accessibility from the additional route connections. This factor was taken into account in the location selection of convenience stores by Kuo et al. (1999, 2002) and for restaurants by Chen and Tsai (2016). In addition, road width is considered to affect customers' behavior patterns, with studies

highlighting the trend of fast-food restaurants and donut shops typically facing a main road (Smith, 1983, 1985). Oh et al. (2015) have also found that the road's width in front of a Korean restaurant chain outlet positively correlates with the store's sales. Sufficient sidewalk space can accommodate more consumers and promote the complementarity and purchase of "comparative goods," such as items from other restaurants (Sevtsuk, 2014). Hence, "proximity to a street corner" (C_2) and "road width" (C_3) are both selected for this dimension.

1.2. Site traits (D_2)

The site itself has always been critical in explaining the choice of location for food retail or restaurants (John et al., 2015). A series of retail location theories have clearly shown that restaurants' location decision-making revolves around the consumer base (Zhai et al., 2015; Xu et al., 2019). Yang et al. (2017) found that leading full-service chains prefer locations in urbanized areas, whereas fast-food chains—such as McDonald's and Pizza Hut—may prefer sites in the urban areas of smaller towns. In addition, the distance from public facilities also indicates the potential for consumption, which is also a commonly selected factor identified throughout the literature (Kuo et al., 1999, 2002; Tzeng et al., 2002; Ho et al., 2013; Chen & Tsai, 2016; Chen et al., 2018).

Although most of the literature related to restaurant location selection has recognized commercial areas as a necessary consideration (Tzeng et al., 2002; Zhang & Xu, 2009; Sevtsuk, 2014; Chen et al., 2018; Xu et al., 2019), restaurants are also often observed around neighborhoods or school areas. This has received a substantial amount of attention in public health research as it relates to the food environment. Studies have found a positive relationship between outlet densities of fast-food stores near a community and purchase frequency (He et al., 2012; Smith et al., 2013). Communities located near a store with sugar-sweetened beverages (SSBs) see an increase in SSB consumption frequency (Adjoian et al., 2014; Duran et al., 2016). Studies have also shown that the density of fast-food stores around schools has increased over time (Day et al., 2015) and that schools near areas with high population densities and commercial areas have more clusters of fast-food outlets and convenience stores (Day & Pearce, 2011; Engler-Stringer et al., 2014; Yang et al., 2017). It is also important to note that the "food delivery industry" is expanding rapidly throughout China—and, more recently, in Taiwan—and is affecting food purchasing behavior (Maimaiti et al., 2018). It was found that 41.86% of food retail stores provide food delivery in the region of the West Lake in Hangzhou city (Maimaiti et al., 2020). Food delivery will expand the existing customer base through a limited number of locations and expand the scope of services, which must be carefully evaluated. Overall, "proximity to public facilities" (C_4), "proximity to communities" (C_5), "proximity to commercial areas" (C_6), and "proximity to schools" (C_7) are all suitable criteria for site traits as they relate to BTS location choice.

Table 1. Proposed dimension/criteria for location determinations of BTS

Dimension	Criteria	Description	Reference
Traffic traits (D ₁)	proximity to public transportation system (C ₁)	Shops with more subway stations and a larger number of bus lines within a certain range have better accessibility to transportation, and will likely attract more potential customers	Chen and Tsai (2016); Chen et al. (2018); Ho et al. (2013); Kuo et al. (1999); Kuo et al. (2002); Tzeng et al. (2002); Oh et al. (2015); Wibisono and Marella (2020)
	proximity to a street corner (C ₂)	Shops near a street corner will likely attract more potential customers	Chen and Tsai (2016); Kuo et al. (1999); Kuo et al. (2002); Tzeng et al. (2002)
	road width (C ₃)	Shop facing a wide road will likely attract more potential customers as more vehicles and pedestrians are likely to pass	Ho et al. (2013); Kuo et al. (1999); Kuo et al. (2002); Tzeng et al. (2002); Oh et al. (2015)
Site traits (D ₂)	proximity to public facilities (C ₄)	Shops near community centers, arts and cultural centers, stadiums and public libraries will likely attract more potential consumers and expand its range via food delivery systems	Chen and Tsai (2016); Chen et al. (2018); Ho et al. (2013); Kuo et al. (1999); Kuo et al. (2002); Wibisono and Marella (2020)
	proximity to the community (C ₅)	Shops located in, or near larger communities will likely attract more potential consumers and expand its range via food delivery systems	Chen and Tsai (2016); Chen et al. (2018); Duran et al. (2016); He et al. (2012); Maimaiti et al. (2018, 2020); Prayag et al. (2012); Qin et al. (2019)
	proximity to commercial areas (C ₆)	Shops located in, or near larger commercial areas will likely attract more potential consumers and expand its range via food delivery systems	Chen and Tsai (2016); Chen et al. (2018); Ho et al. (2013); Kuo et al. (1999); Kuo et al. (2002); Maimaiti et al. (2018, 2020); Prayag et al. (2012); Tzeng et al. (2002); Wibisono and Marella (2020)
	proximity to schools (C ₇)	Shops located in school areas, such as University towns or near larger schools, will likely attract more potential consumers and expand its range via food delivery systems	Chiang et al. (2011); Cutumisu et al. (2017); Day et al. (2015); He et al. (2012); Kuo et al. (1999); Kuo et al. (2002); Sevtsuk (2014); Qin et al. (2019)
	agglomeration effect (C ₈)	Although areas with more BTSs may indicate a risk of competition, it is more likely attract more potential consumers and expand its range via food delivery systems as agglomeration can aid customers in choosing their beverage based on different tastes and the atmosphere of the area/store	Chen and Tsai (2016); Chen et al. (2018); Ho et al. (2013); John et al. (2015); Kuo et al. (1999); Kuo et al. (2002); Tzeng et al. (2002)
Shop traits (D ₃)	types of shop (C ₉)	Two types of shop, including the street shop and shop in a department store, need to be considered. Street stores attract more passers-by, while shops in commercial complexes attract more consumer and expand its range via food delivery systems	Xu et al. (2019); Yang et al. (2017)
	sizes of shop (C ₁₀)	A shop's size must be able to support various usage needs, such as shaking tea, brewing tea, and storage of raw materials. The new generation of BTS may provide more seats in the store, and a larger size may thus be required	Chen and Tsai (2016); Ho et al. (2013); Kuo et al. (1999); Kuo et al. (2002); Yap et al. (2019); Wibisono and Marella (2020)
	rent (C ₁₁)	Shops may incur a higher rent due to better transportation and location conditions, larger size, or visibility	Chen and Tsai (2016); Chen et al. (2018); Day et al. (2015); Fraser et al. (2010); Fleischhacker et al. (2013); Ho et al. (2013); Yap et al. (2019); Wibisono and Marella (2020)
	business hours (C ₁₂)	Shops with longer business hours have more time to supply tea to consumers and are located in business districts with similarly long total business hours	Oh et al. (2015); Chen and Tsai (2016)
	visibility (C ₁₃)	Shops with strong visibility, such as those located at the core of the main street or commercial complex, will increase their visibility and will be enhanced via billboard advertisements	Chen and Tsai (2016); Chen et al. (2018); Kuo et al. (1999); Kuo et al. (2002); Wibisono and Marella (2020)

Agglomeration effects should also be considered in terms of location determinants. Hotelling (1929) has emphasized the presence of agglomeration effects in the retail industry, demonstrating that proximity to competitors is an indicator of attractiveness and competitiveness (Chen & Tsai, 2016). Eaton and Lipsey (1975) have also considered the agglomeration of homogeneous stores as a mechanism through which consumers can compare prices and products to reduce search costs. The clustering of restaurants in the Central Business District of Hamilton, New Zealand, exemplifies the notion that clustering not only can promote the sharing of facilities and promotion costs but can also provide multiple options for consumers, thereby reducing the search costs and increasing the attraction of restaurants and the area in general (Prayag et al., 2012). Empirical research conducted in Cambridge and Somerville (UK) and Massachusetts (USA) found that restaurants and bars were more concentrated than were clothing, clothing accessories, or food retail stores (such as supermarkets) (Sevtsuk, 2014). This is because restaurants and bars provide “comparative goods,” and agglomeration can help customers decide based on different tastes or atmospheres (among others), hence saving time costs. However, agglomeration may face strong competition risks (John et al., 2015), and many studies have included competitors as a consideration in site selection (Kuo et al., 1999, 2002; Tzeng et al., 2002; Prayag et al., 2012; Ho et al., 2013; Chen & Tsai, 2016; Chen et al., 2018). Although most of the BTSs offer similar tea-mixed beverages at first glance, they still have some differences, such as in taste and place, among others, and the aggregation phenomenon is common (see Figure 1). Therefore, the “aggregation effect” (C_8) is also selected as a criterion for site traits.

1.3. Shop traits (D_3)

In addition to external factors, some criteria related to shops' physical conditions are also considered. As indicated by spatial interaction theory, the store's attributes have become one of the important trade-offs considered by consumers when purchasing goods (Prayag et al., 2012). A systematic review of the literature by Yap et al. (2019) also found that most of the academic research on location decision-making for retail facilities will include the store's size (space).

In China, large commercial complexes, such as department stores or shopping malls, are often important for driving urban development in fast-growing cities and providing food retail stores and restaurants to urban residents (Qin et al., 2019; Xu et al., 2019). Therefore, in addition to traditional types of shops on streets, outlets in commercial complexes or larger department stores are also considered a location choice. Chen and Tsai (2016) have also pointed out that a shop's size and visibility are the main considerations when evaluating restaurants' location. They have suggested that larger shops have greater performance potential in sales, especially when coupled with conditions of moderate population growth rate or lack of proximity to Mass Rapid Transit (MRT) stations or stops. Thus, “types of shop” (C_9) and “size of shop” (C_{10}) are both selected for this dimension.

