A Game Analysis on City Differentiated Positioning Strategy

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Abstract. By using game theory, this paper analyzes the problem of positioning competition of a city in a multidimensional attribute psychological space. The results show that in equilibrium, homogeneity, and differentiation of city positioning coexist, homogeneity in most aspects and differentiation in a key aspect. The results of a multi-stage dynamic game between two cities show that the benefits of simultaneous positioning and successive positioning are quite different. There exists a remarkable first-mover advantage in the city positioning game.

Keywords: City Positioning; Game Theory; Differentiation; Homogenization; First-Mover Advantage

1 Introduction

In today's era, globalization has become the background of city development, and what globalization has brought to cities is a matter of opinion. One view is that globalization makes all cities similar and homogenizes the economies of all global cities. If this is true, cities are bound to compete fiercely as they attract talent, capital, and resources around the world. For example, when attracting investment, various places compete to give large companies preferential policies, such as tax exemptions and exemptions, and fall into price wars similar to those in product competition. Another view is that in today's world, globalization does create some homogenization, but it does not assimilate the professional differences of cities. Each city may have an advantage in some particular way, but they are not all competitive. That said, each city has its own contribution, there are some key differences, and cities do not simply compete with each other. Differences in the specialization of cities are more important than the ranking of cities [1]. As competition between cities and regions intensifies, city differentiation and competitive advantage become increasingly important [2]. This paper adopts the game theory method to obtain the results of positioning competition in the two-dimensional attribute psychological space of cities and finds that cities do become homogenous in basic attributes during equilibrium. Still, they are not homogenized in dominant attributes, showing differentiated characteristics, and theoretically explain the motivation of city positioning differentiation. At the same time, strategic suggestions for reasonable positioning are given for cities that pursue differentiated positioning.

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2 City positioning model

2.1 Basic assumptions

The model studied in this paper is an extension and variation of Hotelling's spatial competition model. He proposed using a spatial framework to describe product and price competition in monopoly industries. Within this framework, the addressing distance is considered a potential variable of the product, and the position of the consumer corresponds to his ideal product. Transportation costs are explained as the consumption due to the utility of not consuming the ideal product [3]. Lancaster has pointed out that the conclusions of the Hotelling model are far less important than the framework it uses location ideas to construct theories for analyzing product differentiation. According to the research needs of city differentiation positioning, this paper extends the assumptions of the Hotelling model.

2.1.1 From enterprise to city

The original linear city model assumes that there are two similar producers in the market, each with only one product, and the characteristics of each product are determined by its location. In the location theory, Christaller's theory of the heartland is the first to shift the object of study from industrial enterprises to retail and other service industries and residents. According to this theory, a city can produce products in a broad sense, like an enterprise, and consumers are city residents. Residents choose the city based on the principle of minimum purchase price. When consumers choose a city, they are actually choosing the products produced in that city. This paper assumes that there are two comparable cities in the market and that the characteristics of the cities are determined by their location in space. Consumers of cities are city stakeholders, including city dwellers.

2.1.2 From physical space to mental space

In Hotelling's original model, "location" meant only physical location, but Hotelling has noted its implications: "In short, there are many reasons why a particular type of buyer prefers one seller over another, but all of these considerations are expressed here by transportation costs." [3] "In the real world, competition between cities has long broken through the limitations of their physical space and expanded to the more important invisible psychological space so that the city itself and the products and services produced by the city are recognized and accepted by external target customers." The proposal of psychological space is based on the existing city spatial structure theory, and throughout the development and evolution of city spatial structure theory, from the study of physical space to the social space, image space, and information space as the mainstay, reflecting the process of spatial structure theory from focusing on physical space to focusing on psychological cognition under the background of increasing mobility of production factors and informatization [4]. In this paper, the "location" in the Hotelling model is extended to the "positioning" of the city, and the location of the city in the psychological space is actually choosing the distance between the city and the psychological preference of the city's customers. The transportation cost in the Hotelling model is the gap between the location of consumers and the location of enterprises in the market. This paper extends it to a psychological, cognitive gap, that is, the gap between the ideal city in the minds of city consumers and the actual city, which is the spatial distance perceived by the city in the psychology of the target customer, and this gap is a kind of utility

loss (disutility) for consumers. This paper uses the transportation cost function in the Hotelling model to represent the utility function that measures this psychological cognitive gap.