In addition, the most prominent location determinant cannot be ignored: “rents.” Higher rents often imply competitive bidding and often correlate with better location conditions (Alonso, 1964; Lin & Yang, 2019). Tzeng et al. (2002) have also found that, from the perspective of experts, in addition to transportation costs, rents are the most important factor in location selection; high leasing costs may affect the ability to leverage operations, leading to the death of restaurants (John et al., 2015). Fast-food stores are often clustered around poor communities and their school district; this choice can be reasonably explained by the availability of low land prices or rents (Fraser et al., 2010; Fleischhacker et al., 2013; Day et al., 2015). Hence, “rent” (C_{11}) is included as a criterion.

Additional features related to business performance include business hours and visibility. Oh et al. (2015) have shown that weekend hours are very important to a Korean family restaurant's operating performance due to the policy of working five days a week. A signboard's visibility will affect the likelihood of potential customers entering the store, which is also considered in the relevant literature (Kuo et al., 1999, 2002; Chen & Tsai, 2016; Chen et al., 2018; Wibisono & Marella, 2020). Hence, “business hours” (C_{12}) and “visibility” (C_{13}) have also been included.

2. Three alternatives for potential evaluation and modelling procedures for a hybrid MADM model

2.1. Three alternatives in Nanjing for potential evaluation

This study selects three pre-selected alternatives in Nanjing, Mainland China, as research cases in evaluating their effects on the choice of a BTS' location. Nanjing, as the capital of Jiangsu Province, makes up part of the core city group situated along the Yangtze River Delta (see Figure 2). At present, the city's population has reached 8.28 million, and eleven administrative regions, including: Gulou District, Qinhuai District, Xuanwu District, Jianye District, Yuhuatai



Note: Nanjing's map was collected by Shi et al. (2019)

Figure 2. The location distribution of three pre-selected alternatives in Nanjing

District, Qixia District, Pukou District, Jiangning District, Liuhe District, Gaochun District and Lishui District (Qi et al., 2019). According to data from Dianping.com, 5,515 BTSs can be found in Nanjing (as of mid- June 2019).

The information concerning each criteria pertaining the three pre-selected alternatives – including pre-selected alternative A (located in Xianlin University town), pre-selected alternative B (located in the highest commercial grade zone in Qinhuai district), and pre-selected alterna-

tive C (located in the new development zone in Pukou district) – was obtained by the research team between June and mid-July 2019. The Baidu Map (<https://map.baidu.com/>) was utilized to measure the information related to traffic traits, while Dianping.com was utilized to confirm whether or not the area can be covered by food delivery services. Information related to the shops was obtained via field research. Please refer to Table 2 for a breakdown of the information collected pertaining to the three sites.

Table 2. Three alternatives in Nanjing for performance evaluation

Dimension	Criteria	Alternative A	Alternative B	Alternative C
Area		Xuezelu commercial area in Xianlin University Town, Qixia District	Xinjiekou Commercial District in Qinhuai District	Jiangbei New District, Pukou District
Traffic traits (D_1)	proximity to public transportation system (C_1)	200 meters away from Xueze Road Station of MRT Line 2, and near 5 bus lines passing by	150 meters away from Xinjiekou Metro Station of MRT 1 and 2; the nearest bus stop has 3 bus lines passing by	Near the construction of Hongyang Plaza Station of Metro Line S8; 2 bus lines passing by
	proximity to a street corner (C_2)	250 meters away from the intersection of Xueze Road and Xianlin Avenue	50 meters away from the intersection of Shigu Road and Rich Road	50 meters from the entrance of B1 in shopping mall
	road width (C_3)	The shop is in the food court, so the road is only 6 meters wide and only pedestrians can pass	The shop faces Shigu Road, which is about 18 meters wide and can be used by vehicles and pedestrians.	The shop is not facing the main arterial roads of the mall and can only be accessed by pedestrians
Site traits (D_2)	proximity to public facilities (C_4)	Located nearby and can deliver via the food delivery system, including (1) Government agency: the Xianlin Office of the Qixia District Government	Located nearby and can deliver via the food delivery system, including (1) Popular tourist attractions: Xuanwu Lake, Chaotian Palace, Presidential Palace, Confucius Temple Scenic Area, Jiangsu Provincial Art Museum, Nanjing Library, Nanjing Museum, Nanjing Geological Museum, Nanjing Folk Customs Museum (Ganxi House), Pilu Temple, Jinling Carvings, Zijin Grand Theater; (2) Large parks: Bailuzhou Park, Xi'anmen Site Park and Dongshuiguan Site Park; (3) Sports Center: Wutaishan Sports Center, Qinhuai Sports Center, Jiangsu Province	Located nearby and can delivered via the food delivery system, including (1) Government agency: the Taishan Sub-district Office; (2) Passenger Station: Nanjing Long-distance Bus Station, Jiangbei Passenger Transport Department; (3) Large-scale parks: Qiaobei Riverside Ecological Park, Baotashan Forest Park, Liuzhou Xiaoyou Park; (4) Sports Center: Pukou Culture and Sports Center
	proximity to the community (C_5)	Located near the Yadong community, the Kangqiao Santa Fe community, and a total of 24 residential communities can be reached via the food delivery system	A total 285 small and medium residential communities can be reached via the food delivery system	A total 64 residential communities can be reached via the food delivery system, and includes larger communities (such as 19 blocks in the Venice communities and 16 blocks in the Huaning Tianrun Ccommunities
	proximity to commercial areas (C_6)	A total of 11 shopping malls, commercial offices and industrial zones – including Rand Information Industry Park, Suning Headquarters – can be reached via the food delivery system	A total of 128 shopping malls, commercial offices and industrial zones – including Deji Mall, Ocean Department Store, Central Mall and Golden Eagle Department Store – can be reached via the food delivery system	A total of 15 Shopping malls, commercial offices and industrial zones – including Xiaoliu Industrial Zone in Nanjing High-tech Zone, Nanjing Railway Logistics Base of China Railway, Baotashan Creative Industry Park – can be reached via the food delivery system

End of Table 2

Dimension	Criteria	Alternative A	Alternative B	Alternative C
Site traits (D ₂)	proximity to schools (C ₇)	More than 10 universities and colleges, and more than 10 primary and secondary schools	10 universities and colleges, and more than 30 primary and secondary schools are located nearby	2 colleges and 8 primary and secondary schools are nearby
	agglomeration effect (C ₈)	There are 19 BTSs within a 10-minute walk (approximately 600 meters) of this area, and 40 BTSs within the delivery range for food delivery systems	There are 51 BTSs within a 10-minute walk, and there are 424 BTSs within the delivery range for food delivery systems	There are 17 BTSs within a 10-minute walk, and there are 53 BTSs within the delivery range for food delivery systems
Shop traits (D ₃)	types of shop (C ₉)	Street shop on first floor of the horizontal food court	Traditional street shop	Street store in B1 of shopping mall
	sizes of shop (C ₁₀)	20 square meters	15 square meters	15 square meters
	rent (C ₁₁)	Monthly rent is RMB 16,600 (RMB 830/square meter)	Monthly rent is approximately RMB 25,833 (RMB 1.722/square meter)	Monthly rent is approximately RMB 10,000 (RMB 667/ square meter)
	business hours (C ₁₂)	Operates from Monday to Sunday between 10 am to 10 pm	Operates from Monday to Sunday between 10 am to 10 pm	Operates from Monday to Sunday between 10 am and 10 pm
	visibility (C ₁₃)	Because it is not on the main road, it is impossible to directly see the shop sign	It is located on Shigu Road, the shop sign can be viewed directly	It is not at the core of department store, its store sign can only be seen at the entrance

2.2. The modelling procedure for the hybrid MADM model

A number of studies have explored location determinants of various food outlets via various MADM models or statistical analyses. As a classic methodology used in decision-making (dos Santos et al., 2019), AHP is the most commonly used approach in location selection (Tzeng et al., 2002; Özcan et al., 2011; Subramanian & Ramathan, 2012; Ho et al., 2013; Dehe & Bamfor, 2015; Zhuang et al., 2017, 2018a, 2018b, 2019; Yıldız & Tüysüz, 2019); however, unrealistic assumptions concerning the independent relationship among the concerning factors presents a drawback (Liu et al., 2018a; Shen & Tzeng, 2018; Chen et al., 2019; Lin et al., 2021). Although the Analytic Network Process (ANP) method tries to explore the mutual influence relationship (Tolga et al., 2013; Neumüller et al., 2015), it also lacks a strong support for interactions relationship (Gölcük & Baykasoğlu, 2016). In order to make the location determinants in choosing a site for a BTS more realistic and persuasive, this study introduces a hybrid MADM model that considers the interaction between the identified factors.

Although existing research has explored location selection for various facilities based on the relationship between concerning factors (Kuo, 2011; Liu et al., 2018a; Shahi et al., 2018; Trivedi, 2018; Wu et al., 2019), this model has not been applied in regard to food retail stores or restaurants. Specifically, four steps are followed for the MADM procedure used in this study. The conceptual framework for modeling is shown in Figure 3 and

descriptions of each procedure are explained simply in the following sub-sections.

Questionnaire-based data collection

This study aimed to explore the determinants regarding the choice of a location for a BTS considering the relationships among dimensions/criteria. The applied MADM model makes use of evaluation via experts' opinions and can be effectively utilized without a large number of samples. Seven experts were surveyed, via either email or fax, between July and August, 2019. The number of experts called upon is equal to that used by Liu et al. (2018b).

The information related to the seven experts are indicated in Table 3. The experts were divided into academic and industrial sectors, of which there were three in the former and four in the latter. The three experts in the academic sector all have doctoral degrees, and are currently associate or assistant professors at their respective universities. They all have working experience of between three and five years and are involved in different academic concerns – such as human geography, land management, and business management. In terms of the industry experts, half of the interviewees have a master's degree and currently hold management positions in the catering and BTS industries. The range of working experience for the industry interviewees spans three to 15 years.

The questionnaire was designed in Chinese, and divided into three parts. The first part was designed to collect the experts' basic information. The second part included a five-point Likert scale (no impact < 0, 1, 2, 3, 4 → very high impact) for evaluating the impact of the relationship

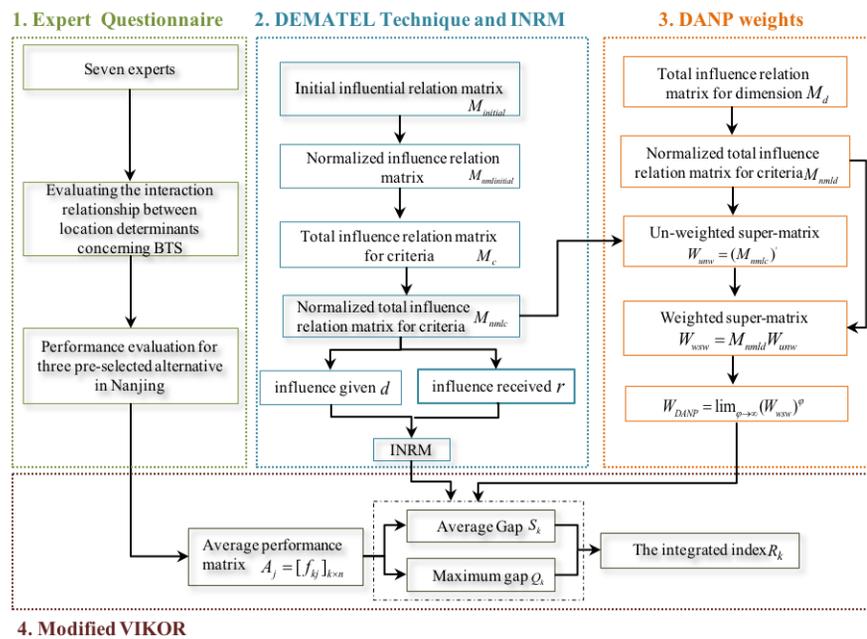


Figure 3. MADM procedures for exploring the location determinants of BTSs

between two certain factors. The third part included a 10-point Likert scale (very unsatisfied $< 1, 2, \dots, 9, 10 \rightarrow$ very satisfied) to evaluate the performance of each criteria for the three pre-selected alternatives (as indicated in Table 2). Full questionnaire form have been provided in Appendix A.

Exploring the relationship between criteria concerning the choice in location of BTSs as based on DEMATEL technique and an INRM

Between 1972 and 1976, the Science and Human Affairs Program of the Battelle Memorial Institute of Geneva (United Nations) developed the DEMATEL technique for clarifying and solving complex problems for global issues (Gabus & Fontela, 1972, 1973). More and more studies have come to recognize the presence of complex interactions throughout the real world, in addition to simple linear relationships (Tzeng & Shen, 2017; Lin et al., 2021). Hence, DEMATEL has been highlighted in a variety of decision-making issues, and Dr. Tzeng, G. H. from Taiwan has further deepened and hybrid-

ized the approach with other methods so as to form a more forward-looking, and solid, hybrid MADM model for use across various decision-making fields (Lin, 2019). With the DEMATEL technique, constructing an influential network relationship map (INRM) to identify the interactions among the criteria under evaluation is an important step. INRM concerns the extent to which a certain criterion affects, and is affected by, other criteria; this is beneficial in identifying which criteria are key in guiding decision-makers in resource allocation tasks. In this study, DEMATEL and INRM are utilized to identify the relationship and their key core between criteria concerning location determinants.

The modeling process for the DEMATEL technique and the INRM is as follows (please refer to the more detailed formulas provided in Appendix B.1): (1) constructing the initial influential relation matrix $M_{initial}$ according to the opinions provided by the experts interviewed; (2) obtaining the normalized influence relationship matrix $M_{nmlinitial}$; (3) calculating the total relationship influence matrix for criteria M_c ; and (4) finally, the sum vector of the row d (representing the sum based on direct or indirect influence had

Table 3. Information of interviewed seven experts

Sector	Number	Department	Degree	Position	Working years
Academic	Expert 1	Human geography	Ph.D.	Associate professor	5
	Expert 2	Land management	Ph.D.	Associate professor	4
	Expert 3	Business management	Ph.D.	Assistant professor	3
Industry	Expert 4	Catering	Bachelor	Chief Operating Officer	15
	Expert 5	BTS industry	Master	Regional manager	3
	Expert 6	BTS industry	Master	Manager	7
	Expert 7	BTS industry	Bachelor	Manager	8

upon the other criteria, i.e. influence given) and the sum vector of the column r (representing the sum concerning how directly or indirectly the criterion is affected by other criteria, i.e. influence received) are indicated in Table 4. Following this, the INRM is established based on $(d + r)$ (horizontal axis) and $(d - r)$ (vertical axis).

In this regard, some attention should be placed upon: (1) the dimension/criteria with bigger $(d + r)$, indicating a stronger total influence, and vice versa; (2) the dimension/criteria with bigger $(d - r)$, indicating a stronger ability to influence other. Among these, criteria with a greater positive $(d - r)$ is deemed as being more important because it belongs to the “cause” that affects others (the larger the positive value, the greater the ability to influence others). Conversely, negative values for $(d - r)$ indicate that the criterion is affected by other criteria – the larger the negative value, the greater the impact had by others.

Calculating the influential weights of criteria of BTS location determinants based on DANP

Although traditional ANP methodology (Saaty, 1996) addresses some unreasonable conditions found in the use of AHP – that is, by relaxing the assumption of relationships found between criteria (Kheybari et al., 2020) – it is still being questioned. Due to users of ANP briefly assuming that the diagonal matrix is equal to the zero matrix and the weighted super-matrix (as obtained by using equal weights – Tzeng & Shen, 2017; Peng & Tzeng, 2019; Lin et al., 2021), ANP methodology is facing a challenge in its ability to compare internal and external dependencies in pairs (Gölcük & Baykasoğlu, 2016). The DANP, combined with DEMATEL and ANP, can better improve upon this shortage (Ou Yang et al., 2013) and the development prospects in the field of MADM (Gölcük & Baykasoğlu, 2016). This revised method introduces the influence relation matrix for criteria and for dimensions based on DEMATEL into the matrix of the traditional ANP. Compared to ANP, DANP has more advantages than traditional ANP (Liu et al., 2018a, 2018b). In this study, the DANP's weighting is utilized for key identification on location determinants and an evaluation foundation for pre-selected location concerning BTSs.

The modeling process for DANP is as follows (please refer to the more-detailed formulas provided in Appendix B.2): (1) M_c , as derived via DEMATEL, is normalized to obtain the normalized total influence relationship matrix for criteria M_{nmlc} ; and the M_d obtained (in a similar way to M_c) is normalized to produce a total influence relation matrix for dimension M_{nmld} ; (2) M_{nmlc} will be transposed to obtain the un-weighted super-matrix $W_{unw} = (M_{nmlc})' - M_{nmld}$ is then also introduced to $W_{unw} = (M_{nmlc})'$ to obtain the weighted super-matrix $W_{wsw} = M_{nmld}W_{unw}$; (3) after W_{wsw} is multiplied by itself a hundred times (that is $W_{DANP} = \lim_{\varphi \rightarrow \infty} (W_{wsw})^\varphi$), the weighted super-matrix converges to become a stable super-matrix, eventually forming a local weight applicable

to the DANP. The global weights of each DANP criteria are calculated based on their local weights, multiply by the local weights of its own dimensions.

Evaluating the performance and GAP of three alternatives in Nanjing based on modified VIKOR methodology

The modified Vlse Kriterijumska Optimizacija I Kompromisno Resenje (VIKOR) method was utilized to evaluate the performance and gap for the three pre-selected cases used in this study. The modified VIKOR was presented by Opricovic and Tzeng (2004, 2007) and carries more advantages than the traditional VIKOR methodology. Traditional VIKOR methodology usually utilizes the class distance function (i.e. zero is equal to a negative ideal solution, and one is equal to a positive ideal solution) for ranking and selecting alternatives. This causes one to “pick the best apple among a barrel of rotten apples.” Liu et al. (2018b) indicated that this is because the selection of alternatives must contain at least two alternatives, and that in the performance of GAP at least one of the alternatives is zero (meaning no improvement is required). In other hands, a GAP ratio cannot be obtained because the denominator of the formula is zero at this time and these criteria must be eliminated when the performance score of the criteria is equal (in context of evaluating multiple alternatives). Importantly, the improvement strategies cannot be obtained. The modified VIKOR methodology utilizes the “ideal values” as the aspiration level (i.e. equal to ten points) and “worst value” as benchmark (i.e. equal to zero points), avoiding traditional questions while also presenting the improvement strategies for achieving the “aspiration level” via combing with INRM via DEMATEL.

The modeling process for modified VIKOR methodology is described as follows (please refer to Appendix B.3 for a more detailed explanation): (1) establishing the average performance score based on the feedback provided by experts and scholars $A_j = [f_{kj}]_{k \times n}$; (2) combining the local weighting of DANP, determining the optimal GAP through the average GAP (with aspiration level S_k) and the maximum GAP (with aspiration level Q_k) for the three pre-selected alternatives form the optimal integration index (R_k).

3. Empirical findings

3.1. Calculated results of DEMATEL and DANP

In terms of DEMATEL, calculated result for the initial influential relation matrix $M_{initial}$ are presented in Table 4; the normalized influence relation matrix $M_{nmlinitial}$ is presented in Table 5; the total influence relationship matrix for criteria M_c is presented in Table 6.

In terms of DANP, the un-weighted super-matrix $W_{unw} = (M_{nmlc})'$ is indicated in Table 7, and the weighted super-matrix $W_{wsw} = M_{nmld}W_{unw}$ is indicated in Table 8.