Like Tabuchi [5], this paper uses the quadratic distance function to represent transportation costs. It is mainly based on two considerations: (1) it is convenient to perform differential operations; (2) More importantly, according to Waterson, "shipping costs expressed in square form may be more applicable in the case of product differentiation, because square transportation costs mean that utility decreases quickly when consumers deviate from their favorite products,....." [6].

2.1.3 From one competition dimension to two competition dimensions

The concept of horizontal product differentiation is at the heart of Hotelling's analysis, and this paper discusses horizontal product differentiation scenarios in city competition, i.e., assuming that cities differ in attributes. Most analyses of strategic product differentiation assume a one-dimensional attribute space and study products with only one attribute. Obviously, this assumption is for mathematical convenience. In fact, most goods have multiple product attributes determined by a vector of attributes. An important direction in the development of horizontal product differentiation models is that the assumptions of the model are gradually approaching the real world. The increase in the dimension of product characteristics and the investigation of the sequential entry situation of enterprises are all developing in the direction of approaching the real world [7]. Hotelling assumes that competition occurs in one unit interval, so products differentiate on only one attribute. But in the real world, cities have multifaceted attributes and are different in many ways. To get closer to reality, this paper extends Hotelling's analysis to a two-dimensional attribute space, where the city's differentiating variables are given by the position in $\mathbf{R}^2$. There are two cities in the space competing with each other; the position of city A is described by the vector $\mathbf{a} = (a_1, a_2)$, and the position of city B is described by the vector $\mathbf{b} = (b_1, b_2)$.

2.2 Consumer utility function and market demand of cities

Consumers are continuously distributed in the unit plane $C = [0,1]^2$, with a two-dimensional uniform distribution density function $g(\mathbf{z})$. $\mathbf{z} = (z_1, z_2)$ is the position of a consumer, that is, the ideal point. The total number of consumers is normalized. That is, it is equal to 1. Consumers have unit demand, and the demand is inelastic. Consumers can be fully covered, ie. $D_A + D_B = 1$. The consumer utility function is $V_i(\boldsymbol{z}), i = \mathrm{A}, \mathrm{B}$.

If consumers choose city A, they get the following utility:

$$V_A(\mathbf{z}) = s - p_A - \sum_{k=1}^{2} t_k (z_k - a_k)^2 \quad (1)$$

If consumers choose city B, they get the following utility:

$$V_B(\mathbf{z}) = s - p_B - \sum_{k=1}^{2} t_k (z_k - b_k)^2 \quad (2)$$

In equation (1) and equation (2), s is the reserved price of a consumer to purchase the product, and p_i is the product price of city i. Quadratic function form is used to represent the distance of a city from an ideal point. t_k is the significance coefficient of feature k. Assuming $t_k = 1, k = 1,2$, then the demand for city A is $D_A = \int_{\{\boldsymbol{z}: V_A(z) \geq V_B(\boldsymbol{z}), \boldsymbol{z} \in C\}} g(\boldsymbol{z}) d\boldsymbol{z}$. Finally, without losing generality, assume that the marginal cost of city production is zero.

3 Game analysis

Next, the sub-game refining Nash equilibrium solution when two cities make positioning decisions simultaneously and successively is discussed. Assuming that the information is complete and perfect, cities can anticipate the impact of changes in their location on equilibrium prices. Compare the similarities and differences of equilibrium results in the case of simultaneous positioning and successive positioning of two cities. When two cities make positioning decisions at the same time, a two-stage game is constructed: in the first stage, both cities choose the location at the same time, and in the second stage, they choose the price at the same time. When two cities make positioning decisions successively, assume a three-stage game, in which the first stage city A is positioned as the first entrant in the market, the second stage city B is positioned as the second entrant in the market, and the two cities in the third stage make pricing decisions at the same time. Intuitively, this game structure captures the fact that in the short term, the price of city products is more flexible and easier to change than the positioning of the city. Pricing decisions for city products are made only after the city's positioning cannot be changed.

3.1 Price equilibrium

According to the inverse induction method, the price equilibrium of the last stage is first analyzed.