Table 4. Initial influential relation matrix $M_{initial}$

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}
C_1	0.000	2.571	3.000	2.571	2.429	2.000	1.714	1.714	2.143	2.429	2.857	2.571	2.714
C_2	1.714	0.000	4.000	1.429	2.429	1.857	1.429	1.429	1.857	1.571	2.000	1.714	1.571
C_3	2.286	3.000	0.000	2.000	2.571	2.429	1.857	1.714	2.429	2.000	2.286	2.000	3.000
C_4	1.571	1.429	2.286	0.000	2.571	1.429	0.857	0.857	1.429	1.857	2.143	2.000	2.286
C_5	2.429	2.000	3.143	2.714	0.000	2.143	1.857	1.714	2.143	1.857	2.429	2.000	2.714
C_6	2.286	2.429	3.429	2.714	3.286	0.000	2.429	2.286	2.714	2.571	2.714	2.429	2.857
C_7	2.429	2.714	3.143	2.286	3.143	2.857	0.000	2.429	2.000	1.429	1.571	1.429	1.571
C_8	2.143	2.143	2.714	1.429	2.857	2.429	2.000	0.000	2.000	1.714	1.857	1.714	1.857
C_9	1.571	1.714	2.857	2.143	2.857	2.143	1.571	1.571	0.000	1.429	1.714	1.571	1.857
C_{10}	2.571	2.143	2.714	3.286	2.857	1.571	1.429	1.571	2.286	0.000	1.429	1.286	2.143
C_{11}	2.857	2.714	3.714	3.571	3.000	2.000	1.571	1.714	2.143	1.286	0.000	1.429	3.000
C_{12}	2.000	2.286	3.143	3.000	2.571	1.571	1.286	1.429	1.571	1.286	1.571	0.000	2.143
C_{13}	2.714	2.143	3.429	2.714	3.286	2.429	1.857	1.571	1.429	1.429	2.429	1.714	0.000

Notes: C_1 = proximity to public transportation system; C_2 = proximity to a street corner; C_3 = road width; C_4 = proximity to public facilities; C_5 = proximity to the community; C_6 = proximity to commercial area; C_7 = proximity to school; C_8 = agglomeration effect; C_9 = types of shop; C_{10} = sizes of shop; C_{11} = rent; C_{12} = business hours; C_{13} = visibility.

Table 5. Normalized influence relation matrix $M_{nmlinitial}$

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}
C_1	0.000	0.068	0.080	0.068	0.065	0.053	0.046	0.046	0.057	0.065	0.076	0.068	0.072
C_2	0.046	0.000	0.106	0.038	0.065	0.049	0.038	0.038	0.049	0.042	0.053	0.046	0.042
C_3	0.061	0.080	0.000	0.053	0.068	0.065	0.049	0.046	0.065	0.053	0.061	0.053	0.080
C_4	0.042	0.038	0.061	0.000	0.068	0.038	0.023	0.023	0.038	0.049	0.057	0.053	0.061
C_5	0.065	0.053	0.084	0.072	0.000	0.057	0.049	0.046	0.057	0.049	0.065	0.053	0.072
C_6	0.061	0.065	0.091	0.072	0.087	0.000	0.065	0.061	0.072	0.068	0.072	0.065	0.076
C_7	0.065	0.072	0.084	0.061	0.084	0.076	0.000	0.065	0.053	0.038	0.042	0.038	0.042
C_8	0.057	0.057	0.072	0.038	0.076	0.065	0.053	0.000	0.053	0.046	0.049	0.046	0.049
C_9	0.042	0.046	0.076	0.057	0.076	0.057	0.042	0.042	0.000	0.038	0.046	0.042	0.049
C_{10}	0.068	0.057	0.072	0.087	0.076	0.042	0.038	0.042	0.061	0.000	0.038	0.034	0.057
C_{11}	0.076	0.072	0.099	0.095	0.080	0.053	0.042	0.046	0.057	0.034	0.000	0.038	0.080
C_{12}	0.053	0.061	0.084	0.080	0.068	0.042	0.034	0.038	0.042	0.034	0.042	0.000	0.057
C_{13}	0.072	0.057	0.091	0.072	0.087	0.065	0.049	0.042	0.038	0.038	0.065	0.046	0.000

Notes: C_1 = proximity to public transportation system; C_2 = proximity to a street corner; C_3 = road width; C_4 = proximity to public facilities; C_5 = proximity to the community; C_6 = proximity to commercial area; C_7 = proximity to school; C_8 = agglomeration effect; C_9 = types of shop; C_{10} = sizes of shop; C_{11} = rent; C_{12} = business hours; C_{13} = visibility.

Table 6. Total influence relationship matrix for criteria M_c

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}
C_1	0.139	0.207	0.267	0.219	0.234	0.181	0.149	0.148	0.181	0.172	0.204	0.181	0.215
C_2	0.157	0.118	0.255	0.163	0.202	0.154	0.123	0.123	0.152	0.131	0.160	0.139	0.162
C_3	0.191	0.212	0.187	0.200	0.232	0.187	0.149	0.145	0.183	0.158	0.186	0.163	0.216
C_4	0.143	0.142	0.199	0.115	0.192	0.132	0.100	0.100	0.130	0.129	0.153	0.137	0.167
C_5	0.193	0.186	0.260	0.215	0.165	0.178	0.147	0.143	0.175	0.153	0.188	0.162	0.208
C_6	0.212	0.220	0.298	0.240	0.274	0.146	0.178	0.174	0.209	0.188	0.216	0.191	0.235
C_7	0.192	0.203	0.260	0.203	0.242	0.195	0.101	0.161	0.172	0.144	0.168	0.148	0.180
C_8	0.176	0.180	0.237	0.173	0.224	0.176	0.144	0.093	0.163	0.142	0.165	0.147	0.177

End of Table 6

	C ₁	C ₂	C ₃	C ₄	C ₅	C ₆	C ₇	C ₈	C ₉	C ₁₀	C ₁₁	C ₁₂	C ₁₃
C ₉	0.153	0.160	0.227	0.180	0.212	0.160	0.126	0.126	0.104	0.128	0.153	0.136	0.168
C ₁₀	0.186	0.179	0.236	0.217	0.223	0.155	0.129	0.132	0.169	0.099	0.155	0.137	0.184
C ₁₁	0.211	0.211	0.285	0.243	0.249	0.182	0.146	0.149	0.182	0.146	0.136	0.156	0.224
C ₁₂	0.166	0.176	0.238	0.203	0.208	0.149	0.121	0.124	0.146	0.127	0.152	0.098	0.177
C ₁₃	0.201	0.191	0.268	0.216	0.246	0.186	0.148	0.141	0.159	0.144	0.190	0.156	0.142

Notes: C₁ = proximity to public transportation system; C₂ = proximity to a street corner; C₃ = road width; C₄ = proximity to public facilities; C₅ = proximity to the community; C₆ = proximity to commercial area; C₇ = proximity to school; C₈ = agglomeration effect; C₉ = types of shop; C₁₀ = sizes of shop; C₁₁ = rent; C₁₂ = business hours; C₁₃ = visibility.

Table 7. Un-weighted super-matrix $W_{unw} = (M_{nmlc})'$

	C ₁	C ₂	C ₃	C ₄	C ₅	C ₆	C ₇	C ₈	C ₉	C ₁₀	C ₁₁	C ₁₂	C ₁₃
C ₁	0.130	0.166	0.187	0.181	0.189	0.171	0.175	0.178	0.164	0.179	0.186	0.167	0.279
C ₂	0.194	0.131	0.208	0.179	0.183	0.177	0.185	0.182	0.172	0.172	0.176	0.178	0.170
C ₃	0.250	0.265	0.183	0.252	0.255	0.240	0.236	0.239	0.244	0.227	0.238	0.240	0.008
C ₄	0.206	0.182	0.196	0.146	0.211	0.193	0.184	0.174	0.193	0.228	0.203	0.205	0.192
C ₅	0.220	0.226	0.227	0.242	0.162	0.220	0.220	0.226	0.228	0.214	0.208	0.210	0.220
C ₆	0.378	0.355	0.388	0.398	0.380	0.292	0.427	0.426	0.389	0.310	0.332	0.378	0.391
C ₇	0.311	0.403	0.310	0.302	0.314	0.358	0.220	0.349	0.306	0.310	0.307	0.307	0.352
C ₈	0.311	0.307	0.302	0.300	0.306	0.350	0.352	0.225	0.305	0.317	0.322	0.314	0.297
C ₉	0.190	0.204	0.202	0.182	0.197	0.201	0.212	0.205	0.151	0.239	0.216	0.208	0.201
C ₁₀	0.180	0.177	0.174	0.180	0.173	0.181	0.177	0.179	0.186	0.133	0.174	0.181	0.202
C ₁₁	0.214	0.211	0.206	0.213	0.212	0.208	0.207	0.208	0.222	0.208	0.171	0.217	0.240
C ₁₂	0.190	0.166	0.180	0.191	0.183	0.183	0.183	0.185	0.197	0.184	0.184	0.140	0.198
C ₁₃	0.226	0.207	0.238	0.233	0.235	0.226	0.222	0.223	0.244	0.277	0.285	0.253	0.251

Notes: C₁ = proximity to public transportation system; C₂ = proximity to a street corner; C₃ = road width; C₄ = proximity to public facilities; C₅ = proximity to the community; C₆ = proximity to commercial area; C₇ = proximity to school; C₈ = agglomeration effect; C₉ = types of shop; C₁₀ = sizes of shop; C₁₁ = rent; C₁₂ = business hours; C₁₃ = visibility.

Table 8. Weighted super-matrix $W_{wsw} = M_{nmlc}W_{unw}$

	C ₁	C ₂	C ₃	C ₄	C ₅	C ₆	C ₇	C ₈	C ₉	C ₁₀	C ₁₁	C ₁₂	C ₁₃
C ₁	0.043	0.071	0.081	0.071	0.072	0.077	0.079	0.081	0.077	0.080	0.087	0.079	0.131
C ₂	0.083	0.056	0.080	0.077	0.079	0.080	0.084	0.083	0.081	0.081	0.083	0.084	0.080
C ₃	0.102	0.105	0.078	0.098	0.110	0.109	0.107	0.109	0.115	0.107	0.112	0.113	0.004
C ₄	0.088	0.078	0.084	0.063	0.081	0.087	0.084	0.079	0.091	0.108	0.095	0.096	0.090
C ₅	0.090	0.084	0.097	0.100	0.070	0.100	0.100	0.103	0.107	0.093	0.098	0.099	0.103
C ₆	0.073	0.069	0.075	0.077	0.074	0.054	0.080	0.079	0.075	0.060	0.064	0.073	0.081
C ₇	0.050	0.078	0.051	0.053	0.061	0.067	0.041	0.065	0.059	0.060	0.059	0.059	0.068
C ₈	0.107	0.116	0.104	0.113	0.105	0.065	0.066	0.042	0.059	0.061	0.062	0.061	0.057
C ₉	0.072	0.077	0.076	0.060	0.064	0.072	0.076	0.074	0.051	0.080	0.070	0.070	0.075
C ₁₀	0.058	0.067	0.056	0.065	0.065	0.065	0.064	0.064	0.062	0.045	0.058	0.061	0.068
C ₁₁	0.081	0.070	0.070	0.075	0.070	0.075	0.074	0.075	0.075	0.070	0.054	0.073	0.085
C ₁₂	0.072	0.061	0.068	0.067	0.062	0.066	0.066	0.067	0.066	0.062	0.062	0.047	0.071
C ₁₃	0.080	0.068	0.080	0.081	0.089	0.081	0.080	0.080	0.082	0.093	0.094	0.085	0.084

Notes: C₁ = proximity to public transportation system; C₂ = proximity to a street corner; C₃ = road width; C₄ = proximity to public facilities; C₅ = proximity to the community; C₆ = proximity to commercial area; C₇ = proximity to school; C₈ = agglomeration effect; C₉ = types of shop; C₁₀ = sizes of shop; C₁₁ = rent; C₁₂ = business hours; C₁₃ = visibility.

3.2. Identification of location determinants of BTSs based on DEMATEL and DANP methodology

The empirical results of DEMATEL and DANP are indicated in Table 9. The results of importance, based on $(d + r)$, indicate that Shop traits (D_3) (24.569) ranks higher than both Site traits (D_2) (21.843) and Traffic traits (D_1) (13.049). Based on the influence received $(d - r)$, as per DEMATEL and INRM (see Figure 4), Traffic traits (D_1) (1.647) and Site traits (D_2) (0.608) produce positive values (indicating cause), whereas Shop traits (D_3) (-2.255) produce a negative value (indicating of effect).

These calculations are intended as a means to analyse the relationship between criteria. In according with $(d - r)$, five criteria present with higher-than-average threshold values of 4.574 (i.e. the average value of all criteria), including: rent (C_{11}) (5.626), visibility (C_{13}) (5.277), proximity to public transportation system (C_1) (4.962), types of shop (C_9) (4.818), and proximity to commercial area (C_6) (4.746); meanwhile, seven criteria fall below the threshold. Analyzing the position of criteria via $(d - r)$ indicates that proximity to a street corner (C_2) (0.607), proximity to public transportation systems (C_1) (0.602), road width (C_3) (0.438), proximity to communities (C_5) (0.340), proximity to commercial areas (C_6) (0.294), types of shop (C_9) (0.176), and proximity to schools (C_7) (0.135) are considered as “causes” which impact other factors (given their positive values), while six criteria belong to the category of “effect” which are impacted by other factors (due to their negative value).

According to the local weighting of DANP in Table 9, the most important dimension is that of Shop traits (D_3) (0.434), followed by Site traits (D_2) (0.351), and, lastly, Traffic traits (D_1) (1.647). The global weights reveal that the first three major weights are present via rent (C_{11}) (0.096), visibility (C_{13}) (0.095), and business hours (C_{12}) (0.085). The three factors carrying the lowest weights are proximity to schools (C_7) (0.064), proximity to communities (C_5) (0.061), and proximity to a street corner (C_2).

By combining the results obtained via DEMATEL and ANP methodology, one can observe that Traffic traits (D_1) and Site traits (D_2) play key roles in decisions made around the choice of a BTS' location and must, therefore, be considered first – this is particularly true for Traffic traits (D_1), which presents with the highest $(d - r)$ value. Once these dimensions, which fall under the category of “cause,” are improved upon, Shop traits (D_3) (which belong to the “effect” grouping) have also be improved. In terms of criteria, although rent (C_{11}), visibility (C_{13}), business hours (C_{12}), and agglomeration effect (C_8) present with higher $(d + r)$ values (as per DEMATEL methodology) and global weights (as per DANP methodology), these criteria should not be the first considerations given their negative $(d - r)$ values. Conversely, criteria which present with positive $(d - r)$ values should be more critical determinants of BTSs' choices for a location. These criteria include, in descending order, proximity to a street corner (C_2), proximity to public transportation systems (C_1), road width (C_3), proximity to communities (C_5), proximity to commercial areas (C_6), types of shop (C_9), and proximity to schools (C_7).

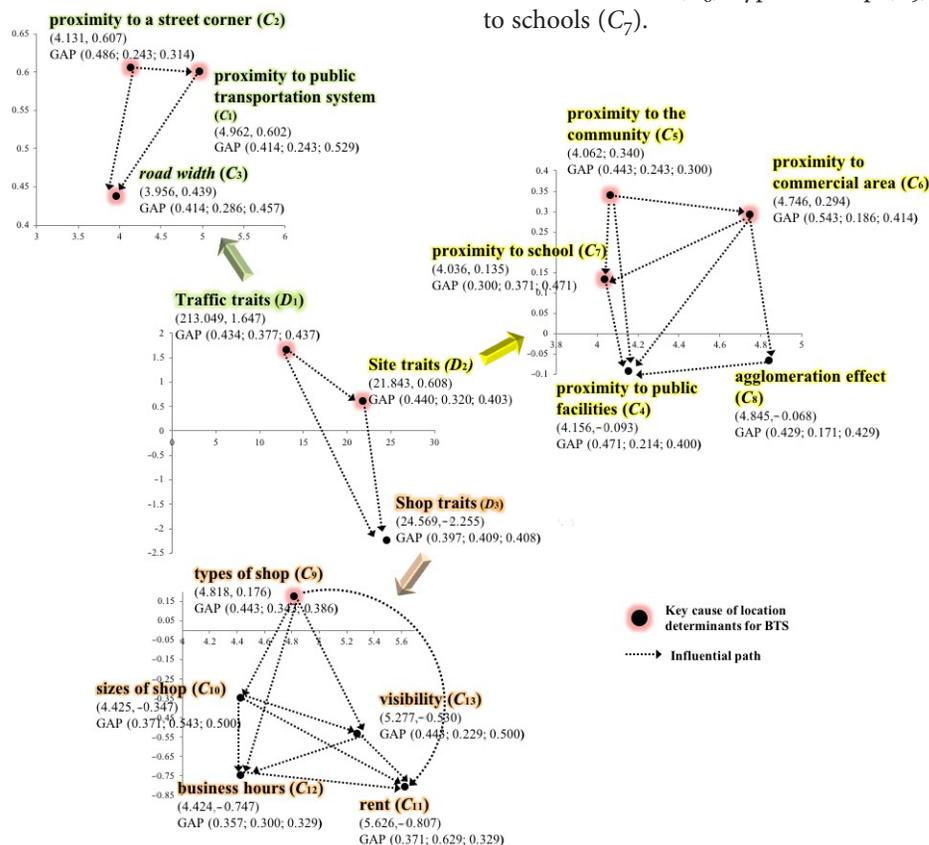


Figure 4. INRM to determine relationships between location determinants of BTSs

Table 9. The result of criteria calculated via DEMATEL and DANP

	<i>d</i>	<i>r</i>	(<i>d</i> + <i>r</i>)	(<i>d</i> - <i>r</i>)	Local weight	Global weight (Ranking)
Traffic traits (<i>D</i> ₁)	7.348	5.701	13.049	1.647	0.216	
proximity to public transportation system (<i>C</i> ₁)	2.782	2.180	4.962	0.602	0.352	0.076(8)
proximity to a street corner (<i>C</i> ₂)	2.369	1.762	4.131	0.607	0.275	0.059(13)
road width (<i>C</i> ₃)	2.197	1.759	3.956	0.438	0.372	0.080(5)
Site traits (<i>D</i> ₂)	11.225	10.617	21.843	0.608	0.351	
proximity to public facilities (<i>C</i> ₄)	2.032	2.125	4.156	-0.093	0.200	0.070(10)
proximity to the community (<i>C</i> ₅)	2.201	1.861	4.062	0.340	0.175	0.061(12)
proximity to commercial area (<i>C</i> ₆)	2.520	2.226	4.746	0.294	0.207	0.073(9)
proximity to schools (<i>C</i> ₇)	2.086	1.950	4.036	0.135	0.183	0.064(11)
agglomeration effect (<i>C</i> ₈)	2.387	2.456	4.843	-0.068	0.235	0.082(4)
Shop traits (<i>D</i> ₃)	11.157	13.412	24.569	-2.255	0.434	
types of shop (<i>C</i> ₉)	2.497	2.321	4.818	0.176	0.182	0.079(6)
sizes of shop (<i>C</i> ₁₀)	2.039	2.386	4.425	-0.347	0.182	0.079(6)
rent (<i>C</i> ₁₁)	2.409	3.216	5.626	-0.807	0.221	0.096(1)
business hours (<i>C</i> ₁₂)	1.838	2.585	4.424	-0.747	0.197	0.085(3)
visibility (<i>C</i> ₁₃)	2.374	2.903	5.277	-0.530	0.219	0.095(2)

3.3. Potential performance and GAP for the three alternatives based on modified VIKOR methodology

Three alternative BTSs, located in Nanjing, were evaluated based on DANP weights reached in combination with a modified VIKOR methodology (see Table 10 for overall results). In terms of the GAP ratio (performance) for the criteria, the minimum GAP for alternative B is 0.312 (6.883) for Site traits (*D*₂), followed by 0.368 (6.315) for Traffic traits (*D*₁) and lastly 0.404 (5.965) for Shop traits (*D*₃). The minimum expected GAP in alternative C is 0.402 (5.976) for Shop traits (*D*₃), followed by 0.406 (5.939) for Site traits (*D*₂), and, lastly, 0.431 (5.685) for Traffic traits (*D*₁). In alternative A, 0.403 (5.973) of Shop traits (*D*₃) was the lowest GAP value, followed by 0.412 (5.876) for Site traits (*D*₂), with the largest GAP value presented by Traffic traits' (*D*₁) 0.430 (5.697).