On the basis of the assumption given in Part 1, the attribute space is a plane with an edge length equal to 1. According to the utility function equations (1) and (2), the indifference point between a consumer's choice of city A and city B lies on a line defined by $p_A + \sum_{k=1}^{2}(z_k - a_k)^2 = p_B + \sum_{k=1}^{2}(z_k - b_k)^2$. Then $\hat{z}_2 = \frac{p_B - p_A + \sum_{k=1}^{2}({b_k}^2 - {a_k}^2)}{2(b_2 - a_2)} - \frac{(b_1 - a_1)}{b_2 - a_2} z_1$.

Without losing generality, assume that the difference in the two attributes between the two cities can be sorted, and the difference in the second attribute is greater, so that $(b_2 - a_2) \geq (b_1 - a_1)$. Name the second attribute as the dominant attribute and the other attribute as the basic attribute. The differentiating factors that form a city's brand mainly include the city's historical role, cultural heritage, cultural customs, geographical characteristics, industrial advantages, economic strength, and development prospects. Through the integration of the above aspects, the unique personality and temperament of one city that distinguishes it from other cities is formed.

A partial equilibrium can be acquired then. The demand for city A is given by the following equation $D_A = \int_0^1 \int_0^{\hat{z}_2} dz_2 dz_1$, namely $D_A = \frac{p_B - p_A + \sum_{k=1}^{2}({b_k}^2 - {a_k}^2) - (b_1 - a_1)}{2(b_2 - a_2)}$. Since the total market demand is 1, therefore $D_B = 1 - D_A$.

The two cities can respectively get profit:

$$\pi_A = p_A D_A \tag{3}$$

$$\pi_B = p_B D_B \tag{4}$$

According to equations (3) and (4), the equilibrium price is:

$$p_A * = \frac{2(b_2 - a_2) + \sum_{k=1}^{2}({b_k}^2 - {a_k}^2) - (b_1 - a_1)}{3} \tag{5}$$

$$p_B *= \frac{4(b_2-a_2)-\sum_{k=1}^{2}(b_k{}^2-a_k{}^2)+(b_1-a_1)}{3} \quad (6)$$

3.2 Scenario 1: The location equilibrium when two cities make positioning decisions at the same time.

Scenario 1 deals with the location equilibrium when two cities make positioning decisions at the same time. Substituting the prices in equations (3) and (4) with the equilibrium prices determined by equations (5) and (6) yields the profit function of the two cities:

$$\pi_A *= \frac{\left[2(b_2-a_2)+\sum_{k=1}^{2}(b_k{}^2-a_k{}^2)-(b_1-a_1)\right]^2}{18(b_2-a_2)} \quad (7)$$

$$\pi_B *= \frac{\left[4(b_2-a_2)-\sum_{k=1}^{2}(b_k{}^2-a_k{}^2)+(b_1-a_1)\right]^2}{18(b_2-a_2)} \quad (8)$$

Calculate the derivatives of equations (7) and (8) with respect to basic attributes a_1, b_1 respectively. It turns out that, for any $\boldsymbol{b}$, $a_1 *= \frac{1}{2}$ is the best response to city A; For any $\boldsymbol{a}$, $b_1 * = \frac{1}{2}$ is the best response of city B. That is, regardless of the value of a_1, $b_1 = \frac{1}{2}$ is the equilibrium solution; Similarly, regardless of the value of b_1, $a_1 = \frac{1}{2}$ is the equilibrium solution. Therefore, in equilibrium, the basic attribute acquires minimal differentiation.

Then, discuss the equilibrium of the two cities on the second attribute, the dominant attribute. Find the first derivatives of profit functions (7) and (8) with respect to a_2, b_2 respectively, $\begin{cases} \frac{\partial \pi_A *}{\partial a_2} = 0 \\ \frac{\partial \pi_B *}{\partial b_2} = 0 \end{cases}$. Since in the equilibrium state $a_1 = b_1 = \frac{1}{2}$, the above first-order condition can be simplified to $\begin{cases} 4a_2{}^2 + (1-4b_2)a_2 - b_2 = 0 \\ 3b_2{}^2 - 4(1+a_2)b_2 + a_{n2}{}^2 + 4a_2 = 0 \end{cases}$. So $a_2 *= -\frac{1}{4}$, $b_2 *= \frac{5}{4}$.

Proposition 1: When two cities make positioning decisions at the same time, their equilibrium positions are respectively $\left(\frac{1}{2}, -\frac{1}{4}\right), \left(\frac{1}{2}, \frac{5}{4}\right)$. In terms of the basic attribute, both cities are positioned in the center of the market. In terms of the dominant attribute, both cities are positioned outside the market. See Figure 1.