The criteria with larger GAP values (lower performance value) among the three alternatives are proposed. In alternative B, rents' (*C*₁₁) value of 0.629 (3.714) is the

largest GAP ratio, followed by 0.529 (4.714) for types of shop (*C*₉) and 0.343 (6.571) for proximity to schools (*C*₇). In alternative C, the largest GAP ratio is 0.514 (4.857), which corresponds to proximity to public transportation systems (*C*₁), followed by 0.500 (5.000) for visibility (*C*₁₃) and 0.486 (5.143) for sizes of shop (*C*₁₀). In alternative A, the largest GAP ratio is 0.529 (4.714) for proximity to commercial areas (*C*₆), followed by 0.471 (5.286) for proximity to a street corner (*C*₂) and 0.443 (5.571) for types of shop (*C*₉).

Overall, the performance values of alternatives A, B, and C are 5.882, 6.365, and 5.903, respectively. Simulating results under different decision-making parameters *v* is indicated via Table 11. Based on the individual least-regret principle (i.e. when *v* = 0), the integrated value *R_k* is 0.529, 0.629, and 0.514, respectively. When considering the average decision-making principle (i.e. when *v* = 0.5), the three cases present values of 0.471, 0.496 and 0.462, respectively. The integrated value based on the group maximum utility principle (i.e. when *v* = 1) are 0.412, 0.363 and 0.410, respectively.

Table 10. Performance and GAP ratios for three pre-selected cases in Nanjing

Dimension/Criteria	Performance			GAP (ratio)		
	A	B	C	A	B	C
Traffic traits (<i>D</i> ₁)	5.697	6.315	5.685	0.430	0.368	0.431
proximity to public transportation system (<i>C</i> ₁)	6.000	7.714	4.857	0.400	0.229	0.514
proximity to a street corner (<i>C</i> ₂)	5.286	7.714	6.571	0.471	0.229	0.343
road width (<i>C</i> ₃)	5.714	7.143	5.429	0.429	0.286	0.457

End of Table 10

Dimension/Criteria	Performance			GAP (ratio)		
	A	B	C	A	B	C
Site traits (D_2)	5.876	6.882	5.939	0.412	0.312	0.406
proximity to public facilities (C_4)	5.571	7.857	5.857	0.443	0.214	0.414
proximity to the community (C_5)	6.000	7.571	7.143	0.400	0.243	0.286
proximity to commercial area (C_6)	4.714	8.286	5.857	0.529	0.171	0.414
proximity to schools (C_7)	7.429	6.571	5.429	0.257	0.343	0.457
agglomeration effect (C_8)	5.857	8.429	6.000	0.414	0.157	0.400
Shop traits (D_3)	5.973	5.965	5.976	0.403	0.404	0.402
types of shop (C_9)	5.571	6.571	6.286	0.443	0.343	0.371
sizes of shop (C_{10})	6.143	4.714	5.143	0.386	0.529	0.486
rent (C_{11})	6.143	3.714	6.714	0.386	0.629	0.329
business hours (C_{12})	6.286	7.143	6.714	0.371	0.286	0.329
visibility (C_{13})	5.714	7.714	5.000	0.429	0.229	0.500
Total performance	5.882	6.365	5.903			
Total gap				0.412	0.363	0.410
Maximum gap				0.529	0.629	0.514

Table 11. Intergraded value R_k under different decision-making parameters ν

Alternative	R_k		
	A	B	C
ν			
0.00	0.529	0.629	0.514
0.10	0.517	0.602	0.504
0.20	0.506	0.576	0.493
0.30	0.494	0.549	0.483
0.40	0.482	0.523	0.472
0.50	0.471	0.496	0.462
0.60	0.459	0.469	0.452
0.70	0.447	0.443	0.441
0.80	0.435	0.416	0.431
0.90	0.424	0.390	0.420
1.00	0.412	0.363	0.410

4. Discussion

The two primary findings are discussed as follow.

4.1. Influential relationships among criteria and key location determinants concerning BTSs

The INRM results obtained via DEMATEL (see Figure 3) indicate that traffic traits (D_1) and site traits (D_2) with positive values of $(d + r)$ are key determinants affecting a BTS; in this regard, traffic traits (D_1) affect site traits (D_2), while shop traits (D_3) are affected by both of the aforementioned. This echoes the viewpoint of retail location theory (Reilly, 1929, 1931; Christaller, 1933, 1966; Alonso, 1964). By playing a connecting role between concerns of accessibility and food outlets, traffic traits (D_1) promote accessibility of location (Tzeng et al., 2002; Lin & Yang,

2019). By contrast, shop traits (D_3), which present with a negative $(d + r)$, is not an important determinant of BTS, although DANP methodology indicates that this category carries the highest weight. These interactions clearly identify the location determinants that are core to BTSs and highlight the advantages of this method.

Following the same logic, all the criteria of traffic traits (D_1) have positive $(d + r)$ values, except for proximity to public facilities (C_4) and the agglomeration effect (C_8). Proximity to a street corner (C_2) shows a larger positive value than has been presented elsewhere (Kuo et al., 1999, 2002; Chen & Tsai, 2016), while proximity to public transportation systems (C_1) (Tzeng et al., 2002; Chen et al., 2018; Lin & Yang, 2019) and road width (C_3) (Sevtsuk, 2014; Oh et al., 2015) are consistent with the results from the literature. Road width (C_3) highlights the higher DANP weights among these criteria, indicating that the interviewed experts believe that road width still has a very important influence on BTS customers who mainly make purchases in person. In addition, the type of shop (C_9), ranked sixth based on its DANP weight—has a positive $(d + r)$ value, indicating that its importance cannot be ignored. This result supports the phenomenon whereby BTSs are often found in large shopping malls in many new development zones but are street-based throughout older China cities.

The criteria related to site traits (D_2) verify that BTSs have become an important part of the daily dietary routines of urban residents in China and Taiwan. It is easy to observe a large number of BTSs across various environments, such as residential areas, commercial areas, or school areas. This also echoes the results from Western-dominated public health research that focuses upon the higher number and density of locations that sell sugary food around commercial areas (Day & Pearce, 2011; Engler-Stringer et al., 2014; Yang et al., 2017), communities

(He et al., 2012; Smith et al., 2013), and schools (Day et al., 2015). Compared to the previous literature regarding restaurants' location—with a focus on business areas (Tzeng et al., 2002; Chen & Tsai, 2016; Chen et al., 2018)—the exploration of site-relevant factors is an innovative approach taken by this research and can give operators a good set of investment guidelines. This also carries implications for the expansion of healthcare research in the prevailing Western-oriented food environment. This is particularly salient given that, although a large number of Western-oriented research fields have shown the relationship between the location of sugary food outlets and health, research focusing on BTSs is lacking. At present, only Tseng et al. (2014) have found that college students who drink more tea in Taiwan have a higher Body Mass Index (BMI), implying that this interesting phenomenon is related to BTSs' business operations. However, it remains a complex issue because BTSs' sell not only tea but also a variety of sugary beverages. Therefore, active and in-depth exploration of the public health evidence concerning the relationship between intake behavior (such as type, frequency, and amount of BTS product intake) and health status (such as the prevalence of overweight, obesity, or even cardiovascular disease) is meaningful in expanding the academic understanding of these phenomena and in promoting public health.

The relative position of the agglomeration effect (C_8) is interesting. The negative value calculated via $(d + r)$ means that it is influenced by other determinants and is thus not the main determinant. This also implies that operators of BTSs may be less willing to agglomerate with each other, given the bigger risks that accompany competition, as reported in the literature (Kuo et al., 1999, 2002; Tzeng et al., 2002; Prayag et al., 2012; Ho et al., 2013; John et al., 2015; Chen & Tsai, 2016; Chen et al., 2018). However, the agglomeration phenomenon of BTSs that is often observed seems to be explained by the "comparison of goods" effect, based on reducing search costs (Hotelling, 1929; Sevtsuk, 2014). This study proposes that different BTSs actually display various beverage features and business strategies despite selling products made of similar inputs (such as tea-making ingredients). Consequently, consumers decide which BTS is more suited to their desires or needs through a process of selection. Another interesting finding is that rent (C_{11}) carries the highest weighting (via the DANP method), echoing the current literature, including Tzeng et al. (2002), Chen and Tsai (2016), and Chen et al. (2019). More important, negative $(d + r)$ values (based on the DEMATEL method) imply that rents belong with the "effect" group. This is a reasonable finding because higher rents are impacted by better traffic, site, or store transit, meaning that it is not difficult to find an agglomeration of BTSs among locations with higher rents in some commercial areas (see Figure 1). This is because shops with better traffic and site transit may acquire more potential customers, even if higher rents come as a tradeoff.

In summary, traffic traits (D_1) and site traits (D_2), along with relevant criteria, are the key factors in explaining the choice made by BTSs in location determination

and will affect shop traits (D_3) and the relevant set of criteria. Specifically, key location determinants for BTSs (as presented by the DEMATEL method, combined with the DANP process) include proximity to public transportation systems (C_1), proximity to a street corner (C_2), road width (C_3), proximity to the community (C_5), proximity to commercial areas (C_6), proximity to schools (C_7), and type of shop (C_9). After BTSs address these determinants, the other factors will be improved, making the location more attractive for BTS operators.

4.2. Different decision-making ranking and improvement strategies for three alternatives in Nanjing

A modified VIKOR methodology was used to evaluate GAP values' potential performance for the three pre-selected alternatives located in Nanjing, China. Simultaneously, the DEMATEL method's results could also provide and form effective improvement strategies to indicate the effectiveness of a BTS location while evaluating alternatives. Among the three alternatives, alternative B has the highest performance value, followed by alternative A, with the worst performer being alternative C. When considering different decision-making strategies, different sorting methods were also presented. When considering only the individual maximum benefit, the ranking is $B > A > C$. As more group benefits are considered, the ranking changes when $v = 0.7$. At this time, the ranking is altered to $A > B > C$. When considering the maximum group benefit, the ranking is presented as $A > C > B$. Such results reflect the advantages of this method used in this study, offering decision-makers different evaluation suggestions according to their needs.

In terms of improvement strategies, rent (C_{11}), size of the shop (C_{10}), and proximity to schools (C_7) had lower performance values (larger GAP ratios) in the case of alternative B. Based on guidance from the DEMATEL method, an improvement in criteria with characteristics that influence others and those demonstrating lower performance—such as proximity to schools (C_7) and road width (C_3)—will further enhance the advantages of BTS locations. Following this logic, alternative C should focus on improving its proximity to public transportation systems (C_1), proximity to schools (C_7), road width (C_3), and proximity to commercial areas (C_6). In alternative A, proximity to commercial areas (C_6), proximity to a street corner (C_2), proximity to the community (C_5), types of shops (C_9), proximity to public transportation systems (C_1), and road width (C_3) should be focused upon to improve the BTS's potential.

Conclusions and research outlook

This work started by improving upon the traditional MADM methods (such as AHP and ANP)—which did not fully consider the mutual influences involved when exploring retail location determinants—for use with BTSs

(having oriental cultural characteristics, especially in China and Taiwan), thus forming a unique research objective. Although Western literature has explored the location of food retail industries, such as fast-food restaurants and convenience stores, this study is, as far as the author knows, the first to explore unique food retailing industries, such as that of BTSs. The hybrid MADM model is proposed as combining the advantages of three decision-making methods to provide decision-makers with better frameworks for thinking about evaluating the location determinants of BTSs, the potential offered by different locations, and the countermeasures needed, using scientific and systematic methods.

The decision-making model proposed via this research can improve and solve several traditional decision-making problems for location evaluation; this is one of the paper's most prominent contributions. First, the DEMATEL method's introduction can clarify the influential relationship between location determinants and provide decision-makers a way to identify each determinant's attribute, such as to cause and effect relations. This method corrects the unrealistic assumption of non-interacting factors related to traditional regression models (Yang et al., 2017) and AHP (Kuo et al., 1999, 2002; Tzeng et al., 2002; Ho et al., 2013; Yıldız & Tüysüz, 2019). Second, the DEMATEL method and the traditional ANP process can make a more realistic DANP method to evaluate actual alternatives. The DANP method, combined with DEMATEL and ANP processes, improves upon the traditional ANP method (Tolga et al., 2013; Neumüller et al., 2015; Wibisono & Marella, 2020). In addition, DEMATEL and DANP processes can also comprehensively identify the key location determinants. Third, a modified VIKOR methodology will also help decision-makers evaluate several BTS alternatives based on different perspectives (such as individuals or groups). More importantly, the INRM formed in combination with the DEMATEL method can provide decision-makers with a good way of identifying the indicators to be prioritized under settings of limited resources to improve performance. Overall, this study should be considered groundbreaking research exploring location determinants for food outlets, based upon a hybrid MADM model and those playing a key role in location selection for operators of BTSs. Further applications of this paper's approach to various food outlets across different regions are recommended to compare and strengthen the supporting evidence of the model's applicability. In addition, this model can be further optimized in future research by, for example, combining it with fuzzy semantics, making it a closer approximation of people's real decision-making processes.

Another major contribution of this study is its exploration of BTSs, the first of its kind. Following this, future work concerning BTSs is proposed. With the rapid development of BTSs in Western cities in recent years, the BTS industry has gradually become familiar to Western urban residents. Future research can use Western cities as a research context to explore differences in this study's results. Such research could provide a better understanding for foreign investment

endeavors in the BTS industry to avoid business promotion failures. In addition, representative retail location theories, such as spatial interaction theory, reveal that merchant factors (such as products, brands, and operations) will become an important factor in weighing distance and consumer behavior. Subsequent research can further utilize big data such as geographic information systems (GIS), for example, and combine it with multiple data sources, such as consumer behavior questionnaires, to explore the relationships between individual factors for different businesses, such as franchise operations, or marketing approaches. In addition, studying the behavioral motivations and intentions of consumers is critical for BTSs when formulating the industry's business management strategies.

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Author contributions

Sheng-Hau LIN and Taiyang, ZHONG conceived the study and were responsible for the design and development of the data analysis. Xiwei HE, and Jia-Hsuan LI were responsible for data collection and interpretation. Gwo-Hshiong TZENG was responsible for modeling MADM. Chih-Chen HSU, Jing-Chzi HSIEH and Taiyang, ZHONG were responsible for manuscript's revision. Sheng-Hau LIN wrote the first draft of the article.

Disclosure statement

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Appendix

Appendix A. Questionnaire sent to experts

Questionnaire exploring the location determinants of Bubble Tea Shop (BTS)

Hello! Thank you for kindly participating in this survey, titled “Questionnaire on exploring the location determinants of Bubble Tea Shop (BTS).” The world-famous “bubble milk tea” originated in Taiwan, and has been Asia’s representative beverage globally. This questionnaire mainly explores the relationship between a BTS’ location determinants and to evaluate three alternative shop locations in Najing, China.

Your opinion will provide relevant analysis (for only for academic purposes), and will not be disclosed or used for other means. The content of the questionnaire must be strictly confidential. Please feel free to answer the questions below. We appreciate your participation in this study.

Part 1. Experts’ information (Single choice, please fill in the relevant part)

a. Academic Sector

1. Department: Land management Business management Other
2. Position:
3. Working year:

b. Industry sector

1. Department: Catering Restaurant BTS Other
2. Position:
3. Working year:

c. Proposed evaluation framework for location determinants of BTS (Please read this table)

Dimension	Criteria	Description
Traffic traits (D_1)	proximity to public transportation system (C_1)	Shops with more subway stations and a larger number of bus lines within a certain range have better accessibility to transportation, and will likely attract more potential customers
	proximity to a street corner (C_2)	Shops near a street corner will likely attract more potential customers
	road width (C_3)	Shop facing a wide road will likely attract more potential customers as more vehicles and pedestrians are likely to pass
Site traits (D_2)	proximity to public facilities (C_4)	Shops near community centers, arts and cultural centers, stadiums and public libraries will likely attract more potential consumers and expand its range via food delivery systems
	proximity to the community (C_5)	Shops located in, or near larger communities will likely attract more potential consumers and expand its range via food delivery systems
	proximity to commercial areas (C_6)	Shops located in, or near larger commercial areas will likely attract more potential consumers and expand its range via food delivery systems
	proximity to schools (C_7)	Shops located in school areas, such as University towns or near larger schools, will likely attract more potential consumers and expand its range via food delivery systems
	agglomeration effect (C_8)	Although areas with more BTSs may indicate a risk of competition, it is more likely attract more potential consumers and expand its range via food delivery systems as agglomeration can aid customers in choosing their beverage based on different tastes and the atmosphere of the area/store
Shop traits (D_3)	types of shop (C_9)	Two types of shop, including the street shop and shop in a department store, need to be considered. Street stores attract more passers-by, while shops in commercial complexes attract more consumer and expand its range via food delivery systems
	sizes of shop (C_{10})	A shop’s size must be able to support various usage needs, such as shaking tea, brewing tea, and storage of raw materials. The new generation of BTS may provide more seats in the store, and a larger size may thus be required
	rent (C_{11})	Shops may incur a higher rent due to better transportation and location conditions, larger size, or visibility
	business hours (C_{12})	Shops with longer business hours have more time to supply tea to consumers and are located in business districts with similarly long total business hours
	visibility (C_{13})	Shops with strong visibility, such as those located at the core of the main street or commercial complex, will increase their visibility and will be enhanced via billboard advertisements

Part 3. Evaluation form for three alternative shops found in Nanjing, China

a. Description of each criterion of the three alternative shops located in Nanjing (Please read this table)

Dimension	Criteria	Alternative A	Alternative B	Alternative C
Area		Xuezelu commercial area in Xianlin University Town, Qixia District	Xuezelu commercial area in Xianlin University Town, Qixia District	Xinjiekou Commercial District in Qinhuai District
Traffic traits (D ₁)	proximity to public transportation system (C ₁)	200 meters away from Xueze Road Station of MRT Line 2, and near 5 bus lines passing by	150 meters away from Xinjiekou Metro Station of MRT 1 and 2; the nearest bus stop has 3 bus lines passing by	Near the construction of Hongyang Plaza Station of Metro Line S8; 2 bus lines passing by
	proximity to a street corner (C ₂)	250 meters away from the intersection of Xueze Road and Xianlin Avenue	50 meters away from the intersection of Shigu Road and Rich Road	50 meters from the entrance of B1 in shopping mall
	road width (C ₃)	The shop is in the food court, so the road is only 6 meters wide and only pedestrians can pass	The shop faces Shigu Road, which is about 18 meters wide and can be used by vehicles and pedestrians	The shop is not facing the main arterial roads of the mall and can only be accessed by pedestrians
Site traits (D ₂)	proximity to public facilities (C ₄)	Located nearby and can deliver via the food delivery system, including (1) Government agency: the Xianlin Office of the Qixia District Government	Located nearby and can deliver via the food delivery system, including (1) Popular tourist attractions: Xuanwu Lake, Chaotian Palace, Presidential Palace, Confucius Temple Scenic Area, Jiangsu Provincial Art Museum, Nanjing Library, Nanjing Museum, Nanjing Geological Museum, Nanjing Folk Customs Museum (Ganxi House), Pilu Temple, Jinling Carvings, Zijin Grand Theater; (2) Large parks: Bailuzhou Park, Xi'anmen Site Park and Dongshuiguan Site Park; (3) Sports Center: Wutaishan Sports Center, Qinhuai Sports Center, Jiangsu Province	Located nearby and can delivered via the food delivery system, including (1) Government agency: the Taishan Sub-district Office; (2) Passenger Station: Nanjing Long-distance Bus Station, Jiangbei Passenger Transport Department; (3) Large-scale parks: Qiaobei Riverside Ecological Park, Baotashan Forest Park, Liuzhou Xiaoyou Park; (4) Sports Center: Pukou Culture and Sports Center
	proximity to the community (C ₅)	Located near the Yadong community, the Kangqiao Santa Fe community, and a total of 24 residential communities can be reached via the food delivery system	A total 285 small and medium residential communities can be reached via the food delivery system	A total 64 residential communities can be reached via the food delivery system, and includes larger communities (such as 19 blocks in the Venice communities and 16 blocks in the Huaning Tianrun Ccommunities
	proximity to commercial areas (C ₆)	A total of 11 shopping malls, commercial offices and industrial zones – including Rand Information Industry Park, Suning Headquarters – can be reached via the food delivery system	A total of 128 shopping malls, commercial offices and industrial zones – including Deji Mall, Ocean Department Store, Central Mall and Golden Eagle Department Store – can be reached via the food delivery system	A total of 15 Shopping malls, commercial offices and industrial zones – including Xiaoliu Industrial Zone in Nanjing High-tech Zone, Nanjing Railway Logistics Base of China Railway, Baotashan Creative Industry Park – can be reached via the food delivery system
	proximity to schools (C ₇)	More than 10 universities and colleges, and more than 10 primary and secondary schools	10 universities and colleges, and more than 30 primary and secondary schools are located nearby	2 colleges and 8 primary and secondary schools are nearby
	agglomeration effect (C ₈)	There are 19 BTSs within a 10-minute walk (approximately 600 meters) of this area, and 40 BTSs within the delivery range for food delivery systems	There are 51 BTSs within a 10-minute walk, and there are 424 BTSs within the delivery range for food delivery systems	There are 17 BTSs within a 10-minute walk, and there are 53 BTSs within the delivery range for food delivery systems
	Shop traits (D ₃)	types of shop (C ₉)	Street shop on first floor of the horizontal food court	Traditional street shop
sizes of shop (C ₁₀)		20 square meters	15 square meters	15 square meters
rent (C ₁₁)		Monthly rent is RMB 16,600 (RMB 830/square meter)	Monthly rent is approximately RMB 25,833 (RMB 1,722/square meter)	Monthly rent is approximately RMB 10,000 (RMB 667/ square meter)
business hours (C ₁₂)		Operates from Monday to Sunday between 10 am to 10 pm	Operates from Monday to Sunday between 10 am to 10 pm	Operates from Monday to Sunday between 10 am and 10 pm
visibility (C ₁₃)		Because it is not on the main road, it is impossible to directly see the shop sign	It is located on Shigu Road, the shop sign can be viewed directly	It is not at the core of department store, its store sign can only be seen at the entrance