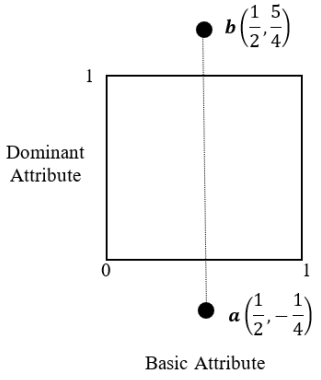

Fig. 1. The equilibrium locations when two cities make positioning decisions at the same time.

The two cities can acquire equilibrium by making a difference in the dominant attribute and convergence in the basic attribute. At that time $\pi_A *= \pi_B *= \frac{3}{4}$. It suggests that when two cities make positioning decisions at the same time, no city can acquire greater benefit than the other.

3.3 Scenario 2: The location equilibrium when two cities make positioning decisions successively.

Scenario 2 deals with the location equilibrium when two cities make positioning decisions successively. Suppose that city A makes positioning decision first, and city B makes positioning decision later. As a late entrant to the market, the decision-making behavior of city B should be determined according to the behavior of city A, so the optimal response function of city B to city A on the two attributes is first sought.

3.3.1 The optimal response function of city B to city A

From the profit function equation (8), the optimal response function of city B on the basic attribute is:

$$b_1 *= \frac{1}{2} \tag{9}$$

Substituting equation (8) with equation (9),

$$\pi_B *= \frac{\left[4(b_2-a_2)+\left({a_1}^2-a_1+\frac{1}{4}\right)-\left({b_2}^2-{a_2}^2\right)\right]^2}{18(b_2-a_2)} \tag{10}$$

According to the first-order condition of equation (10) to b_2, namely $\frac{\partial \pi_{B^*}}{\partial b_2} = 0$, the optimal response function of city B on the dominant attribute is solved. It can be seen that b_2 is determined by the following formula:

$$-3{b_2}^2 + 4(a_2+1)b_2 - {a_2}^2 - 4a_2 - \left({a_1}^2 - a_1 + \frac{1}{4}\right) = 0 \tag{11}$$

3.3.2 The equilibrium locations of the two cities

Substituting equation (7) with equation (9) to find the first-order condition of $\pi_A *$ to a_1, and b_2 of equation (7) is determined by equation (11), i.e. $\frac{\partial b_2}{\partial a_1} = \frac{2a_1-1}{4a_2+4-6b_2}$. By $\frac{\partial \pi_{A^*}}{\partial a_1} = 0$,

$$a_1 *= \frac{1}{2} \tag{12}$$

Substituting equation (11) with equation (12) yields $b_2 *= \frac{4+a_2}{3}$. Thus $\pi_A *= \frac{4}{243}(2a_2 + 5)^2(2 - a_2)$. Taking the derivative of this expression with respect to a_2, the equilibrium position of city A on the second attribute is $a_2 *= \frac{1}{2}$, thus $b_2 *= \frac{3}{2}$.

Proposition 2: When two cities make positioning decisions successively, their equilibrium positions are respectively $\left(\frac{1}{2},\frac{1}{2}\right),\left(\frac{1}{2},\frac{3}{2}\right)$. In terms of the basic attribute, both cities are positioned in the center of the market. In terms of the dominant attribute, the city that first enters the market is positioned in the center of the market, and the city that enters the market later is positioned outside the market. See Figure 2.

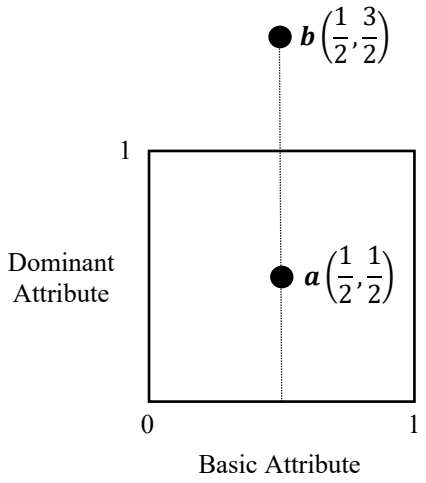

Fig. 2. The equilibrium locations when two cities make positioning decisions successively.