b. Evaluation form for the three alternatives (Please fill in the relevant sections)

Please indicate your satisfaction with the 13 criteria in terms of each alternative in the table below. If you are most satisfied with "Proximity to public transportation systems (C_1)," please insert 10 points; if you are not satisfied, fill in 1.

Dimensions	Criteria	Evaluation (very unsatisfied \leftarrow 1, 2, ..., 9, 10 \rightarrow very satisfied)		
		A	B	C
Traffic traits (D_1)	proximity to public transportation system(C_1)			
	proximity to a street corner (C_2)			
	road width (C_3)			
Site traits (D_2)	proximity to public facilities (C_4)			
	proximity to the community (C_5)			
	proximity to commercial areas (C_6)			
	proximity to schools (C_7)			
	agglomeration effect (C_8)			
Shop traits (D_3)	types of shop (C_9)			
	sizes of shop (C_{10})			
	rent (C_{11})			
	business hours (C_{12})			
	visibility (C_{13})			

Appendix B. MADM model

B.1 Modeling procedure for DEMATEL

(1) **First step:** The initial influential relation matrix $M_{initial}$ is constructed, in which a_{ij} indicates the degree of influence of one certain criterion i on another criterion j , and n represents the criteria selected:

$$M_{initial} = [a_{ij}]_{n \times n} \tag{A.1}$$

(2) **Second step:** $M_{initial}$ is divided by the sum of each row and each column to obtain a normalized influence relation matrix $M_{nmlinitial}$:

$$M_{nmlinitial} = kA, \tag{A.2}$$

where $k = \min \left\{ 1 / \max_i \sum_{j=1}^n a_{ij}, 1 / \max_j \sum_{i=1}^n a_{ij} \right\}$.

(3) **Third step:** Then, $M_{nmlinitial}$ after power processing (i.e. $\lim_{h \rightarrow \infty} M^{kh}_{nmlinitial} = [0]_{n \times n}$) obtains the total influence relationship matrix for criteria M_c is obtained:

$$M_c = M_{nmlinitial} (I - M_{nmlinitial})^{-1} \tag{A.3}$$

After that, each row and column are summed up respectively to get the sum vector of the row d and the sum vector of the column r , in which superscript ' represents transposition:

$$d = \left[\sum_{i=1}^n t_{ij} \right]_{n \times 1} = [d_i]_{n \times 1}; \tag{A.4}$$

$$r = \left[\sum_{i=1}^n t_{ij} \right]'_{n \times 1} = [r_i]'_{n \times 1} \tag{A.5}$$

B.2 Modeling procedure for DANP

(1) **First step:** The first step is to normalize the M_c obtained by DEMATEL (Eq. A.3) for getting the normalized total influence relation matrix M_{nmlc} :

$$M_{nmlc} = \begin{bmatrix} M_{nmlc}^{11} & M_{nmlc}^{1j} & M_{nmlc}^{1p} \\ M_{nmlc}^{i1} & M_{nmlc}^{ij} & M_{nmlc}^{ip} \\ M_{nmlc}^{p1} & M_{nmlc}^{pj} & M_{nmlc}^{pp} \end{bmatrix}_{n \times n | q < n, \sum_{j=1}^p p_j = n} \tag{A.6}$$

Following way that obtain M_c , the total influence relationship matrix for dimension M_d is normalized and then obtain the normalized influence relationship matrix for dimension $M_{nml d}$, as follows:

$$M_{nml d} = \begin{bmatrix} M_{nml d}^{11} & M_{nml d}^{1j} & M_{nml d}^{1p} \\ M_{nml d}^{i1} & M_{nml d}^{ij} & M_{nml d}^{ip} \\ M_{nml d}^{p1} & M_{nml d}^{pj} & M_{nml d}^{pp} \end{bmatrix}_{n \times n | q < n, \sum_{j=1}^p p_j = n} \tag{A.7}$$

(2) **Second step:** M_{nmlc} is transposed to get the unweighted super-matrix $W_{unw} = (M_{nmlc})'$. Traditional ANP indicated the blank or 0 shown in the W_{nmlw}^{pp} :

$$W_{nmlw} = (M_{nmlc})' = \begin{bmatrix} W_{nmlw}^{11} & W_{nmlw}^{i1} & W_{nmlw}^{p1} \\ W_{nmlw}^{1j} & W_{nmlw}^{ij} & W_{nmlw}^{pj} \\ W_{nmlw}^{1p} & W_{nmlw}^{ip} & W_{nmlw}^{pp} \end{bmatrix}_{n \times n | p < n, \sum_{j=1}^p p_j = n} \tag{A.8}$$

Then, M_{nmld} is also introduced into $W_{unw} = (M_{nmld})'$ for obtaining the weighted super-matrix $W_{wsw} = M_{nmld}W_{unw}$:

$$W_{wsw} = M_{nmld}W_{unw} = \begin{bmatrix} M_{nmld}^{11} \times W_{nmld}^{11} & M_{nmld}^{1j} \times W_{nmld}^{i1} & M_{nmld}^{1p} \times W_{nmld}^{p1} \\ M_{nmld}^{i1} \times W_{nmld}^{1j} & M_{nmld}^{ij} \times W_{nmld}^{ij} & M_{nmld}^{ip} \times W_{nmld}^{pj} \\ M_{nmld}^{p1} \times W_{nmld}^{1p} & M_{nmld}^{pj} \times W_{nmld}^{ip} & M_{nmld}^{pp} \times W_{nmld}^{pp} \end{bmatrix}_{n \times n | q < n, \sum_{j=1}^p p_j = n}, \tag{A.9}$$

where M_{nmld}^{ij} is a scalar and $\sum_{j=1}^p p_j = n$.

(3) Third step: According to the concept of Markov chain, the weighted super-matrix W_{wsw} is multiplied by a hundred times to obtain a finite super-matrix as follow:

$$W_{DANP} = \lim_{\varphi \rightarrow \infty} (W_{wsw})^\varphi. \tag{A.10}$$

In other words, the weighted super-matrix is limited by φ power of W_{wsw} meaning super-matrix should converge and become a stable super-matrix in long term if it is larger enough, and hence obtaining the weight of DANP W_{DANP} .

B.3 Modeling procedure for modified VIKOR

(1) First step: The potential alternative performance matrix A_j is established based on opinion of experts, in which k represents the three alternative number in this study:

$$A_j = [f_{kj}]_{k \times n}. \tag{A.11}$$

(2) Second step: The S_k and Q_k is indicated to represent the average GAP with aspiration level and the maximum GAP with the aspiration level, respectively. W_{DANP} represents the local weight of the DANP:

$$S_k = L_k^{A=1} = \sum_{j=1}^n [w_j \left(\frac{|f_j^{aspire} - f_{kj}|}{|f_j^{aspire} - f_j^-|} \right)]; \tag{A.12}$$

$$Q_k = L_k^{p=\infty} = \max_j \left\{ \frac{|f_j^{aspire} - f_{kj}|}{|f_j^{aspire} - f_j^-|} \mid j = 1, 2, \dots, n \right\}. \tag{A.13}$$

(3) Third step: Integration index R_k is obtained based on the principle of a minimum integration GAP, i.e. $\min_k L_k^p$.

$$R_k = v \frac{(S_k - S^{aspire})}{(S^- - S^{aspire})} / + (1 - v) \frac{(Q_k - Q^{aspire})}{(Q^- - Q^{aspire})}. \tag{A.14}$$

In this study, the group benefits (i.e. utilizing the maximum group utility $\min_k S_k$) will be highlighted when p is smallest (i.e. $p = 1$). Hence, $S^{aspire} = \min_k S_k$ (i.e. $S^{aspire} = 0$), $S^- = \max_k S_k$ (i.e. $S^- = 1$). Then, R_k is equal to as follows:

$$R_k = vS_k + (1 - v)Q_k, \tag{A.15}$$

where v is trade-off parameter for decision-making. This value can allow the decision maker to judge the intergrade value R_k in different decision-making situations. When v is greater than 0.5, it means that the decision maker is more inclined to adopt a “maximal group utility strategy.” Conversely, when v is closer to zero, it indicates that the decision maker is more inclined to adopt the “maximum individual utility strategy.”