Intuitively, the city that is positioned first occupies a favorable market position. Currently, $\pi_A* = \frac{8}{9}$, $\pi_B* = \frac{2}{9}$. There is a huge difference in profit between the city that is positioned first and the city that is positioned later, and the profit of the former is four times that of the latter, reflecting the existence of the first-mover advantage in city positioning.

4 Case study: the city positioning competition between Zibo and Jinzhou

Zibo is a medium-sized city in Shandong Province in eastern China. Jinzhou is a medium-sized city in Liaoning Province in northeastern China. Both are prefecture-level cities and regional central cities. All have thousands of years of long history, rich resources, and convenient transportation. Both cities have traditions in the barbecue industry, but since 2023, there has been a big gap in driving the city's brand with barbecue.

As a typical industrial city in Shandong Province, Zibo's industrial development was affected by the impact of the novel coronavirus epidemic and the change in the trade situation. The local government was saddled with huge debts, and how to restore the development of the city's economy became a difficult problem facing the local government. Taking barbecue as the starting point, driving the development of related service industries, and boosting consumption became an important work idea of the Zibo municipal government in 2023. In early March 2023, as the fuse, college students were invited to take the high-speed train to Zibo to eat barbecue, which was widely publicized on multiple social media platforms, thus triggering Zibo to become an Internet celebrity city on social media. The popularity of Zibo barbecue is the result of multi-party cooperation. The first is the government's planning and guidance. Volunteers were arranged at the railway station to provide consultation and promotion services such as transportation, accommodation, barbecue, and travel routes for

returning and returning passengers; the regular bus lines passing through the barbecue restaurant were rearranged, and 21 "barbecue" bus lines were customized; 24 round-trip "barbecue tour" trains between Jinan West and Zibo were opened; and 38 youth stations could be checked into at half price for college students from colleges and universities outside the city. The second is the cooperation of the people. Residents, drivers, businesses, students, and media actively participated and took the initiative to support. Consumers regard the Zibo barbecue industry itself as cost-effective and honest. As for the city of Zibo, consumers feel the enthusiasm and care for tourists, the high efficiency of the government, and the people-friendly and pragmatic style. The joint efforts of many parties have created the character and cultural core of Zibo.

According to data from the Zibo Bureau of Statistics, consumption showed a clear acceleration growth trend in March, with retail sales of consumer goods reaching 11.1 billion yuan in the first quarter, an increase of 11.1%. In the first quarter, the sales (turnover) of wholesale, retail, accommodation, and catering increased by 9.5%, 15%, 16%, and 25.2% respectively.

After the Zibo barbecue became popular, Jinzhou was anxious. In terms of barbecue skills and deliciousness, Jinzhou barbecue is no less than Zibo barbecue, or even better. Jinzhou barbecue is an intangible cultural heritage of Jinzhou City, which amazes people with its unique culinary art. But for years, the influence of Jinzhou barbecue has been limited to the local area, and there has never been such a tourism boom. The explosion of Zibo barbecue made relevant government departments and industry practitioners in Jinzhou feel intense pressure. They actively thought about the best way to use Jinzhou barbecue to drive the Jinzhou city brand and took measures such as issuing coupons to the public to attract customers. However, the popularity of Zibo barbecue is wider than barbecue itself. Still, it is the result of urban marketing involving the government's executive power, urban business environment, integrated marketing communication, and other aspects.

Summary: City brand positioning is the competition that occurs in the psychological space of consumers. Zibo and Jinzhou are cities of the same level, and the basic attributes of cities are similar. Both cities have the intention of making barbecue a differentiating attribute. There are proud barbecue industries, and they all regard barbecue as a business card of the city. But Zibo has seized the opportunity in the positioning battle to use barbecue as a differentiated attribute of the city. Nowadays, when it comes to barbecue, the first thing consumers think of is Zibo barbecue. In the competition of this attribute, Zibo undoubtedly occupies the central position of consumer psychological space and has achieved a huge first-mover advantage. Although Jinzhou has better barbecue skills and taste, it has yet to take the lead in the psychological space of consumers. The number of tourists attracted by barbecue is quite different, and the impact on local business and finances is also quite different. The city positioning competition between Zibo and Jinzhou veryfied the proposed model in this article.

5 Conclusion and discussion

5.1 Homogenization and differentiation coexist in city positioning

The results of this paper show that in the city space of the two competitive dimensions, the equilibrium acquired by city competitive positioning shows obvious characteristics. First, whether the two cities are positioned at the same time or successively, in terms of equilibrium, on the basic attribute, the two cities are in the same position in the consumer psychological space, and they are positioned in the center of the market. Only on the dominance attribute do the two cities have significantly different positions in the consumer's psychological space. Reducing the pressure of price competition is accomplished by differentiation in the dominant attribute.

This conclusion is evident in the real world. As we can see, there are similarities and differences between cities; homogenization and differentiation coexist. As Sassen said, in today's world, globalization does create some homogenization, but it does not assimilate the professional differences of cities, and there are some key differences between cities. No matter how standardized the most advanced airports, office areas, etc., no two cities are the same [1]. For example, in a certain region, especially within a metropolitan area, some secondary cities have the advantage of specialization in the global, national, or regional city system [8].

The reason for the coexistence of homogenization and differentiation in city positioning may be that like the incentive-health two-factor theory in management, the basic attributes of similar cities are very close and difficult to achieve differentiation. The performance of each city in the basic attribute is difficult to distinguish, and it is difficult to cause consumers' preference for a city based on the basic attributes alone, which can also be regarded as the health care factor in the two-factor theory. What arouses consumer interest or loyalty is an attribute that can achieve differentiation, and it is this attribute that determines the city's profit, which is the dominant attribute in this model and can also be regarded as a motivating factor in two-factor theory. For city consumers, health factors are basic attributes that all similar cities should have, and there is no difference between cities in these aspects. It is difficult for consumers to prefer these aspects of each city. Motivating factors are glamorous attributes that can be preferred by city consumers and are unique to each city. This function is easy to differentiate and can influence consumer preferences and choices.

5.2 The existence of the first-mover advantage in city positioning

The results of this paper show that in the city space of the two competing dimensions, the results of simultaneous positioning and successive positioning of the two cities are very different. When the two cities are positioned at the same time, on the dominant attribute, in the equilibrium state, both cities are positioned outside the market, with the market center as the midpoint symmetrically distributed. This shows that the two cities are very different in terms of dominance attributes and that no city is in a better position in the consumer psychological space than the other, so no city can achieve greater benefits than the other. The profits of the two cities are the same. When the two cities successively make positioning decisions, on the dominant attribute, in the equilibrium state, the city that is positioned first is located in the center of the market, and the city that is positioned later is located far away from the market; that is to say, the city that is positioned first occupies a favorable position in the psychological

space of consumers. As a result, the two cities receive different profits. The first mover gets four times the latter, reflecting a great first-mover advantage in city positioning. Comparing the very different profit of the two cities in the two situations of simultaneous positioning and successive positioning, it is found that whether they can preemptively position and occupy a favorable position on the dominant attribute has a huge impact on the city's profit.

The first-mover advantage explains the motivation of cities to pursue differentiated positioning on attractive attributes actively. Dai Yuanchu [9] proposed that when all cities do brand marketing in the same way, there are two ways to win competitive advantage: one is to be at the forefront because it is the first to attack and preemptively occupy the cognitive space of the public's brain, and to generate cognitive associations between common values and unique cities, so as to realize the first association advantage among similar city brands; The second is to find out their own unique personality and unique brand value in the same city, so that the public can easily distinguish it from other brands in the homogeneous city brand promotion. This paper argues that these two approaches are essentially the same; both are to find the unique personality and value of a city brand, discover its differences from competitors, and thus generate city brand value. Therefore, if a city already occupies the advantage of consumer psychology in a key attribute, then it enjoys the advantage of being a first mover, and what it needs to do is maintain this first position. If a city fails to gain a favorable position in its existing city positioning, there are two possible strategies for it: one is to discover new consumer needs and new opportunities in the environment and try to replace the current first mover; The second is to implement the blue ocean strategy, find charming new attributes, and become the first place in the new competition dimension.

5.3 Recommendations for city managers

The advice for city managers is that they should first sort out multiple aspects of city competition and identify the basic dimensions and the dominant dimensions. In the basic dimensions, it is necessary to reach the average level and general level of similar cities. At the same time, in the city positioning, we should attach great importance to those city charm attributes that can achieve differentiation, take them as the dominant dimensions, and highlight the differentiated value and competitive advantage of the city brand compared with the competitive city according to the needs of the target market, so as to occupy a unique position in the minds of customers and become the first place in the corresponding field in the minds of city consumers.

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